*Progressive Education Society's*

**Modern College of Arts, Science and Commerce,**

**Shivajinagar, Pune - 5**

# Third Year of B.Sc. (NEP 2024) Syllabus

## Course under NEP 2020

*Progressive Education Society's*

**Modern College of Arts, Science and Commerce,**

**Shivajinagar, Pune - 5**

**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5101**

**Course Name: Distribution theory**

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

**Examination Scheme: CIA: 40 Marks** **End-Sem: 60 Marks**

**Prerequisite Courses:**

- Basic knowledge of calculus.
- Basic knowledge of probability models.

**Course Objectives:** The students will learn:

- Various standard probability distributions.
- Relationship between standard probability distributions.
- Applications of standard probability distributions.

**Course Outcomes:** At the end of the course the students are expected to:

1. Define continuous bivariate random variable.
2. Illustrate the concepts of expectations, moments, mgf. of continuous bivariate random variable.
3. Define standard continuous probability distributions.
4. Study inter-relations of continuous probability distributions
5. Study properties of continuous probability distributions
6. Understand the concept of order statistic.

**Course Contents**

| | **Title and content** | **Lectures** |
|---|---|---|
| **Unit 1** | **Continuous Bivariate Distributions** | **10** |
| | 1.1 Continuous bivariate random vector or variable $(X, Y)$: Joint p. d. f., joint c. d. f, properties (without proof), probabilities of events related to random variables (events in terms of regions bounded by regular curves, circles, straight lines). Marginal and conditional distributions.<br>1.2 Expectation of r.v.(X,Y), expectation of function of r.v. $E[g(X,Y)]$, joint moments, $Cov(X,Y), Corr\ (X,Y)$, conditional mean, conditional variance,<br>$E[E(X\|Y = y)] = E(X)$ & $E[E(Y\|X = x) = E(Y)$ , regression as a conditional expectation.<br>Theorems on expectation:<br>(i) $E(X + Y) = E(X) + E(Y)$,<br>$(ii)\ E(XY) = E(X)\ E(Y), if\ X\ and\ Y$ are independent,<br>generalization to k variables. $E(aX + bY + c), Var\ (aX + bY + c)$<br>(statement only proof not expected).<br>Independence of random variables $X\ and\ Y$ and also itsextension to $k$ random variables. Moment generating function (MGF): $M_{X,Y}\ (t_1, t_2)$ , properties, MGF of marginal distribution of random variables(r.v.s.), properties<br>i) $M_{X,Y}\ (t_1, t_2) = M_X\ (t_1, 0)\ M_Y\ (0, t_2)$ if X and Y are independent r.v.s.,<br>ii) $M_{X+Y}\ (t) = M_{X,Y}\ (t, t)$<br>iii) $M_{X+Y} = M_X\ (t)\ M_Y\ (t)$ if X and Y are independent r.v.s.<br>Probability distribution of transformation of bivariate r. v.<br>$U = \phi_1\ (X,Y)\ , V = \phi_2(X,Y)$ .<br>examples on bivariate normal distribution. | |
| **Unit 2** | **Standard continuous probability distributions** | |
| **I** | **Beta distributions** | **10** |
| | Beta distribution of first kind: p.d.f.<br>$f(x) = \frac{1}{B(m,n)} x^{m-1}(1-x)^{n-1} \quad ; \ 0 \leq x \leq 1, m, n > 0$<br>Notation : $X \sim \beta_1\ (m, n)$,<br>Nature of probability curve, symmetry, mean, variance, properties, $r^{th}$ raw moment, harmonic mean, median for $\beta_1(m, m)$. Relation with U(0,1).<br>The probability distributions of $\frac{1}{X}, X+Y, X-Y, XY, \frac{X}{Y}$ , where X and Y are i.i.d $_1(1, 1)$.<br>Beta distribution of second kind: p.d.f. | |

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|---|---|---|
| | $$f(x)=\frac{1}{B(m,n)}\frac{x^{m+1}}{(1+x)^{m+n}};\ X\geq 0,\ m,n\geq 0$$ Notation : $X\sim \beta_2\ (m,n)$, Nature of probability curve, symmetry, mean, ariance, properties, $r^{th}$ raw moment, harmonic mean, median for $\beta_2(m,m)$. Interrelation between $\beta_1\ (m,n)$ and $\beta_2\ (m,n)$. Distribution of $\frac{X}{Y}$, $\frac{X}{X+Y}$ etc. when X and Y are independent gamma variates. Relation between distribution functions of $\beta_1\ (m,\ n)$ and binomial distribution. Real life situations and applications and model sampling using R. | |
| **II** | **Cauchy Distribution** | **06** |
| | p.d.f. $$f(x)=\frac{\lambda}{\mu}\frac{1}{\lambda^2+(x-\mu)^2};\ -\infty\leq X,\mu\leq\infty;\lambda\geq 0$$ Notation: $X\rightarrow C(\mu,\lambda)$, Nature of probability curve. Distribution function, quartiles, non – existence of moments, distribution of i) $1/X$ ii) $X^2$ iii) $aX+b$, where $X\sim C(0,1)$. Additive property for two independent Cauchy variates (statement only).Statement of distribution of the sample mean, comment on limiting distribution of sample mean. Relationship with uniform, Student's –t and normal distributions. Applications of $(\mu,\lambda)$. | |
| **III** | **Weibull Distribution** | **06** |
| | p.d.f. $$f(x)=(\alpha/\beta)*(x/\beta)^{\alpha-1}*\exp(-(x/\beta)^{\alpha}),\quad x\geq 0,\alpha,\beta>0$$ Notation : $X\sim W(\alpha\ ,\beta)$. probability curve, location parameter, shape parameter, scale parameter. Distribution function, quartiles, mean and variance, coefficient of variation. Relationship with gamma and exponential distribution. Hazard rate, IFR and DFR property. Real life situations and applications, model sampling. | |
| **IV** | **Laplace (Double exponential) distribution** | **06** |
| | p.d.f $$f(x)=\frac{\lambda}{2}\exp(-\lambda\lvert x-\mu\rvert),\ -\infty<x,\mu<\infty,\lambda>0$$ Notation: $X\sim L\ (\mu,\ \lambda)$. Nature of the probability curve. Distribution function, quartiles, comment on MLE of $\mu,\lambda$. MGF, CGF, moments and cumulants, $\beta_1$, $\beta_2$, $\gamma_1$, $\gamma_2$. Laplace distribution as the | |

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|---|---|---|
| | distribution<br>of the difference of two i.i.d. exponential variates with mean $(1/\lambda)$.<br>Applications and real life situations, model sampling. | |
| **V** | **Lognormal distribution** | **07** |
| | p.d.f.<br>$f(x)=\frac{1}{(x-a)\sigma\sqrt{2\pi}}\exp\left(-\frac{(\log(x-a)-\mu)^2}{2\sigma^2}\right), \quad X > a,$<br>$-\infty < \mu < \infty, \sigma > 0$<br><br>Notation: $X \sim LN\ (a,\ \mu,\ \sigma^2)$. Nature of the probability curve. Moments ($r^{th}$ moment of $(X-a)$), first four moments, $\beta_1$ and $\gamma_1$ coefficients, quartiles, mode.<br>Relation with $N\ (\mu, \sigma^2)$ distribution Distribution of $\prod X_i$, Xi's are independent lognormal variates. Applications and real life situations, model sampling. | |
| **VI** | **Compound and Mixture distributions** | **05** |
| | Introduction to compound and mixture distributions; compound and mixture of Binomial distribution, Poisson distribution ; compound and mixture of normal distribution. | |
| **VII** | **Order Statistics** | **10** |
| | Order statistic for a random sample of size $n$ from a continuous distribution, definition. Derivation of distribution function and density function of the i-th order statistic $X_{(i)}$, particular cases for $i = 1$ and $i = n$. Distribution of $_{(i)}$ for random sample from uniform and exponential distribution. Derivation of joint p.d.f. of $(X_{(i)},\ X_{(j)})$, probability distribution of sample range $X_{(n)} - X_{(1)}$. Distribution of sample median. $o$rr$(X_{(i)},\ X_{(j)})$ when $X_1, X_2, \ldots . X_n$ are i.i.d uniform r.v.s, distribution of $X_{(n)} - X_{(1)}$ and sample median. Comment on unbiased estimator of $\theta$ for $U(0,\ \theta)$ and exponential$(\theta)$ based on order statistics. Joint distribution of $X_{(1)}, X_{(2)}, \ldots . X_{(n)}$ | |

**References:**


1. Bhuyan K.C (2010): Probability Distribution Theory and Statistical Inference .
2. Dasgupta Anirban, (2010). Fundamentals of Probability: A First Course, Springer Publication
3. H. Cramer: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
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7. S.C. Gupta and V. K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88 Darya Ganj, New Delhi.
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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5102**

**Course Name: Statistical Inference**

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

**Examination Scheme: CIA: 40 Marks** **End-Sem: 60 Marks**

**Prerequisites:**

- Knowledge of probability and probability models
- Sampling distributions

**Course Objectives:** The students will learn

- To study various methods of estimation of parameters and functions of parameters.
- To make comparison between the various types of estimators.
- To obtain best estimators and applications of different methods of estimations of parameters for standard probability models.
- To perform the Most Powerful and Uniformly Most Powerful tests for the parameters to be tested.
- The Need of various non-parametric tests.

**Course Outcomes**: At the end of the course the students are expected to:

1. To learn concept parameter, parameter space, estimator.
2. To study general problem of estimating an unknown parameter by point and interval estimation.
3. To obtain an unbiased estimator, sufficient estimator, efficient estimator for various distribution.
4. To obtain a confidences interval for a parameter.
5. To study the basic concepts of testing of hypotheses.
6. Derive the Most Powerful and Uniformly Most Powerful tests for various pmfs/pdfs.
7. Distinguish between Most Powerful and Uniformly Most Powerful tests.
8. Distinguish between parametric or non-parametric tests.
9. Apply parametric or non-parametric tests depending on nature of the real-life data.

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Point Estimation** | **02** |
| | 1.1 Notion of a parameter, parameter space, sample space as a set of all possible values of $(X_1, X_2, . . ,X_n)$,general problem of estimating an unknown parameter by point and interval estimation.<br>1.2 Notion of a parameter, parameter space, sample space as a set of all possible values of $(X_1, X_2, . . ,X_n)$,general problem of estimating an unknown parameter by point and interval estimation.<br>1.3 Mean Squared Error (MSE) of an estimator. | |
| **Unit 2** | **Methods of Estimation** | **10** |
| | 2.1 **Method of moments:** Derivation of moment estimators for standard distributions.<br>2.2 Definition of likelihood as a function of unknown parameter, for a random sample from i) discrete distribution ii) continuous distribution, distinction between likelihood function and p.d.f./p.m.f.<br>2.3 **Method of maximum likelihood:** Derivation of maximum likelihood estimator (M.L.E.) for parameters of standard distributions Use of iterative procedure to derive M.L.E. of location parameter μ of Cauchy, truncated binomial and Poisson distributions truncated at zero. Invariance property of M.L.E.<br>2.4 a) M.L.E. of θ in uniform distribution over i) (0, θ)<br>ii) (-θ, θ) iii) (mθ, nθ) (m<n)<br>b) M.L.E. of θ in $f(x ; \theta)= Exp \{-(x- \theta)\}, x > \theta$.<br>c) M.L.E. of location parameter in Laplacedistribution.<br>Illustrations of distributions, where M.L.E. and moment estimators are same and distinct. | |
| **Unit 3** | **Criteria of Estimation** | **15** |
| | 3.1 **Unbiasedness:**<br>Definition of an unbiased estimator, biased estimator, positive and negative bias, illustrations and examples (these should include unbiased and biased estimators for the same parameters).<br>Proofs of the following results regarding unbiased estimators:<br>a) Two distinct unbiased estimators of (θ) give rise to infinitely many estimators.<br>b) If T is an unbiased estimator of θ , then ø(T) is unbiased estimator of ø(θ ) provided ø(.) is a linear function.<br>3.2 Notion of uniformly minimum variance unbiased estimator (UMVUE), uniqueness of UMVUE whenever it exists.<br>3.3 Sufficiency:<br>Concept and definition of sufficiency, statement of the Fisher-Neyman factorization theorem with proof for discrete probability distribution.<br>Pitmann – Koopman form and sufficient statistic; Exponential family of | |

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| | probability distributions with single valued parameter and sufficient statistic.<br>Proofs of the following properties of sufficient statistics:<br>i) If T is sufficient for θ, then ø (T) is also sufficient for θ provided ø is a one to one and onto function.<br>ii) If T is sufficient for θ then T is also sufficient for ø (θ).<br>iii) M.L.E. is a function of sufficient statistic.<br>3.4 **Efficiency:**<br>Definition, concept , relative efficiency of $T_1$ w.r.t. $T_2$ for (i) unbiased (ii) biased estimators.<br>3.5 **Fisher information function:**<br>Amount of information contained in statistic $T = T(X_1, X_2, \ldots, X_n)$. Statement regardinginformation in sample and in a sufficient statistic T.<br>3.6 **Cramer- Rao Inequality:**<br>Statement and proof of Cramer –Raoinequality,Cramer – Rao Lower bound(CRLB),definition ofminimum variance bound unbiased estimator(MVBUE) of ø (θ).Proofs of following results:<br>a) If MVBUE exists for θ then MVBUE exists for ø(θ) where ø (.) is a linear function.<br>b) If T is MVBUE for θ then T is sufficient for θ.<br>Comparison of variance with CRLB, Efficiencyof unbiased estimator T w.r.t. CRLB. | |
| **Unit 4** | **Interval Estimation** | **03** |
| | 4.1 Notion of interval estimation, definition of confidence interval (C.I), length of C.I., Confidence bounds, confidence coefficient. Definition of pivotal quantity and its use in obtaining confidence intervals.<br>4.2 Interval estimation for the following cases:<br>i) Mean (μ) of normal distribution ($\sigma^2$ known and $\sigma^2$unknown).<br>ii) Variance ($\sigma^2$) of normal distribution (μ knownand μ unknown). | |
| **Unit 5** | **Parametric Tests** | **04** |
| | 5.1 Statistical hypothesis, problem of testing of hypotheses. Definition and illustrations of (i) simple hypothesis, (ii) composite hypothesis, (iii) test of hypothesis, (iv) critical region, (v) type I and type II errors. Probabilities of type I error and type II error. Problem of controlling the probabilities of errors of two kinds.<br>5.2 Definition and illustrations of (i) level of significance, (ii) observed level of significance (p-value), (iii) size of a test, (iv) power of a test. | |
| **Unit 6** | **Most Powerful and Uniformly most powerful tests** | **11** |
| | 6.1 Non-randomised test functions. Definition of most powerful (M.P.) level α test of simple null hypothesis against simple alternative. Statement of Neyman - Pearson (N-P) lemma for constructing the most powerful level α test of simple null hypothesis against simple alternative hypothesis. Illustrations.<br>6.2 Power function of a test, power curve, definition of uniformly most powerful (UMP) level α test for one sided alternative. Illustrations. | |

| Unit 7 | Non-parametric Tests | 15 |
|---|---|---|
| | 7.1 Concept of non- parametric tests. Distinction between parametric and nonparametric Tests. Concept of distribution free statistic. One tailed and two tailed test procedure of i) Sign test, ii) Wilcoxon signed rank test iii) Mann Whitney U test, iv) Run test, one sample and two samples problems.<br>7.2 Empirical distribution function $S_n$ (x). Properties of $S_n$ (x) as estimator of F (.). Kolmogorov – Smirnov test for completely specified univariate distribution (one Sample problem only) for two sided alternative hypotheses. Complexity with chi-square test. | |

**References:**


1. Agarwal, B.L. (2003). Programmed Statistics, second edition, New Age International Publications, Delhi
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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5103**

**Course Name: Data Mining**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:** Knowledge of probability and probability distributions

**Course Objectives:** The students shall get concepts of

- To study classification algorithm and regression algorithm in real life situation.
- To learn supervised and unsupervised algorithm for the data.
- Ability to apply all machine learning algorithm for real life situation.
- To understand how to perform evaluation of various learning algorithm and do model selection.

**Course Outcomes**: At the end of the course the students will be able to learn:

1. To study data cleaning process in data mining.
2. To apply various supervise learning algorithms for data analysis, particularly when data is large.
3. To apply various unsupervised learning algorithms for data analysis, particularly when data is large.
4. Apply various ML algorithms for model free Statistical Inference, which can be studied by any one from any discipline.
5. To Study the clustering, association analysis and able to do outlier detection.
6. To analysis and validation of algorithms that enable computers (machines) to learn from data.

**Course Content:**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Introduction to Data Mining** | **05** |
| | 1.1 Data preparation for knowledge discovery: Data understanding and data cleaning tools, Data transformation, Data Discretization, Data Visualization.<br>1.2 Data Mining Process: CRISP and SEEMA, Supervised and unsupervised learning techniques. | |

| Unit 2 | **Supervised Learning** | 15 |
|---|---|---|
| | 2.1 Supervised learning<br>2.2 Learning with Classification - Decision Tree, Support Vector Machine (two-dimensional data), Naive Bayes, K-Nearest Neighbors, Logistic regression.<br>2.3 Evaluating model performance - False positives, False negatives Confusion matrix, Accuracy, Precision, Recall, Cross Validation and Comparison<br>2.4 Regression Metrics: R- Square, Adjusted R Square<br>2.5 Classification and Evaluation Matrix<br>2.6 Artificial Neural network: Concept of Deep learning, Artificial Neural network - Neurons, Activation function, Perceptron learning algorithm, training of perceptron | |
| **Unit 3** | **Unsupervised Learning** | **06** |
| | 3.1 Un-supervised learning<br>3.2 Clustering algorithms - Hierarchical clustering, K-means clustering,<br>3.3 Rule based learning - Association rule mining, Apriori, Support and Confidence parameters and comparison. | |
| **Unit 4** | **Model Evaluation, Selection and Classification Accuracy** | **04** |
| | 4.1 Model evaluation and selection: Metrics for evaluating classifier performance.<br>4.2 Concept of training data, testing data and validation of model, Cross-Validation. | |

**References:**


1. Chattamvelli, R. (2015). Data mining methods. Alpha Science International
2. Mitchell T.M. (1997): Machine Learning, McGraw-Hill.
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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5104**

**Course Name: Lab course on 24ScStaU5101, 24ScStaU5102 and 24ScStaU5103**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

- Knowledge of descriptive statistics.
- Knowledge of probability and probability models.

**Course Objectives:** The students will learn

- To simulate random sampling from some continuous probability distributions.
- To construct confidence interval from quartiles and correlation coefficient.
- Methodology to compute M.L.E. , Moment estimator of parameter understudy
- To perform the Most Powerful and Uniformly Most Powerful tests for the parameters to be tested.
- The need of various non-parametric tests.

| Sr. No. | Title of experiment | Number of Practicals |
|---|---|---|
| 1 | Simulation from Cauchy, beta first and second kind distribution | 1 |
| 2 | Simulation from Weibull, Laplace distribution. | 1 |
| 3 | Simulation from lognormal and Pareto distribution | 1 |
| 4 | Fitting of lognormal distribution. | 1 |
| 5 | Construction of confidence interval for population median, quartile. | 1 |
| 6 | Construction of confidence interval for correlation coefficient using pivotal quantity. | 1 |
| 7 | M.L.E. and Moment estimator of truncated Binomial and truncated Poisson (truncated at zero) | 1 |
| 8 | Testing of hypotheses ( Probability of type I error and type II error, power of test) | 1 |
| 9 | Construction of Most Powerful test and plotting of power function. | 1 |
| 10 | Construction of Uniformly Most Powerful test (UMP) test and plotting of power function. | 1 |
| 11 | Non – Parametric Test (Sign test, Wilcoxon's Signed Rank test, Mann-Whitney U test). | 1 |
| 12 | Non – Parametric Test (Run Test, Kolmogorov- Smirnov Test). | 1 |
| 13 | Data Mining _I | 1 |
| 14 | Data Mining -II | 1 |
| 15 | Experiential learning | 1 |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5201**

**Course Name: Regression Analysis**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:** Probability Models, Sampling distributions and inference

**Course Objectives:** The students will understand

- Fitting of simple linear regression model
- Fitting of multiple linear regression model
- Logistic regression model
- Testing significance of regression
- Regression diagnostics and residual analysis
- Model building

**Course Outcomes**: After completion of the course students will be able to fit an appropriate regression model to real life data sets.

1. Analyse bivariate data using scatter plots and correlation measures to determine relationships between variables.
2. Apply the least squares method to estimate regression parameters and evaluate model adequacy using hypothesis tests, ANOVA, and residual analysis.
3. Construct multiple linear regression models by estimating parameters using the least squares method and solving normal equations.
4. Evaluate model adequacy through statistical tests, detection of multicollinearity, and selection of optimal regression models.
5. Develop and interpret univariate logistic regression models, including parameter estimation and hypothesis testing.
6. Assess model fit using deviance, likelihood ratio tests, and other statistical measures

**Course Contents:**

| Unit | Title and Content | No. of lectures |
|---|---|---|
| **Unit 1** | **Simple Linear Regression Model** | **10** |
| | 1.1 Bivariate data, Scatter Diagram and Correlation<br>1.2 Fitting of simple linear regression model: $Y = \beta_0 + \beta_1 X + \varepsilon$ where $\varepsilon$ is a continuous random variable (error component) with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$. Estimation of $\beta_0$ and $\beta_1$ by the method of least squares.<br>1.3 Properties of estimators of $\beta_0$ and $\beta_1$.<br>1.4 Estimation of $\sigma^2$.<br>1.5 Interval estimation in simple linear regression model.<br>1.6 Evaluating the regression model (Tests of hypothesis of $\beta_1$, Analysis of variance, Coefficient of determination, adjusted coefficient of determination.)<br>1.7 Residual analysis: Standardized residuals, Studentized residuals, residual plots, PRESS residual.<br>1.8 Corrective measures: dealing with non-constant variance and non-linearity.<br>1.9 Outliers: Detection and treatment. | |
| **Unit 2** | **Multiple linear regression model** | **12** |
| | 2.1 Introduction to linear algebra.<br>2.2 Multiple linear regression model: $Y = \beta_0 + \beta_1 X_1 + . . + \beta_p X_p + \varepsilon$ Estimation of regression parameters $\beta_0, \beta_1, ..., \beta_p$ by the method of least squares, obtaining normal equations, solutions of normal equations.<br>2.3 Estimation of $\sigma^2$.<br>2.4 Interval estimation for regression coefficients.<br>2.5 Assessing adequacy of model: Tests for significance of regression, tests for individual regression coefficients, coefficient of determination<br>2.6 Multicolinearity: detection and treatment.<br>2.7 Model building: Criteria for evaluating subset regression models, computational techniques for variable selection. | |
| **Unit 3** | **Logistic regression model** | **8** |
| | 3.1 Introduction to logistic regression<br>3.2 Univariate logistic regression model: Defining and fitting the model, interpretation of parameters and testing of hypotheses of model parameters, deviance, LR test | |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5202**

**Course Name: Lab course on 24ScStaU5201**

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

**Examination Scheme: CIA: 20** **End-Sem: 30**

| Sr. No. | Title of Experiment/ Practical |
|---|---|
| 1 | Correlation analysis and scatter plot interpretation. |
| 2 | Basics of linear algebra for regression - I |
| 3 | Basics of linear algebra for regression - II |
| 4 | Fitting and interpretation of simple linear regression model. |
| 5 | Residual analysis and diagnostics in simple linear regression. |
| 6 | Fitting of multiple linear regression model. |
| 7 | Residual analysis and diagnostics in multiple linear regression.-I |
| 8 | Residual analysis and diagnostics in multiple linear regression.-II |
| 9 | Model building using forward selection method. |
| 10 | Model building using backward elimination method. |
| 11 | Fitting and Interpretation of simple logistic regression model. |
| 12 | Odds ratio and its interpretation in logistic regression. |
| 13-15 | Experiential learning. |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5203**

**Course Name: Stochastic Processes**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:** Matrix theory and Probability theory

**Course Objectives:** The students will be able to learn

- Concept of stochastic process
- Classification of stochastic process and their states
- Applications of stochastic process.

**Course Outcomes**: At the end of the course the students will be able to:

1. Identify and apply the appropriate stochastic models to analyze real life data .
2. Study concept of Markov chain and calculate probabilities for various events.
3. Study stochastic processes.
4. Differentiate among types of stochastic processes.
5. Study stationary distribution of stochastic processes.
6. Estimate the parameters in stochastic processes.

**Course Content:**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Introduction to Stochastic Process** | **15** |
| | 1.1 Definition of a Stochastic process, state space, parameter space, types of stochastic processes<br>1.2 Markov chains (MC) $\{X_n, n \geq 0\}$, finite MC, time homogeneous M.C. one step transition probabilities, and transition probability matrix (t.p.m.), stochastic matrix.<br>1.3 n-step transition probability matrix, Chapman Kolmogorov equation,<br>1.4 Initial distribution, joint distribution function of $\{X_0, X_1, \ldots X_n\}$ ,<br>1.5 Partial sum of independent and identically distributed random variables as Markov chain | |

| | | |
|---|---|---|
| | 1.6 Illustrations such as random walk, Gambler's ruin problem, Probability of ultimate ruin, expected gain. Ehrenfest chain. (Without proof). | |
| **Unit 2** | **Classification of States** | **07** |
| | 2.1 First return probability, probability of ever return. Classification of states, as persistent and transient states. Mean recurrence time being persistent as class property.<br>2.2 Classification of states: Communicating states.<br>2.3 Decomposition of state space, closed set of states, irreducible set of states, irreducible MC.<br>2.4 Periodicity of M.C, Periodicity is class property, aperiodic M.C., ergodic M. C. | |
| **Unit 3** | **Stationary Distribution and Poisson Process.** | **08** |
| | 3.1 Stationary distribution. Examples of unique, multiple and no solution. Relation between mean recurrence time and stationery probability. Case when initial distribution coincides with stationary distribution.<br>3.2 Stationary distribution for an irreducible ergodic finite. Long run behavior of a M.C.<br>3.3 Poisson process: Postulates and properties of Poisson process.<br>3.4 Probability distribution of N(t), the number of occurrences of the event in (0,t] (Statement only). | |

**References:**


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2. Bhat, B.R. (2000). Stochastic models: Analysis and applications, New Age International.
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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU5204**

**Course Name: Lab Course on 24ScStaU5203**

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

**Examination Scheme: CIA:20 Marks** **End-Sem: 30 Marks**

**Prerequisites:** Matrix theory and Probability theory

**Course Objectives:** The students will be able to learn

1. Concept of stochastic process
2. Classification of stochastic process and their states
3. Applications of stochastic process.
4. Identify and apply the appropriate stochastic models to analyze real life data .

**Course Contents**

| Sr. No. | Title of Experiment/ Practical |
|---|---|
| 1 | Construction of transition probability matrix (t.p.m). |
| 2 | Realization of Markov Chain |
| 3 | Verification of Chapman Kolmogorov equations. Finding n step transition probability matrices |
| 4 | Finding $P(X_n \| X_{n-1})$ and $P(X_n \| X_1, X_2, \ldots X_n)$ and marginal distribution of $X_n$. |
| 5 | Examples on random walk, and Ehrenfest chain. |
| 6 | Gambler's ruin problem: probability of ultimate ruin and expected gain |
| 7 | Classification of states-I. Finding mean recurrence time. Finding closed sets of MC. |
| 8 | Classification of states -II .(Recurrent , transient ) |
| 9 | Periodicity and ergodicity of a Markov chain. |
| 11 | Stationary distribution of a given Markov chain. |
| 12 | Realization of Poisson process (Simulation) |
| 13 | Several examples on Poisson Process. |
| 14-15 | Experiential learning |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 23ScStaU5501**

**Course Name: Lab course Statistical Analysis using Python Programming.**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisite Courses:** Descriptive Statistics, discrete and continuous probability distributions, Parametric and Non -Parametric tests.

**Course Objectives: T**o use Python as a tool for statistical computing for:

- Importing data sets using Python and importing several libraries.
- Graphical Representation of data.
- Calculation of measures of central tendency and measures of dispersion.
- Calculation of probabilities and drawing a random sample from several discrete and continuous distribution.
- Performing parametric and non-parametric tests.

**Course Outcomes:** On completion of the course, student will be able to perform statistical Computations using Python.

**Course Contents:**

**All practical are to be performed using Python programming.**

| Sr. No. | Title of Experiment/ Practical |
|---|---|
| 1 | Introduction to Python- I. |
| 2 | Introduction to Python- II |
| 3 | Introduction to Python- III. |
| 4 | Graphical Representation of data by importing libraries :Bar Chart, Histogram, Boxplot, pie charts ,scatter plot). |
| 5 | Use of control flow statements ( if else, for and while). |
| 6 | Computation of Descriptive Statistics for ungrouped data (Measures of central tendency and measures of dispersion). |
| 7 | Computation of Descriptive Statistics for grouped data. (Measures of central tendency and measures of dispersion). |
| 8 | Measures of skewness and kurtosis (ungrouped and grouped data). |
| 9 | Computation of correlation coefficient and fitting of regression line. |
| 10 | Calculation of probabilities for standard discrete probability distributions and drawing a random sample from distributions. |
| 11 | Calculation of probabilities for standard continuous probability distributions and drawing a random sample. |
| 12 | Testing of Hypothesis I (Parametric tests) |
| 13 | Testing of Hypothesis II (Non-Parametric tests) |
| 14 | One way ANOVA. |
| 15 | Two-way ANOVA. |

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**Third Year of B.Sc. (NEP 2024) (Minor)**

**Course under NEP 2020**

**Course Code: 24ScStaU5301**

**Course Name: Applied Statistics**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Pre-requisite Courses:** Basic probability and probability distributions.

**Course Objectives:**

- To study concept of correlation and regression analysis.
- To learn multiple and partial correlation.
- To learn application of various regression model.
- To learn various sampling technique.
- Identify appropriate sampling design for sampling survey.
- Fit appropriate queuing model.

**Course Outcomes:** On completion of the course, student will be able to–

1. To study concept of correlation and regression analysis.
2. To learn fitting of linear regression model.
3. To learn concepts of sampling technique and census.
4. Identify appropriate sampling design for the sampling survey.
5. To study queuing model for real life situation.
6. To study vital event and measure vital statistics.

**Course Contents :**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Population and Sample** | **5** |
| | 1.1 Notion of a statistical population, concept of population and sample from a population with illustrations, concept of census, advantage and disadvantage of census. advantage and disadvantage of sampling<br>1.2 Description of simple random sampling with and without replacement (SRSWR and SRSWOR), Stratified random sampling, systematic sampling, cluster sampling, two stage sampling. | |
| **Unit 2** | **Correlation and Regression analysis** | **7** |
| | 2.1 Bivariate data, Scatter diagram and interpretation.<br>2.2 Concept of correlation between two variables, positive correlation, negative correlation, no correlation.<br>2.3Covariance between two variables, Karl Person's coefficient of correlation(r), limits of r ($-1 \leq r \leq 1$), interpretation. coefficient of determination<br>2.4 Regression: Introduction, real life situations for regression and correlation simple linear regression.<br>2.6 Fitting of regression line using least square method.<br>2.7 Examples and problems. | |
| **Unit 3** | **Time Series** | **10** |
| | 1.1 Introduction, Definition, Components of Time Series<br>1.2 Methods of estimating Trends: least square (linear and second degree), Moving averages (with periods 3,4,5), Exponential smoothing,<br>1.3 Method of estimating seasonality: simple average method<br>1.4 cyclical variation: definition, distinction from seasonal variation.<br>1.5. Irregular variation: definition, illustration | |
| **Unit 4** | **Analysis of variance** | **5** |
| | Concept and technique of one way and two-way ANOVA, examples and problems. | |

**References:**


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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6101**

**Course Name: Sampling Theory and Statistical Quality Control**

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

**Examination Scheme: CIA: 40 Marks** **End-Sem: 60 Marks**

**Prerequisites:**

- Knowledge of descriptive statistics.
- Knowledge of probability and probability models.

**Course Objectives:** The students will learn

- the basic knowledge of complete enumeration and sample, sampling frame, sampling distribution, sampling and non-sampling errors, principal steps in sample surveys, limitations of sampling etc.
- various statistical sampling schemes such as simple, stratified and systematic sampling.
- to conduct the sample surveys and selecting an appropriate sampling techniques.
- how to compare the various sampling techniques.

**Course Outcomes**: At the end of the course the students are able to:

1. Design and execute the simple random sampling with replacement and without replacement and comparison between them.
2. Understand stratified random sampling, different allocation problem of sample size in stratified random sampling and accordingly design and execute sampling.
3. Apply systematic random sampling for collecting the sample data.
4. Determine adequate sample size for various sampling procedures.
5. Use appropriate sampling design to collect data.
6. Compute estimates of parameters and variability in estimates of parameter understudy according to the sample design.
7. Compare SRSWOR, SRSWR, stratified random sampling and systematic random sampling.
8. Design an appropriate control chart for given process.
9. Draw conclusions regarding state of control of process and obtain control limits for future use.
10. Apply the single and double sampling plan in the given situation.

**Course Content:**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Sampling** | **09** |
| | 1.1 Different sampling schemes, Concept of distinguishable elementary units, sampling units, sampling frame, random sample, Requisites of a good sample, Simple random sampling (Probability sampling) from finite population of size (N), i) with replacement (SRSWR) ii) without replacement (SRSWOR),<br>1.2 Definitions of population mean, population variance and population total as parameters, inclusion probabilities of a unit in SRS.<br>1.3 Sample mean $(\overline{y})$ as an estimator of population mean$(\overline{Y})$, derivation of expectation and standard error of $\bar{y}$, N$\bar{y}$ as an estimator of population total, derivation of expectation and standard error of N$\bar{y}$, Estimator of above standard errors, both in case of SRSWR and SRSWOR, confidence interval for population mean, population total, standard error.<br>1.4 Sampling for proportion as an application of a simple random sampling with $X_i$ as zero or one. Sample proportion (p) as An estimator of population proportion (P) of units possessing a certain attribute, derivation of expectation and standard error of (p), Np as an estimator of total number of units in the population possessing a certain attribute, derivation of expectation and standard error of Np. Estimator of above standard error both in case of SRSWR and SRSWOR. | |
| **Unit 2** | **Determination of Sample Size** | **04** |
| | 2.1 Determination of the sample size for estimating population mean, population total and population proportion for the given:<br>i) Margin of error and confidence coefficient.<br>ii) Coefficient of variation of the estimator and confidence coefficient. | |
| **Unit 3** | **Stratified Random Sampling** | **12** |
| | 3.1 Stratification, basis of stratification, real life situation where stratification can be used.<br>3.2 Stratified random sampling as a sample drawn from individual strata using SRSWOR in each stratum.<br>3.3 $\overline{y_{st}} = \frac{\sum N_i \bar{y_i}}{N}$ as an estimator of population mean $(\bar{Y})$, derivation of expectation and standard error of $\overline{y_{st}}$ , N$\overline{y_{st}}$ as an estimator of population total, derivation of expectation and standard error of N $\overline{y_{st}}$, Estimator of above standard errors.<br>3.4 Problem of allocation, Proportional allocation, Neyman's allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used.<br>3.5 Cost and variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation, Neyman's allocation as a particular case of optimum allocation in cost and variance analysis. | |

| | | |
|---|---|---|
| **Unit 4** | **Systematic Sampling (Population size divisible by sample size)** | **05** |
| | 4.1 Real life situations where systematic sampling is appropriate. Techniques of drawing a sample using systematic sampling.<br>4.2 Estimation of the population mean and population total, standard error of these estimators.<br>Comparison of systematic sampling with SRSWOR. | |
| **Unit 5** | **Statistical Quality Control: Introduction** | **04** |
| | 5.1 Meaning of the terms quality, six sigma,TQM and purpose of Statistical Quality Control(SPC), on line process control methods (control charts)and offline process control methods (Sampling plans).<br>5.2 Introduction to seven Process Control (PC) Tools of SPC (i) Check Sheet, (ii) Cause and effect diagram(iii) Pareto Diagram, (iv) Histogram, (v) Control chart, (vi)Scatter Diagram,(vii) Design of Experiments (DOE). | |
| **Unit 6** | **Control charts** | **18** |
| | 6.1 Chance causes and assignable causes of variation, statistical basis of control charts, exact probability limits, k -sigma limits, justification for the use of 3-sigma limits for normal distribution and using Chebychev's inequality for non-normal distributions. Criteria for detecting lack of control situations: (i) At least one point outside the control limits (ii) A run of seven or more points above or below central line. (iii) Presence of a non-random pattern eg. cycle or linear trends etc. Control chart technique as hypotheses testing problem. Construction of control charts for (i) standards given, (ii) standards not given.<br>6.2 Control charts for variables (I) R chart and $\bar{X}$ chart construction of R chart when the process standard deviation is specified: control limits, drawing of control chart, plotting of sample ranges,<br>determination of state of control process, corrective action if the process is out of statistical control.<br>Construction of $\bar{X}$ chart when the process average is specified: control limits, drawing of control chart, plotting of sample means, determination of state of control of process, corrective action if the process is out of statistical control.<br>(II) Construction of R chart when the process standard deviation (σ) is not given: control limits, drawing of control chart, plotting sample range values, revision of control limits if necessary, estimate of σ for future use. Construction of $\bar{X}$ chart when the process average μ is not given: drawing of control chart, plotting sample means, revision of control limits of $\bar{X}$ chart, if necessary. Probability of catching a shift. Estimate of μ and σ for further use. Determination of state of control of the process. Identification of real life situations where this technique can be used. Limitations of $\bar{X}$, R charts.<br>**Note**: To find revised control limits of any control chart delete the sample points above UCL and points below LCL (assuming a search for assignable causes at those points), in case of R and charts, first of all, revisions of control limits of R is to be completed and then by using the observations for | |

| | | |
|---|---|---|
| | which R chart shows the process is under control, the control limits for $\bar{X}$ chart should be determined. Revision of control limits of $\bar{X}$ chart be continued without revising the value of $R$ or $\sigma$.<br>6.3 Control charts for Attributes<br>6.3.1: p - chart (a) Construction and working of p-chart when subgroup sizes are same and value of the process fraction defective P is specified: control limits, drawing of control chart, plotting of sample fraction defectives. Determination of state of control of the process. (b) p-chart when subgroups sizes are different and value of the process fraction defective P is not specified with separate control limits, drawing of control chart, plotting sample fraction defectives, determination of state of control of the process. Interpretation of high and low spots. Identification of real life situations. Probability of catching a shift.<br>6.3.2: C chart (a) Construction of c-chart when standard is given; control limits justification of 3 sigma limits, drawing of control chart, plotting number of defects per unit. (b) Construction of c chart when standard is not given; control limits, explanation for the use of 3 sigma limits, drawing of control chart. Plotting number of defects per unit. Determination of state of control, Identification of real life situations. | |
| **Unit 7** | **Process Capability Indices** | **02** |
| | 7.1 Specification limits, natural tolerance limits and their comparisons, decisions based on these comparisons, estimate of percent defectives.<br>7.2 Capability ratio and capability indices ($C_p$), capability performance indices $C_{pk}$ with respect to machine and process, interpretation, relationship between (i) $C_p$ and $C_{pk}$ (ii) defective parts per million and $C_p$. | |
| **Unit 8** | **Acceptance Sampling Plan for Attributes** | **08** |
| | 8.1 Introduction: Concept of sampling inspection plan with rectification, Comparison between 100% inspection and sampling inspection. Procedures of acceptance sampling with rectification, Single sampling plan and double sampling plan. Probabilities of acceptance and rejection<br>8.2 Explanation of the terms: Producer's risk and Consumer's risk, Operating characteristic (OC) curve, Acceptable Quality Level (AQL), Lot Tolerance Fraction Defective (LTFD) and Lot Tolerance Percent Defective (LTPD), Average Outgoing Quality (AOQ) and Average Outgoing Quality Limit (AOQL), AOQ curve, Average Sample Number (ASN), Average Total Inspection (ATI)<br>8.3 **Single Sampling Plan:** Computation of probability of acceptance using Poisson approximation, Derivation of AOQ and ATI. Graphical determination of AOQL, Determination of a single sampling plan by: a) lot quality approach b) average quality approach. | |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6102**

**Course Name: Reliability Theory and Survival Analysis**

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

**Examination Scheme: CIA: 40 Marks** **End-Sem: 60 Marks**

**Prerequisites:** Knowledge of probability and probability distributions

**Objectives:** The students shall get concepts of

- Structural properties of coherent system.
- Reliability of coherent system.

**Course Outcomes**: At the end of the course the students will be able to learn:

1. Coherent and Non-coherent systems.
2. Structural properties of a coherent system.
3. Compute reliability of a coherent system.
4. Compute importance of components of a system and to do pivotal decomposition of a complex system.
5. To study the basic concepts of survival analysis.
6. To study different types of lifetime distributions.
7. To study the concept censoring, different types of censoring and its applications in real life situations.
8. Use of Non-parametric method used to estimate the survival function.

**Course Content:**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Structural Properties of coherent system** | **15** |
| | 1.1 Binary system of independent components, order of the system different types of systems, concept of the structure function, structure function of series system, parallel system, k-out-of-n system, essentially parallel and series system, reliability block diagram, guidelines for construction of reliability block diagram.<br>1.2 Coherent structure function (maximum 4 components), relevant component, increasing structure function, pivotal decomposition of structure function, dual of a structure function (proof of dual of series system of order n is parallel system of order n ,dual of the parallel system of order n is a series system of order n, dual of k-out- of - n system is (n-k+1)- out of – n system), path sets, cut sets, minimal path and cut set, representation of coherent system in terms of minimal path sets and cut sets, dual coherent structure function, relative importance of components, module of the coherent system, modular decomposition of coherent system. | |
| **Unit 2** | **Reliability of coherent system** | **08** |
| | 2.1 Reliability (h(p)) of system of independent components, Basic properties of system reliability (such as reliability function is increasing function, system and component redundancy etc.),<br>2.2 Computation of reliability of coherent system by using minimal path and cut set representation.<br>2.3 Upper and lower bound on system reliability by using exact system reliability, relative importance of a component.<br>2.4 Reliability of Binary Components and Systems<br>2.4 Examples to show that systems with higher reliabilities can be constructed using components of low values of reliabilities, i.e. unreliable components. | |
| **Unit 3** | **Survival Analysis : Introduction** | **22** |
| | 3.1 Definitions: Hazard rates, hazard function, survival function, Concept of distributions with increasing and decreasing failure rate (IFR/DFR), Average Increasing (Decreasing) Failure Rate (IFRA/ DFRA),<br>3.2 Relationship between: i) Survival function and hazard function ii) Density function and hazard rate.<br>3.3 No ageing, proof of the properties of no ageing:<br>i) Cauchy functional equation ii) Constant failure rate iii) Constant means residual life iv) Exponential life distribution v) Exponential Equilibrium distribution vi) Identity function as the TTT transforms<br>3.4 Positive and negative ageing: IFR, DFR IFRA, DFRA, NBU, NWU, | |

| | | |
|---|---|---|
| | NBUE, NWUE, DMRL, IMRL, HNBUE, HNWUE, bathtub failure rate.<br>3.5 Proof of the Implications: IFR $\Rightarrow$ IFRA, IFR $\Rightarrow$DMRL, IFRA $\Rightarrow$ NBU, NBU $\Rightarrow$ NBUE, DMRL $\Rightarrow$ NBUE, DFR $\Rightarrow$ DFRA, DFR $\Rightarrow$ IMRL, DFRA $\Rightarrow$ NWU, NWU$\Rightarrow$ NWUE. | |
| **Unit 4** | **Censoring and Nonparametric estimation of survival function** | **08** |
| | 4.1 Concept of censoring, order censoring, time censoring, right random censoring, left random censoring, undersigned censoring.<br>4.2 Nonparametric estimation of survival function, confidence band on survival function, actuarial estimator of survival function and its variance using Greenwood's formula, Kaplan Meier estimator of survival function and its variance in the presence of censored observations. | |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6103**

**Course Name: Actuarial Statistics**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

- Basic terminologies involved in Insurance business.
- Basic Mathematics.
- Basic knowledge of Insurance policies/ products.

**Course Objective:** The Course aims to provide students:

- key statistical knowledge and skills needed to analyse and interpret data associated with insurances.
- develop insight behind the different products of life insurance.

**Course Outcome**: Students who successfully complete this course should be able to :

1. Understand different types of risk and which are insurable.
2. Understand the role of Actuary in risk management and in insurance business.
3. Understand the importance of life tables.
4. Understand concept of interest and interpret different products of life insurance.
5. Distinguish between annual premium, survival benefit premium and death benefit premium.
6. Calculate different types of premiums in different scenarios.

**Course Content:**

| Unit 1 | Insurance Business | 03 |
|---|---|---|
| | 1.1 Insurance companies as business organizations.<br>1.2 Role of insurance business in Economy.<br>1.3 Concept of risk, types of risk, characteristics of insurable risk.<br>1.4 Working of insurance business, introduction of terms such as premium, policy, policyholder and benefit.<br>1.5 Role of Statistics in insurance.<br>1.6 Insurance business in India. | |
| **Unit 2** | **Feasibility of Insurance Business** | **03** |
| | 2.1 Measurement of adverse financial impact, Expected value principle.<br>2.2 Concept of utility function<br>2.3 Feasibility of insurance business.<br>2.4 Illustrative examples. | |
| **Unit 3** | **Survival Distribution and Life Tables** | **11** |
| | 3.1 Time- until death random variable, its d.f. and survival function in actuarial notation.<br>3.2 Force of mortality, Deferred probability.<br>3.3 Interrelations among d.f., survival function, force of mortality and p.d.f.<br>3.4 Curtate future life random variable, its p.m.f and survival function in actuarial notation.<br>3.5 Construction of life table.(different terms like $l_x$,$d_x$, $L_x$, $T_x$, $e_x$ etc.) | |
| **Unit 4** | **Models for Life Insurance** | **11** |
| | 4.1 Theory of compound interest, effective rate of interest, discount factor.<br>4.2 Insurance payable at the end of the year of death, present value random variable, actuarial present value.<br>4.3 Derivation of actuarial present value for n-year term life insurance, whole life insurance and endowment insurance. | |
| **Unit 5** | **Annuities** | **11** |
| | 5.1 Annuities – certain, annuity due, annuity immediate.<br>5.2 Discrete life annuities: n-year temporary life annuity due and a whole life annuity due, present value random variables of the payment, and their actuarial present values. | |
| **Unit 6** | **Benefit Premiums** | **09** |
| | 6.1 Concept of a loss random variable.<br>6.2 Equivalence principle<br>6.3 Computation of fully discrete premium for n- year term life insurance, whole life insurance and endowment insurance.<br>6.4 Variance of loss random variable | |

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| | **Books Recommended**<br>1. Bowers N.L. Jr., H.S.Gerber, J.C. Hickan, D.A.Jones, C.J.Nesbitt, (1997). Actuarial Mathematics, Society of Actuaries, U.S.<br>2. Deshmukh, S. R. (2009). Actuarial Statistics, Universities Press, Hyderabad, India<br>3. Robin cunningham, Thomson N. Herzog, Richard L. Models for quantifying risk, $4^{th}$ edition, ACTEX publications, 2011<br>4. Dickson, David C.M, Hardy, Mary R. and Waters, Howard R, Acturial mathematics for life contingency risks, international series on actuarial Science, Cambridge, 2009<br>5. Narang, Uma, Insurance Industry in India: Features, Reforms and outlooks, New Century Publication. | |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6104**

**Course Name: Lab course on 24ScStaU6101, 24ScStaU6102 and 24ScStaU6103**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:** Theory of estimation and distribution theory .

**Course Objectives:** Students are expected to learn

- Sampling schemes via SRSWR, SRSWOR for both qualitative and quantitative type variables,
- Stratified random sampling and cost and variance analysis in it.

**Course Content:**

| Sr. No. | Title of experiment | No. of Practical |
|---|---|---|
| **1** | Simple random sampling (estimation of population mean, population total with standard errors), i) with replacement, ii) without replacement. Confidence interval for population mean and population total | **1** |
| **2** | Stratified Random Sampling: Proportional and Neyman's allocation, comparison with SRSWOR | **1** |
| **3** | Cost and Variance Analysis in Stratified Random sampling. | **1** |
| **4** | Designing a questionnaire, Data Reliability testing by using<br>a) Kuder Richardson Coefficient (KR-20)<br>b) Cronbach's Coefficient Alpha | **1** |
| **5** | R chart, $\overline{X}$ chart I | **1** |
| **6** | p-chart (for fixed and variable sample size) | **1** |
| **7** | Single sampling plan for attributes: OC curve, AOQ, AOQL, ATI using Poisson approximation | **1** |
| **8** | Determination of single sampling plan for attributes by i) Lot Quality Approach ii) Average Quality Approach | **1** |
| **9** | Classification of life time distributions | **1** |
| **10** | Non-parametric survival analysis. | **1** |
| **11** | Problems based on accumulated value, present value and effective rate of discount | **1** |
| **12** | Construction of life table | **1** |

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|---|---|---|
| **13** | Computation of discrete Annuity | **1** |
| **14** | Computation of benefit premium for n-year term insurance, whole life insurance and endowment insurance | **1** |
| **15** | Experiential learning | **1** |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6201**

**Course Name: Design of Experiments**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

- Basic concepts from linear algebra and probability distributions.
- Concept of linear regression model.

**Course Objective:**

- To understand concepts of design of experiments and apply it to real life data.

**Course Outcome:** After completion of the course students will able to learn

1. Concept of Basic design like CRD, RBD and LSD.
2. Analysis data collected from CRD, RBD and LSD.
3. Concept and analysis of covariance models.
4. how to compare the pairs of treatment means using different methods.
5. analysis of factorial experiments.
6. to Apply appropriate model and analysis tool for real life data.

**Course Content:**

| Unit | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Design of Experiments** | **18** |
| | 1.1 Analysis of variance (ANOVA): concept and technique.<br>1.2 Basic terms of design of experiments: Experimental unit, treatment, layout of an experiment.<br>1.3 Basic principles of design of experiments: Replication, randomization and local control. Choice of size and shape of a plot for uniformity trials, the empirical formula for the variance per unit area of plots.<br>1.4 Completely Randomized Design (CRD) : Application of the principles of design of experiment in CRD, Layout, Model: (Fixed effect ) | |

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|---|---|---|---|
| | | $X_{ij} = \mu + \alpha_i + \varepsilon_{ij}$<br>$i = 1,2,\dots,t \;\; ; \;\; j = 1,2,\dots.,n_i$<br>assumptions and interpretations. Breakup of total sum of squares with respect to components. Estimation of parameters, Testing normality of residuals graphically, expected values of mean sums of squares, components of variance, preparation of (ANOVA) table, testing equality of treatment effects, procedure to test the hypothesis<br>$H_0 : \alpha_1 = \alpha_2 = \cdots = \alpha_t = 0$<br>Comparison of treatment means using box plot techniques. Statement of Cochran's theorem. F test for testing $H_0$ with justification (independence of chi- square is to be assumed), test for equality of two specified treatment effects using critical difference (C.D). | |
| | 1.5 | Randomized Block Design (RBD) : Application of the principles of design of experiments in RBD, layout<br>Model ( Fixed Effects)<br>$X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$<br>$i = 1,2,\dots.,t \;\; ; \; j = 1,2,\dots\dots,b$<br>Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, Testing normality of residuals graphically, expected values of mean sums of squares, components of variance, preparation of<br>analysis of variance table, Hypotheses to be tested<br>$H_{01} : \alpha_1 = \alpha_2 = \cdots = \alpha_t = 0$<br>$H_{02} : \beta_1 = \beta_2 = \cdots = \beta_b = 0$<br>F-test for testing $H_{01}$ and $H_{02}$ with justification (independence of chi-squares is to be assumed), test for equality of two specified treatment effects using critical difference (CD). | |
| | 1.6 | Latin Square Design (LSD): Application of the<br>principles of design of experiments in LSD, layout,<br>Model : ( Fixed Effects)<br>$X_{ij(k)} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ij(k)}$<br>$i = 1,2,\dots,m \quad j = 1,2,\dots\dots,m$ and<br>$k = 1,2,\dots,m$<br>Assumptions and interpretations.<br>Breakup of total sum of squares into components.<br>Estimation of parameters, Testing normality of residuals graphically, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, hypotheses to be tested.<br>$H_{01} : \alpha_1 = \alpha_2 = \cdots = \alpha_m = 0$<br>$H_{02} : \beta_1 = \beta_2 = \cdots = \beta_m = 0$<br>$H_{03} : \gamma_1 = \gamma_2 = \cdots = \gamma_m = 0$<br>and their interpretation.<br>Justification of F test for $H_{01}$, $H_{02}$ and $H_{03}$ (independence of chi-square is to be assumed). Preparation of ANOVA table and F test for $H_{01}$, $H_{02}$ and $H_{03}$ testing for equality of two specified treatment effects, comparison of | |

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|---|---|---|
| | treatment effect using critical difference, linear treatment contrast and testing its significance.<br>1.7 Linear contrasts, orthogonal contrast, Scheffe's method for comparing contrasts, Tuckey's procedure for comparing pair of treatment means (applicable to C.R.D. ,R.B.D. and L.S.D.)<br>1.8 Identification of real life situations where the above designs are used. | |
| **Unit 2** | **Analysis of Covariance (ANOCOVA) with One Concomitant Variable** | **06** |
| | 2.1 Situations where analysis of covariance is applicable.<br>2.2 Model for covariance in CRD Estimation of parameters (derivations are not expected<br>Preparation of analysis of variance – covariance table, test for $\beta = 0$, test for equality of treatment effects (computational technique only). | |
| **Unit 3** | **Design and Analysis of Factorial Experiments** | **06** |
| | 3.1 General description of $m^n$ factorial experiment, $2^2$ and $2^3$ factorial experiments arranged in RBD.<br>3.2 Definitions of main effects and interaction effects in $2^2$ and $2^3$ factorial experiments. Yate's procedure, preparation of ANOVA table, test for main effects and interaction effects. | |

**References:**


1. Cochran W.G. and Cox, C.M. (1968) Experimental Design, John Wiley and Sons, Inc., New York.
2. Dass, M.N. and Giri,N.C. (1986) Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi
3. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pt. Ltd. Kolkata
5. Gupta S.C. and Kapoor V.K. (2006). Fundamentals of Applied Statistics, S. Chand Sons, New Delhi
6. Johnson, R.A., Miller, I. and Freund, J. (2010). Probability and Statistics for engineers, Prentice Hall, India.
7. Montgomery, D.C. (2001). Design and Analysis of Experiments, John Wiley and sons Inc., New Delhi.
8. Snedecor, G.W. and Cochran, W.G. (1994). Statistical Methods, 8th edition, Affiliated East West Press, New Delhi
9. Wu, C.F.J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc. Hoboken, New Jersey.

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6202**

**Course Name: Lab course on 24ScStaU6201**

**Teaching Scheme: 4 Hours/Week** **Credit: 02**

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

- Statistical Inference, Distribution theory.

**Course Objectives:** Students are expected to learn

1. Analysis of variance techniques for CRD, RBD and LSD.
2. Analysis of covariance techniques for CRD, RBD and LSD.
3. Analysis of factorial experiments.

**Course Content:**

| Sr. No. | Title of experiment | Number of Practicals |
|---|---|---|
| **1** | Planning a lay out and analysis of C.R.D. I (checking adequacy of the model) | 1 |
| **2** | Analysis of C.R.D.II (checking normality assumption, Efficiency, Duncan's, Tuckey's and Fisher's LSD , Scheffe's method) | 1 |
| **3** | Analysis of R.B.D. I | 1 |
| **4** | Analysis of R.B.D. II II (checking normality assumption, Efficiency, Duncan's, Tuckey's and Fisher's LSD , Scheffe's, method) | 1 |
| **5** | Analysis of L.S.D. I | 1 |
| **6** | Analysis of L.S.D. II II (checking normality assumption, Efficiency, Duncan's, Tuckey's and Fisher's LSD Scheffe's method) | 1 |
| **7** | Analysis of non-normal data-I using Kruskal -Wallis Test | 1 |
| **8** | Analysis of non-normal data-II (Using Transformations) | 1 |
| **9** | Analysis of covariance in C.R.D.-I | 1 |
| **10** | Analysis of covariance in C.R.D.-II | 1 |
| **11** | Analysis of $2^2$ factorial experiments in R.B.D. | 1 |
| **12** | Analysis of $2^3$ factorial experiments in R.B.D. | 1 |
| **13-15** | Experiential learning | 3 |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6203**

**Course Name: Medical Statistics**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

- Knowledge of descriptive statistics
- Knowledge of probability and probability distributions
- Design of experiments
- Testing of hypothesis
- Sampling Schemes

**Objectives:** The students will be able to learn:

1. Understanding of the principles of epidemiology and the concept of natural history of disease particularly with respect to possible clinical interventions.
2. Understanding of the purposes for conducting clinical trials.
3. The phases of clinical trials and the types of study designs typically used in clinical trials.

**Course Outcomes**: At the end of the course the students will be able to:

1. Understanding of the models of population growth, including linear, exponential, and sigmoidal growth and their applications in biological and ecological studies.
2. Understanding of the basic concepts of epidemiology, including odds, odds ratio, and relative risk used in the study of disease occurrence and spread.
3. Estimation and interpretation of odds ratio and confidence intervals, and their relationship with parameters in logit models used in epidemiological analysis.
4. Understanding of contingency table analysis, including symmetry in square contingency tables, collapsing of tables, and the concept of Simpson's paradox.
5. Understanding of the history, phases, and design of clinical trials, including different trial designs such as parallel, cross-over, cross-sectional, and longitudinal studies.
6. Understanding of bioavailability and bioequivalence studies, including non-inferiority trials and the importance of statistical methods in evidence-based medical research

**Course Content:**

| | Title and content | Lectures |
|---|---|---|
| **Unit 1** | **Models of population growth** | **03** |
| | 1.1 Linear Growth<br>1.2 Exponential growth<br>1.3 sigmoidal growth | |
| **Unit 2** | **Epidemiology** | **14** |
| | 2.1 Introduction to Epidemiology<br>2.2 Odds, odds ratio, relative risk.<br>2.3 Estimation of odds ratio (OR), Confidence interval for OR. Relation with parameter in a logit model.<br>2.4 Symmetry in square contingency tables, collapsing tables and Simpson's paradox. | |
| **Unit 3** | **Clinical trials** | **26** |
| | 3.1 General information on history of drug discovery including Louis Pasteur (rabies and small pox), Ronald Ross and malaria, Alexander Fleming and penicillin, Jonas Salk and polio, cholera, asthma, diabetes, blood pressure, heart attack, arthritis.<br>3.2 Phases of clinical trial, purpose, duration, cost, drug regulatory bodies, ICH, statistical analysis plan, clinical study report.<br>3.3 Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, objectives and end points 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. Inference for 2×2 crossover design: Classical methods of interval testing for bioequivalence, nonparametric methods.<br>3.4 Two treatments, two periods cross over design. | |
| **Unit 4** | **Bioequivalence and bio-availability** | **05** |
| | 4.1 Bioequivalence and bio-availability, non-inferiority trial, non-parametric methods.<br>4.2 Practice based medical research, evidence based medicine. | |
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|---|---|---|
| | **References:**<br>1. A.p .Gore and S. A, Paranjape ,(2000) Course on mathematical and statistical Ecology, Kluwer, publishing Holland.<br>2. M.B. Kulkarni, V.R. Prayag, (2004) " Introduction to Statistical Ecology, SIPF Academy, Nasik 41.<br>3. Agresti A. (1996) Categorical Data Analysis. Wiley, New York.<br>4. J.N.S. Matthews (2006) Introduction to Randomized Controlled clinical Trials, Chapman and Hall.<br>5. Stephen Sann (2000) Statistical Issues in drug Development, John Wiley.<br>6. Steven Diantadosi (2000) Clinical Trials – A methodological Perspective, John Wiley.<br>7. L.M. Friedmon, C.D. Forbes, D.L. Demats (2000) Fundamentals of Clinics Trials, Spinner.<br>8. Steve selvin (2004)Epidemiologic Analysis, Oxford Press.<br>9. M.M. Shoukni, C.A. Pavse (1999) Statistical Methods for Health Sciences, CPC Pree.<br>10. Steve Salvin, (1999) Statistical Analysis of Epidomiologic Data, Oxford. | |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 24ScStaU6204**

**Course Name: Lab Course on 24ScStaU6203**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisites:**

**Course Objectives:** Students are expected to learn fitting of various models and analysis of clinical data.

**Course Content:**

| Sr. No. | Title of Practical |
|---|---|
| 1 | Fitting of Linear Growth Model |
| 2 | Fitting of Exponential Growth Model |
| 3 | Fitting of Logistic (Sigmoidal) Growth Model |
| 4 | Calculation of Incidence, Prevalence and Mortality Rates |
| 5 | Computation of Odds, Relative Risk and Odds Ratio |
| 6 | Estimation of Odds Ratio and 95% Confidence Interval |
| 7 | Logistic Regression and Interpretation of Adjusted Odds Ratio |
| 8 | Analysis of Simpson's Paradox and Mantel–Haenszel Method |
| 9 | Test for Symmetry in Square Contingency Tables (McNemar's Test) |
| 10 | Sample Size Determination for Clinical Trials |
| 11 | Analysis of Parallel Design Clinical Trial |
| 12 | Analysis of 2×2 Cross-Over Design |
| 13 | Sequential Monitoring in Phase III Clinical Trial |
| 14 | Design and Analysis of Phase II (Single-Stage and Two-Stage) Trials |
| 15 | Bioequivalence Testing using TOST Procedure |

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**Third Year of B.Sc. (NEP 2024)**

**Course under NEP 2020**

**Course Code: 23ScStaU6501**

**Course Name: Lab Course on Operations Research**

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

**Examination Scheme: CIA: 20 Marks** **End-Sem: 30 Marks**

**Prerequisite Courses:**

- Basic concepts of linear algebra.
- Graphical method.

**Course Objectives:** On completion of the course, student will be able to

- To understand various methods of operational research to obtain optimum solutions and apply it to real life data.
- To understand the concept of duality in linear programming.

**Course Contents:**

| Sr. No. | Title of Experiment/ Practical |
|---|---|
| 1 | Formulate the linear programming problem (LPP). |
| 2 | Solving LPP using graphical method (Cases: feasible solution ,infeasible solution, no solution, unbounded solution, alternate solution ) |
| 3 | Solving LPP using simplex method (Cases: feasible solution ,infeasible solution) |
| 4 | Solving LPP using simplex method (Cases: unbounded solution, alternate solution ) |
| 5 | Solving LPP using Big-M method. |
| 6 | Solving LPP using Two phase method. |
| 7 | Finding dual of given primal problem and solution it. |
| 8 | Formulate Transportation problem (TP) and Find initial basic feasible solution using least cost method, Vogel's approximation method. |
| 9 | Finding Optimal solution of TP using modified distribution method. |
| 10 | Finding Optimal solution of TP using modified distribution method (in case of degeneracy occurs.) |
| 11 | Problems on CPM |
| 12 | Problems on Sequencing |
| 13-15 | Experiential learning |