Model Curriculum for Three/Four -Year Degree Course

(With Multiple Entry /Exit Options)

Based on NEP-2020

Gangadhar Meher University, Amruta Vihar, Sambalpur

Odisha

Statistics Syllabus

(Effective from the Academic Session 2026-27)

Odisha State Higher Education Council, Bhubaneswar
Government of Odisha

SCHOOL OF STATISTICS

Tabular Presentation of the Papers Semester wise

Semester	Name of the Papers
I	1. Descriptive Statistics
	2. Linear Algebra
II	3. Probability and Probability Distributions
	4. Calculus
III	5. Sampling Distributions
	6. Parametric Statistical Inference
	7. Survey Sampling & Indian Official Statistics
IV	8. Real and Numerical Analysis
	9. Linear Regression Analysis and Forecasting (NPTEL)
	10. Statistical Quality Control
V	11. Design of Experiments
	12. Statistical Computing using R Programming
	13. Operations Research
VI	14. Non-parametric Statistical Inference
	15. Multivariate Analysis
VII (With Research)	16. Time Series Analysis
	17. Optimization Techniques
	18. Econometrics
VII (Without Research)	16. Time Series Analysis
	17. Optimization Techniques
	18. Econometrics
	19. Stochastic Process
VIII (With Research)	20. Scientific Computing using MATLAB (NPTEL)
	21. Actuarial Statistics
	22. Dissertation
VIII (Without Research)	20. Scientific Computing using MATLAB (NPTEL)
	21. Actuarial Statistics
	22. Bayesian Parametric Inference
	23. Strategy: An Introduction to Game Theory (NPTEL)

Template of Three-Year Degree Course with Single Major and Two Minors

Semester	Major-I	Minor-I	Minor-II	Multidisciplinary Course	AEC	SEC	VAC	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	**2X4=8** Descriptive Statistics (Paper-I) Linear Algebra (Paper-II)	**1X4=4** Descriptive Statistics (Paper-I)		**1X3=3** Statistical Methods for Scientists and Engineers (NPTEL) (MDC-I)	**1X4=4** Odia		**1x3=3** Environmental Studies and Disaster management		**22**
II	**2X4=8** Probability and Probability Distributions (Paper-III) Calculus (Paper-IV)		**1X4=4** Probability and Probability Distributions (Paper-I)	**1X3=3** Survival Analysis and Biostatistics (MDC-II)	**1X4=4** English	**1X3=3** Introduction to Statistics and data analyses (SEC-I)			**22**
									44
III	**3X4=12** Sampling Distributions (Paper-V) Parametric Statistical Inference (Paper – VI) Survey Sampling & Indian Official Statistics (Paper– VII)	**1X4=4** Survey Sampling & Indian Official Statistics (Paper-II)		**1X3=3** Demography (MDC-III)			**1X3=3** Ethics and Values		**22**
IV	**3X4=12** Real and Numerical Analysis (Paper – VIII) Linear Regression Analysis and Forecasting (Nptel) (Paper – IX) Statistical Quality		**1X4=4** Statistical Quality Control (Paper-II)					**1X4=4** Project Work	**20**

	Control (Paper – X)								
									42
V	**3X4=12** Design and Analysis of Experiments (Paper–XI) Statistical Computing Using R Programming (Paper – XII) Operations Research (Paper – XIII)	**1X4=4** Operations Research (Paper-III)				**1X3=3** Data Analytics I (SEC-II)	**1X3=3** Indian Knowledge System		**22**
VI	**2X4=8** Non-Parametric Statistical Inference (Paper – XIV) Multivariate Analysis (Paper–XV)		**1X4=4** Non-Parametric Statistical Inference (Paper-III)			**1X3=3** Analytical Ability and Logical Reasoning (SEC-III)	**1X3=3** Research Methodology		**18**
									40
Total	**15X4=60**	**3X4=12**	**3X4=12**	**3X3=9**	**2X4=8**	**3X3=9**	**3X4=12**	**1X4=4**	**126**

SCHOOL OF STATISTICS

THREE YEAR DEGREE COURSE WITH SINGLE MAJOR AND TWO MINORS

COURSE STRUCTURE OF UG STATISTICS HONOURS UNDER NEP			
SEMESTER	Course Code	Course Name	Credit
I	MAJOR-I (Paper-I)	Descriptive Statistics	4
	MAJOR-I (Paper-II)	Linear Algebra	4
	MINOR-I (Paper-I)	Descriptive Statistics	4
	MULTIDISCIPLINARY COURSE (MDC-I)	Statistical Methods for Scientists and Engineers (NPTEL)	3
	ABILITY ENHANCEMENT COURSE (AEC-I)	Odia	4
	VALUE ADDED COURSE (VAC-I)	Environmental Studies and Disaster Management	3
		Total	**22**
II	MAJOR-I (Paper-III)	Probability and Probability Distributions	4
	MAJOR-I (Paper-IV)	Calculus	4
	MINOR-II (Paper-I)	Probability and Probability Distributions	4
	MULTIDISCIPLINARY COURSE (MDC-II)	Survival Analysis and Biostatistics	3
	ABILITY ENHANCEMENT COURSE (AEC-II)	English	4
	SKILL ENHANCEMENT COURSE (SEC-I)	Introduction to Statistics and data analyses	3
		Total	**22**
III	MAJOR-I (Paper-V)	Sampling Distributions	4
	MAJOR-I (Paper-VI)	Parametric Statistical Inference	4
	MAJOR-I (Paper-VII)	Survey Sampling & Indian Official Statistics	4
	MINOR-I (Paper-II)	Survey Sampling & Indian Official Statistics	4
	MULTIDISCIPLINARY COURSE (MDC-III)	Demography	3
	VALUE ADDED COURSE (VAC-II)	Ethics and Values	3
		Total	**22**

COURSE STRUCTURE OF UG STATISTICS HONOURS UNDER NEP			
SEMESTER	**Course Code**	**Course Name**	**Credit**
IV	MAJOR-I (Paper-VIII)	Real and Numerical Analysis	4
	MAJOR-I (Paper-IX)	Linear Regression Analysis and Forecasting (Nptel)	4
	MAJOR-I (Paper-X)	Statistical Quality Control	4
	MINOR-II (Paper-II)	Statistical Quality Control	4
	Community Engagement & Services/Fieldwork/ Internship (CESFI-I)	Project Work	4
		Total	**20**
V	MAJOR-I (Paper-XI)	Design and Analysis of Experiments	4
	MAJOR-I (Paper-XII)	Statistical Computing Using R Programming	4
	MAJOR-I (Paper-XIII)	Operations Research	4
	MINOR-I (Paper-III)	Operations Research	4
	SKILL ENHANCEMENT COURSE (SEC-II)	Data Analytics I	3
	VALUE ADDED COURSE(VAC-III)	Indian Knowledge System	3
		Total	**22**
VI	MAJOR-I (Paper-XIV)	Non-Parametric Statistical Inference	4
	MAJOR-I (Paper-XV)	Multivariate Analysis	4
	MINOR-II (Paper-III)	Non-Parametric Statistical Inference	4
	SKILL ENHANCEMENT COURSE (SEC-III)	Analytical Ability and Logical Reasoning	3
	VALUE ADDED COURSE(VAC-IV)	Research Methodology	3
		Total	**18**

Programme Offered: B.A./B.Sc.(Hons.)Statistics

PROGRAM OUTCOME

When the student joins college after school they are free to make their own choices which are very instrumental in changing their attitude towards life and society. It is very important to give the man appropriate and conducive environment to learn and grow. After completion of the degree apart from his/her specialty in the program of his/her choice the student earns a lot during their three years stay that makes them mature enough to take the right decisions at the right time. Students develop analytical thinking and good communication skills during classroom teaching (through projects/presentation/practical) and also as they participate in various activities both at departmental as well as college level. Being a State University, the student gets a chance to communicate with students of other districts of Odisha and other states of India which makes them culturally sensitive and socially interactive. As part of various departmental /college seminars and workshops he learns to respect and protect the environment. These programs also help in generating gender sensitization and building of ethical values to become a responsible citizen when he/she graduates from the college.

OUTCOME DETAILS

PSO1	Apply the concepts, principles and methods of statistics to various fields of study
PSO2	Understand the importance and value of statistical principles and convert a problem description into testable research hypotheses.
PSO3	Select appropriate statistical tools to investigate a research hypothesis.
PSO4	Perform data analysis by apply appropriate statistical methodology and interpret result in a variety of settings.
PSO5	Compute statistical measures using software and programs.
PSO6	Apply likelihood principles and calculus to derive fundamental results in probability, estimation and hypothesis testing.
PSO7	Select standard experiment designs, with consideration of selection process, data collection, issues of bias, causality and confounding, based on specifications of a scientific study.
PSO8	Write code to extract and reformat real data and to utilize statistical programming environments.

PSO9	Acquire skills to write competitive examinations and get opportunities for job placements in various sectors
PSO10	Move for higher level learning

Statistics is the language of the uncertainties riddled modern information age. This program is a compact combination of detailed courses of Statistics and adequate number of courses on Computer Science, Mathematics and Operations research to complement and offer diversification after the completion of program. The thrust of the program is to provide a platform for pursuing higher studies leading to post-graduate or doctorate degrees. Along with these students are equipped with skill enhancement courses like Research methodology, Statistical packages and R language. This enhances theoretical rigor with technical skills which prepare students to become globally competitive to enter into a promising professional life even after graduation. This program offers a range of traditional avenues in academics, Govt. Service, IAS, Indian Statistical/ Economic Services, Industries, Commerce, Investment Banking, Banks and Insurance Sectors, CSO and NSSO, Research Personnel/Investigator in Govt. organizations such as NCAER, IAMR, ICMR, ICAR, RBI, Statistical and Economic Bureau & various PSUs., Market Research, Actuarial Sciences, Biostatistics, Demography etc. It also provides an array of non-traditional employment avenues ranging from Stock Brokers Analyst, Sports Analyst, Poll Analyst, Business Analyst, Financial Analyst, Content Analyst etc.

Semester-I
MAJOR-I (Paper-I)
Descriptive Statistics

COURSE OUTCOMES

CO1: Understand the scope and necessity of Statistics
CO2: Tabulate and represent the data in diagrams and graphs
CO3: Apply the formula and calculate descriptive measures of statistics
CO4: Analyze the nature of data and interpret the measures
CO5: Analyze the data and predict the future values using curve fitting

LEARNING OUTCOMES

The learning objectives include summarizing the data and to obtain its salient features from the vast mass of original data. After completing this course, the students should have developed a clear understanding of Concepts of statistical population and sample, variables and attributes.

Unit I

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram, stem and leaf diagram and Ogives, consistency and independence of data with special reference to attributes.

Unit II

Measures of Central Tendency: mean, median and mode, Measures of Dispersion: Range, Inter Quartile Range, Quartile Deviation, Mean Deviation, Variance and Standard Deviation, Coefficient of Variation, Moments, Absolute Moments, Skewness and Kurtosis, Sheppard's Corrections.

Unit III

Bivariate data: Definition, Scatter Diagram, Simple, Partial and Multiple Correlation (3variablesonly), Rank Correlation. Simple linear regression, Principle of least squares and fitting of polynomials and exponential curves.

Unit IV

Index Numbers: Definition, construction of index numbers and problems there off or weighted and unweighted index numbers including Laspeyer's, Paasche's, Edgeworth-Marshall and Fisher's Ideal Index numbers. Errors in Index numbers. Chain base index numbers, conversion of fixed based to chain-based index numbers

and vice-versa. Consumer price index numbers, Cost of living index number, Uses and limitations of index numbers.

Text Books

- ✓ *P. N Arora, Sumeet Arora: Comprehensive Statistical Methods, S Chand*
- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, The World Press, Kolkata.*
- ✓ *Gupta, S.C. and Kapoor,V.K.(2008): Fundamentals of Mathematical Statistics, 4th Edition, Sultan Chand & Sons*

Suggested Readings

- ✓ *Miller, Irwin and Miller, Mary lees (2006): John E. Freund's Mathematical Statistics with Applications, (7thEdn.), Pearson Education, Asia.*
- ✓ *Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.*
- ✓ *R S N Pillai & Bagavathi :Practical Statistics, S Chand*
- ✓ *C B Gupta: An Introduction to Statistical Methods, Vikas Publishing*

List of Practicals

Emphasis should be given on interpretation of results.

1. Graphical representation of data–Simple Bar Diagram, Multiple Bar Diagram and Divided Bar Diagram, Histogram, Stem and leaf diagram, Pie diagram, Frequency polygon and frequency curve.
2. Problems based on Measures of Central Tendency.
3. Problems based on Measures of Dispersion.
4. Problems based on Moments, Skewness and Kurtosis.
5. Scatter Diagram, Karl Pearson correlate on coefficient and rank correlation coefficient (with and without tie).
6. Lines of regression, angle between lines and estimated values of variables.
7. Calculate price, quantity and cost of living index numbers.

MAJOR-I (Paper-II)
Linear Algebra

COURSE OUTCOMES

CO1: Be able to gain proficiency in solving systems of Linear equations using matrices and demonstrate a working knowledge of algebraic properties of matrices.

CO2: Be able to acquire facility working with general vectors paces, linear transformations, coordinate vectors and the changing of bases.

CO3: Use the basic concepts of vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.

CO4: Evaluate determinants and use them to discriminate between invertible and noninvertible Matrices; Use the characteristic polynomial to compute the eigen values and eigen vectors of a square matrix and use them to diagonalizeable matrices when this is possible.

CO4: Discriminate between diagonalizable and non- diagonalizable matrices; orthogonally diagonalizable symmetric matrices and quadratic forms.

LEARNING OUTCOMES

To learn the basic ideas of abstract algebra and techniques with proof in pure mathematics and further, it can be use in many other courses. Algebra is one of the most important courses in the field of statistical computing. The course serves as a building block that will enable students to learn more advanced techniques that will help them to solve problems more quickly and easily. After completing course, students should have developed a clear understanding of: Theory of equations; Properties of matrices and determinants; Linear equations; Rank of a matrix; Generalized inverse; Characteristics roots and vectors; Quadratic forms. The students will be conversant for their potential studies of Markov chain & stochastic process, Multivariate analysis, Regression analysis, Design of Experiments.

Unit I

Theory of equations, statement of the fundamental theorem of Algebra and its consequences. Relation between roots and coefficients of any polynomial equations. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis.

Unit II

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices,

orthogonal matrices, singular and non-singular matrices and their properties.Trace of a matrix, unitary, involuntary and nilpotent matrices.

Unit III

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Adjoint and inverse of a matrix and related properties. Solution to the system of linear equations $AX = b$: Cramer's rule and matrix method, row reduction and echelon forms.

Unit IV

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Characteristic roots and Characteristic vectors, Properties of characteristic roots, Cayley Hamilton theorem and Quadratic forms.

Text Books

- ✓ *V K Khanna & S K Bhambri: A Course in Abstract Algebra, Vikas Pub.*
- ✓ *Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra*

Suggested Readings

- ✓ Biswas,S.(1997):A Text book of Matrix Algebra, New Age International,1997.
- ✓ Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
- ✓ Hadley G.: Linear Algebra. Narosa Publishing House (Reprint),2002.
- ✓ Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons.
- ✓ Schaum's Outlines: Linear Algebra, Tata McGraw-Hill, 3rd Edition, 2006.

List of Practicals

1. Finding roots of an algebraic equations
2. Solution of linear equations by matrix method.
3. Rank and Inverse of a matrix
4. Characteristics roots and characteristics vector of a matrix.
5. Applications of matrices.

Semester-II
MAJOR-I (Paper-III)
Probability and Probability Distributions

COURSE OUTCOMES

CO1: Concept of probability, different approaches to the theory of probability. Concept of events, mutually exclusive independent and exhaustive events. Sample space and its properties. Use the basic probability rules including addition and multiplicative laws, conditional probability and Bayes theorem.

CO2: Gain knowledge on random variables. Distinguish between discrete and continuous random variables. Probability mass function and probability density function.

CO3: Understand Mathematical expectation of a random variable. Conditional expectation and variance and conditional expectations.

CO4: Understand the most common discrete and continuous probability distributions and their real-life applications. Identify their characteristics.

CO5: Identify the type of statistical situation to which different distributions can be applied. Use the different distributions in solving statistical problems.

LEARNING OUTCOMES

To present the general theory of statistical distributions as well as the standard distributions found in statistical practice. To train students with essential tools for statistical analyses at the post graduate level. Fostering understanding through real-world statistical applications. A probability distribution is a statistical model that shows the possible outcomes of a particular event or course of action as well as the statistical likelihood of each event. Probability distribution functions are quite important and widely used in actuarial science (insurance), engineering, physics, evolutionary biology, computer science and even social sciences such as psychiatry, economics and even medical trials.

Unit I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability —classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Unit II

Random variables: discrete and continuous random variables, probability mass function (p.m.f.), probability density function (p.d.f.) and cumulative distribution function (c.d.f.), illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete

and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables.

Unit III

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, Cumulants generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

Unit IV

Standard discrete probability distributions: Uniform, Bernoulli, Binomial, Poisson, Geometric, along with their properties and limiting/approximation cases. Standard continuous probability distributions: Uniform, Normal, Exponential, Beta and Gamma along with their properties and limiting/approximation cases.

Text Books

- ✓ Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- ✓ Ravish R Singh & Mukul Bhatt: Probability and Statistics, S Chand
- ✓ Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Mathematical Statistics, 4th Edition (Reprint), Sultan Chand & Sons

Suggested Readings

- ✓ *Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7thEdn.), Pearson Education, Asia.*
- ✓ *Iyengar: Probability and Statistics S Chand*
- ✓ *Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint),Tata McGraw-Hill Pub. Co. Ltd.*
- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8thEdn. The World Press, Kolkata.*
- ✓ *Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi*

List of Practicals

1. Fitting of Binomial and Geometric distributions
2. Fitting of Poisson distributions
3. Fitting of Normal and One-parameter exponential distributions
4. Application problems based on Binomial, Geometric, Poisson, One-parameter exponential and Normal distributions.

MAJOR-I (Paper-IV)
Calculus

COURSE OUTCOMES

CO1: Understand the type of variable and useful in the development of the function.

CO2: Verify the value of the limit of a function at a point using the definition of the limit .

CO3: Understand the consequences of the Intermediate value theorem for continuous function Know the chain rule and use it to find derivatives of composite functions and obtain expression for higher order derivatives of a function using the rule of differentiation.

CO4: Solve integrals and evaluation of multiple integrals with numerical problems and solve the partial differential equations.

LEARNING OUTCOMES

Calculus is versatile and Valuable tool for the statistics. Calculus being used in statistics involves integrating over sections of a probability distribution. The content of this paper involves differential calculation, integral calculus and solution of different differential equations which are extremely prevalent in more advanced statistical application. To compute and analyze limits, derivatives, and integrals functions. To recognize the appropriate tools of calculus to solve applied problems.

Unit I

- Differential Calculus: Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation (two variables). Indeterminate forms: L-Hospital'srule, Leibnitz rule for successive differentiation.
- Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables. Transformations and Jacobians.

Unit II

Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double integral. Beta and Gamma functions: properties and relationship between them.

Unit III

Differential Equations: Exact differential equations, integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations.

Homogeneous differential equations of order n with constant coefficients.

Unit IV

Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

Text Books

- ✓ *Shanti Narayan & P K Mittal: Differential Calculus S Chand*
- ✓ *Shanti Narayan: Integral Calculus S Chand*

Suggested Readings

- ✓ *Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2nd Edition-2004).*
- ✓ *Surjeet Singh & Qazi Zameeruddin: Modern Algebra, Vikas Publishing*
- ✓ *SK Shah& S C Garg: A Text Book of Algebra, Vikas Publishing*
- ✓ *Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.*
- ✓ *Differential calculus by Das & Mukherjee, U.N Dhar Publication, Kolkatta, 2010.*
- ✓ *Integral Calculus by Das & Mukherjee, U.N Dhar Publication, Kolkatta,2010.*
- ✓ *Advanced Differential Equations by Md Raisinghania, S Chand & Company Pvt Ltd.*

List of Practicals

1. Determination of Maxima and Minima
2. Using definite integral obtain the area under curve.
3. Applications of differential equations.
4. Applications Partial Differential Equations.
5. Applications of Beta and Gamma function.

Semester-III
MAJOR-I (Paper-V)
Sampling Distributions

COURSE OUTCOMES

CO1: To understand the concept of sampling distributions and their applications in statistical inference.

CO2: To understand the process of hypothesis testing and its significance. Analyze the properties and applications of various probability functions and Weak law of Large

Numbers.

CO3: Testing of statistical hypothesis, Neymann Pearson Lemma.

CO4: Understand Likelihood Ratio test, applications and properties.

CO5: Understand test of significance, tests based on normal, t, F and Chi- square distributions.

LEARNING OUTCOMES

Statistical Inference is a crucial part of the process of informing ourselves about the world around us. Statistical inference helps us understand our world and make sound decisions about how to act. The content of this paper is based on basic statistical methodology which is vital for industry, biosciences and others streams. To learn the development of null and alternative hypotheses.

Unit I

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their interrelations, Chebyshev's inequality, Weak law of large numbers (W.L.L.N.), Strong law of large numbers (S.L.L.N.) and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T.

Unit II

Definitions of random sample, parameter and statistics, sampling distribution of a statistics, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, critical region, level of significance, Type I and Type II errors, concept of p-value. Large sample tests for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

Unit III

Exact sampling distribution: Definition and derivation of p.d.f. of Chi-square with n degrees of freedom(d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., Cumulant generating function, mode, additive property and limiting form of Chi-square distribution. Tests of significance and confidence intervals based on Chi-square distribution.

Unit IV

Exact sampling distributions: Student's t-distribution (including Behrens–Fisher problem), Snedecor's F-distribution, derivations of their p.d.f's, nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form

of these distributions. Relationship between t, F and Chi-square distributions. Test of significance and confidence Intervals based on t and F distributions.

Text Books

- ✓ *Goon, A. M., Gupta, M. K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.*
- ✓ *P. N Arora, Sumeet Arora: Comprehensive Statistical Methods, S Chand*

Suggested Readings

- ✓ *Rohatgi V.K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn., John Wiley and Sons.*
- ✓ *Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.*
- ✓ *Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.*
- ✓ *Mood, A. M., Graybill, F. A. and Boes, D. C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata Mc Graw-Hill Pub. Co. Ltd.*
- ✓ *Deepak Chawala: Research Methodology, Vikas publication.*

List of Practicals

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness of fit.
7. Testing of independence of attributes.
8. Testing based on 2×2 contingency table without and with Yates' corrections.
9. Testing and confidence intervals of equality of two population variances.

MAJOR-I (Paper-VI)

Parametric Statistical Inference

COURSE OUTCOMES

CO1: Understand the concept of Statistical Inference, types of inference, Characteristics of point estimation

CO2: Know the concept of efficiency, sufficiency, C R inequality and its applications

CO3: Know the concept of sufficient statistic, Neyman Factorization theorem, Rao-Blackwell theorem and its applications. Formulate null and alternative hypotheses and apply small, large sample

CO4: Know the different methods of estimation. Compute probabilities of types of error, MP tests and MLR property

CO5: Know the concept of interval estimation, Confidence intervals for parameters of some distributions Binomial, Poisson, Normal. Understand UMP and UMPU test with their applications. Obtain asymptotic confidence interval of a parameter and its relation with testing of hypothesis problem

CO6: Can understand the sequential sampling procedures

LEARNING OUTCOMES

Statistical inference: Drawing conclusions about the whole population on the basis of a sample. Statistical inference is the process of deducing properties of an underlying probability distribution by analysis of data. Inferential statistical analysis infers properties about a population, this includes testing hypotheses and deriving estimates. To learn the development of null and alternative hypotheses. To learn types of errors, non-parametric tests. To perform Test of hypothesis as well as obtain MP, UMP tests.

Unit I

Estimation: Concepts of point estimation, Criterion of a good estimator, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistics. Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. , minimal and complete statistics, Cramer-Rao inequality and MVB estimators (statement and applications).

Unit II

Methods of Estimation: Method of moments, method of maximum likelihood, Method of minimum Chi-square, method of minimum variance, method of least square, basic idea of Bayes' estimators.

Unit III

Principles of test of significance: Null and alternative hypotheses (simple and composite),Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman

Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit IV

Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on binomial and normal distributions.

Text Books

- ✓ *Goon A.M., Gupta M.K.: Das Gupta. B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.*
- ✓ *Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol. II, (4th ed.), World Press.*

Suggested Readings

- ✓ *Rohatgi ,V. K. and Saleh ,A. K. Md. E.(2009): An Introduction to Probability and Statistics. 2nd Edn. John Wiley and Sons.*
- ✓ *Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics(6th*
- ✓ *Edition), Prentice Hall of India.*
- ✓ *Dudewicz, E. J., and Mishra, S. N.(1988): Modern Mathematical Statistics John Wiley & Sons.*
- ✓ *Mood A.M, Graybill F.A. and Boes D.C,: Introduction to the Theory of Statistics, McGraw Hill.*
- ✓ *Bhat B.R, Srivenkatramana Tand Rao Madhava K. S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd*.

List of Practical

1. Unbiased estimators(including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Maximum Likelihood Estimation
4. Most powerful critical region(NPLemma)
5. Uniformly most powerful critical region
6. Unbiased critical region
7. Power curves
8. OC function and OC curve, ASN function and ASN curve

MAJOR-I (Paper-VII)

Survey Sampling & Indian Official Statistics

COURSE OUTCOMES

CO1: Understand the basic principles underlying survey design and estimation

CO2: Apply the different sampling methods for designing and selecting a sample from a population.

CO3: Implement Cluster sampling, Ratio and Regression estimation in real life Problems.

CO4: Apply unequal probability sampling designs viz. PPSWR, PPSWOR including Lahiri's method and Murthy's estimator for survey. Analyze the nature of data and interpret the measures.

CO5: Understand the structure and functioning of Indian Official Statistical System

LEARNING OUTCOMES

Survey Sampling provides the tolls/ techniques for selecting a sample of elements from a target population keeping in mind the objectives and nature of population. Most of the research work is done through Sample Survey. The students are able to know about Indian Official Statistical System. After completing the course, students should have developed clear understanding of: Basic concepts of survey sampling, Principles of survey sampling and main steps involved in selecting a sample, Simple random sampling, Stratified random sampling, Systematic sampling, Ratio and Regression method of estimation, Cluster sampling (equal cluster size), Concepts of sub sampling, Indian Official Statistical System.

Unit I

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: probability and non-probability samplings, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of the in variances and sample size determination.

Unit II

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Systematic Sampling: Technique($N = nk$), estimates of population mean and total, variances of these estimates. Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Unit III

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, comparison with SRSWOR. Cluster sampling(equal clusters only) estimation of population mean and its variance.

Unit IV

Present official statistical system in India, methods of collection of official statistics, its quality and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), National Statistical Office (NSO) and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

Text Books

- ✓ *Sukhatme, P.V., Sukhatme, B. V. Sukhatme, S. Asok, C.(1984). Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics.*
- ✓ *Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.*
- ✓ *http://mospi.nic.in/*

Suggested Readings

- ✓ Cochran W.G.(1984):Sampling Techniques(3rdEd.),Wiley Eastern.
- ✓ Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- ✓ DesRajandChandhokP.(1998):SampleSurveyTheory,NarosaPublishingHouse
- ✓ Goon A.M., Gupta M.K. and Dasgupta B.(2001):Fundamentals of Statistics(Vol.2), World Press.
- ✓ J K Sharma(2014) Business Statistics, Vikas Publication.

List of Practicals

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods. Compare the efficiencies of above two methods relative to

SRS.

5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra- class correlation coefficient, efficiency as compared to SRS.

Semester IV
MAJOR-I (Paper-VIII)
Real and Numerical Analysis

COURSE OUTCOMES

CO1: Describe fundamental properties of the real numbers that lead to the formal development of real analysis. Comprehend rigorous arguments developing the theory underpinning real Analysis

CO2: Demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration. Construct rigorous mathematical proofs of basic results in real analysis. Understand abstract ideas and rigorous methods in mathematical analysis to solve practical problems

CO3: Solve equations using numerical methods

CO4: Interpolate the value using techniques of numerical methods

CO5: Perform numerical integration using Trapezoidal and Simpson's rule

LEARNING OUTCOMES

Students will have the knowledge of basic properties of the field of real numbers, the knowledge of the series of real numbers and convergence, Bolzano — Weirstrass theorem, Cauchy criteria, the knowledge of real functions-limits of functions and their properties, notion of continuous functions and their properties and the differentiability of real functions and related theorems Numerical Analysis: Theory of finite differences deals with the changes that take place in the value of the dependent variable due to finite changes in the independent variable. On completion of the course, students should have achieved as follows:

Unit I

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Supremum and infimum, open and closed sets,

sequences and their convergence. Infinite series, positive termed series and their convergence, Comparison test, D' Alembert's ratio test, Cauchy's nth root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only).

Unit II

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions.

Unit III

Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae.

Unit IV

Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighths rule, Weddle's rule with error terms. Stirling's approximation to factorial. Solution of differential equations of first order.

Text Books

- ✓ *Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, NewDelhi,1994.*
- ✓ *Shanti Narayan: A Course of Mathematical Analysis S Chand*
- ✓ *Goel B.S. and Mittal S.K.: Numerical Analysis, Pragati Prakashan, ND, 2008*

Suggested Readings

- ✓ Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
- ✓ Shanti Narayan: A course of Mathematical Analysis, 12th Edition, S. Chand & Co.(Pvt.) Ltd., New Delhi,1987.
- ✓ Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24th Edition, R. Chand & Co., New Delhi, 2003.
- ✓ Bartle, R.G. and Sherbert, D.R. (2002): Introduction to Real Analysis (3rdEdition), John Wiley and Sons (Asia) PVT. Ltd.
- ✓ Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.

List of Practicals

1. Interpolation with equal and unequal intervals.
2. Problems on Lagrange's interpolation
3. Numerical Integration(Trapezoidal, Simpson's and Weddle's method)
4. Stirling's approximation.

MAJOR-I (Paper-IX)
Linear Regression Analysis and Forecasting (Nptel)

COURSE OUTCOMES

CO1: To understand about the correlation structure among the variables and understand the linear regression equation and least square method for estimating the parameters of the model

CO2: Can able to test the hypothesis related to the significance of regression coefficients

CO3: Understand the Gauss-Markov set-up and estimation of error variance

CO4: Can be able to analyze the graphs before fitting the model and check for the model validation

CO5: Can handle the problem of Correlated errors and collinearity in the model

CO6: Can be able to forecast with regression and also build scenario-based forecasting. Can Build a predictive regression model and check for fitted values and cross-validation.

CO7: Understand the concepts of Nonlinear regression

LEARNING OUTCOMES

Forecasting is an important aspect of any experimental study. The forecasting can be done by finding the model between the input and output variables. The tools of linear regression analysis help in finding out a statistical model between input variables and output variable which in turn provides forecasting. For example, the yield of a crop depends upon the area of crop, quantity of seeds, rainfall etc. The statistical relation between yield and area of crop, quantity of seeds, rainfall etc. can be determined bythe regression analysis and forecasting can be done to know the yield in future. The accuracy of forecasting depends upon the goodness of obtained model. What are its steps and checks required to obtain a good model and in turn, how to do forecasting is being aimed to be taught in this course.

Unit I

Regression Analysis, Steps in regression Analysis, Simple Linear Regression Model: Covariance and Correlation coefficient Estimation by Method of least squares, Testing of Hypothesis of regression coefficient, Confidence Intervals, Predictions, Measuring the quality of fit. Multiple Linear Regression, Centering and scaling, Properties of Least square estimators, multiple correlation coefficient, Tests of hypothesis of regression coefficients in a linear model, Variable selection procedures: Forward selection procedure and backward elimination procedure.

Unit II

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Gauss-Markov theorem, Estimation of error variance.

Regression Diagnostics: The standard regression assumptions, various types of residuals, Graphical methods, Graphs before fitting a model, Graphs after fitting a model, model checking assumptions for linearity and normality, Leverage, influence and outliers, measures of influence: Cook's distance

Unit III

Problem of multicollinearity, its effect on inference and forecasting, detection of multi-collinearity, criteria for evaluating equations: Residual mean square, Mallows Cp, Information criteria, Problem of auto correlation, detection and removal, Durbin- Watson statistic and its limitations.

Unit IV

Forecasting with regression, Ex-ante versus ex-post forecasts, Scenario based forecasting, Building a predictive regression model, Prediction intervals, Fitted values and cross-validation, Nonlinear regression, Forecasting with a nonlinear trend, Correlation, causation and forecasting.

For details please visit - https://archive.nptel.ac.in/content/syllabus_pdf/111104098.pdf

Text Books

- ✓ *Draper, N.R.and Smith, H.: Applied Regression Analysis, John Wiley & Sons.*
- ✓ *Chatterjee, S. and Hadi A. S.: Regression Analysis by Example, Wiley*

Suggested Readings

- ✓ *Sengupta, D, Linear model: an integrated approach, World Scientific Pub.*
- ✓ *Weisberg, S. (2005). Applied Linear Regression (Third edition).Wiley.*
- ✓ *Wu, C. F. J. and Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.*
- ✓ *Renchner, A.C. and Schaalje, G. B. (2008). Linear Models in Statistics (Second*

edition), John Wiley and Sons

List of Practicals

1. Estimability of linear functions(full rank and not a full rank case)
2. Simple Linear Regression
3. Multiple Regression
4. Tests for Regression diagnostics
5. Autocorrelation testing
6. Nonlinear regression

MAJOR-I (Paper-X)
Statistical Quality Control

COURSE OUTCOMES

CO1: Understand the concept of quality, specification limits and tolerance limits

CO2: Construct and draw control charts for variables ,attributes and interpret them

CO3: Understand basic of production process monitoring and apply concept of control charts on it. Apply various sampling plans for product control

CO4: Analyze the nature of data and interpret the quality of product. Apply the acceptance and continuous sampling plans in production process. Compute capability indices

CO5: Apply reliability and other related measures based on standard distributions. Know and apply the concept of weighted control charts, six sigma, ISO: 9000 series standards and Taguchi design.

LEARNING OUTCOMES

Acquire knowledge and develop analysis skills and industrial experimentation. Acquire knowledge on acceptance sampling principles and methods. Develop skills to analyse quality related data using advanced statistical methods. To develop scientific view to analyze the industrial data about specific perspective. To learn the statistical quality control techniques used in industries such as control charts, acceptance sampling plans etc. To learn some advanced control charts, capability indices and the concept of six-sigma.

Unit I

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO

quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts-Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.

Unit II

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Analysis of patterns on control chart, estimation of process capability. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

Unit III

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD,AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

Unit IV

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM).Organizational Structure and Six Sigma training Plans-Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection.

Text Books

- ✓ *Montogomery, D.C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.*

Suggested Readings

- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.*
- ✓ *Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.*
- ✓ *Montogomery, D.C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.*
- ✓ *Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.*
- ✓ *Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.*

List of Practicals

1. Construction and interpretation of statistical control charts

2. X-bar & R-chart
3. X-bar & s-chart
4. np-chart, p-chart, c-chart and u-chart
5. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves

Semester V
MAJOR-I (Paper-XI)
Design and Analysis of Experiments

COURSE OUTCOMES

CO1: Experimental Design Replication, Randomization and Local control. Concepts of experimental design

CO2: One-way and two-way classification without interactions

CO3: CRD, RBD and LSD Layout and their Statistical analysis- Efficiencies of LSD over RBD and CRD

CO4: Analysis of RBD and LSD with one observation and two observations per cell

CO5: Factorial Experiment: main and interaction effects and statistical analysis in 2^2, $2^3$and 3^2designs. Concepts of Total and partial confounding

LEARNING OUTCOMES

DOE is a tool to develop an experimentation strategy that maximizes learning using a minimum of resources. Extensively used by engineers and scientists involved in the improvement of manufacturing processes to maximize yield and decrease variability. It is widely used in many fields with broad application across all the natural and social sciences, to name a few: Biostatistics, Agriculture, Marketing, Software engineering, industry etc. After completing Course in DOE students should have developed a clear understanding of: The fundamental concepts of design of experiments. To learn the basic principles in the design of simple experiments. To learn different tests for comparing pairs of treatment means, ANOVA, factorial experiments, fractional factorial experiments, confounding, BIBD, PBIBD with solving real life examples. To learn the applications of different designs in agriculture.

Unit I

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect and random effect models (one observation per cell), Analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect and random effect models.

Experimental designs: Role, historical perspective, terminology, experimental

error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Unit II

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD)–layout, model and statistical analysis, relative efficiency, Analysis with missing observations.

Unit III

Factorial experiments: advantages and disadvantages, notations and concepts,2^2, 2^3, 2^n and 32 factorial experiments, design and its analysis and applications.

Unit IV

Total and Partial confounding for 2^n ($n \leq 5$), 3^2 and 3^3. Factorial experiments in a single replicate. Advantages and disadvantages. Balanced Incomplete Block Design (BIBD)–parameters, relationships among its parameters.

Text Books

- ✓ *Gupta, S.C. and Kapoor, V.K.(2008): Fundamentals of Applied Statistics, 4th Edition(Reprint), Sultan Chand & Sons*
- ✓ *Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.*

Suggested Readings

- ✓ *Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.*
- ✓ *Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.*
- ✓ *Kempthorne, O.(1965): The Design and Analysis of Experiments. John Wiley.*
- ✓ *Montgomery, D.C.(2008):Design and Analysis of Experiments, John Wiley.*

List of Practicals

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. Analysis of an RBD with one missing observation
5. Analysis of an LSD with one missing observation
6. Analysis of 2^2 and 2^3 factorial in CRD and RBD
7. Analysis of a completely confounded two level factorial design in 2 blocks
8. Analysis of a completely confounded two level factorial design in 4 blocks

9. Analysis of a partially confounded two level factorial design

MAJOR-I (Paper-XII)
Statistical Computing Using R Programming

COURSE OUTCOMES

CO1: Get familiar with R software and learn basics of R with descriptive statistics. Access online resources for R and import new function packages into the R workspace. Import, review, manipulate and summarize data-sets in R

CO2: Compute probabilities and fitting of probability distribution and plotting with R environment

CO3: Explore small and large data-sets to create testable hypotheses and identify appropriate statistical tests

CO4: Perform correlation, regression analysis and appropriate statistical tests for real life situations using R

CO5: Perform appropriate statistical tests and ANOVA for real life situations using R

LEARNING OUTCOMES

After understanding R the student is able to familiar and to develop learning mindsets to analyze statistical data through R software and to learn basic syntax, coding and vocabulary to aid in data analysis.

Unit I

- **Introduction to R:** Downloading and installation of R and R-Studio. Introduction to R and R-Studio.
- **Directory and working vectors:** Setting of working directory, Entering and manipulating data in R, Basic classes of objects (character, numeric, integer, complex, logical),Vectors and their attributes (names, length, type).
- **Arrays and Data types:** (matrices, frames, list), Combining data (cbind, rbind). Importing/Exporting data into R
- **Generating Sequences**, function repeats, component extraction (for vectors, matrices, list, frames), Creating factors, Basic statistical functions (mean, median, mode, standard deviation, skewness, kurtosis etc.), installing packages and library, importing data from other sources (Excel etc.).

Unit II

- **Descriptive Statistics and Probability Distribution-** Introduction, Working with Univariate, Descriptive Statistics in R; Measuring the Central Tendency —Mean and Median, Measuring Spread — Quartiles and the Five-Number Summary, Understanding Numeric Data —Uniform and Normal

Distributions; Probability Distribution.

- **Plotting-** Introduction, Visualizing Numeric Variables—Boxplots, Visualizing Numeric Variables—Histograms, Exploring Relationships between Variables, Visualizing Relationships – Scatter Plots; Correlation Plots from Data Sets.

Unit III

Correlation and Regression: Correlation (Karl Pearson & Spearman's rank correlation), linear models in R (simple and multiple). Scatter plot and Regression line, testing of correlation and regression coefficients. Generating a Diagnostic Plot of a Fitting Model, Summarizing Linear Model Fits, Using Linear Regression to Predict Unknown Values, Generating a Diagnostic Plot of a Fitting Model.

Unit IV

- **Testing Normality:** Anderson-darling test, Shapiro-Wilk test
- **Estimation and Testing:** Tests of significance for the parameters of normal distribution i.e. mean and variance (one sample and two sample problems) and the relevant confidence intervals. One-way and Two-way Analysis of Variance, Chi- square test for independence and association.

Text Books

- ✓ *Fundamentals of Computers, E. Balagurusamy*
- ✓ *ANSIC, Balagurusamy*
- ✓ *Introduction to Statistics and Data Analysis- With Exercises, Solutions and Applications in R, Christian Heumann, Michael Schomaker, Shalabh*
- ✓ *Gardener, M. Beginning R: The Statistical Programming Language, Wiley India*
- ✓ *Monalisha Pattnaik, Statistical Computing using R Programming, Kalyani Publishing.*

Suggested Readings

- ✓ *Balagurusamy, E.(2011): Programming in ANSIC, 6th Edition, Tata Mc Graw Hill.*

  Kernighan , B.W.
- ✓ *Gottfried, B.S.(1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata Mc Graw Hill*

List of Practicals

1. Different types of Plotting
2. Mean, Median and Mode and descriptive statistics of Data
3. Skewness and kurtosis of Data

4. Student's t test and Chi-square test
5. One way ANOVA and Two way ANOVA.
6. Correlation analysis
7. Regression analysis
8. Binomial distribution

MAJOR-I (Paper-XIII)

Operations Research

Course Outcomes

CO1: Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.

CO2: Apply simplex method to solve real life problems.

CO3: Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems

CO4: Understand the concept of Game theory, PERT/ CPM, simulation, investment analysis with real life applications. Understand the concept and solving the problem of game theory

CO5: Understand the concept of inventory model and solving the problem of inventory models

LEARNING OUTCOMES

The Operations Research is not only confined to any specific agency like defense services but today it is widely used in all industrial organizations. It can be used to find the best solution to any problem be it simple or complex. It is useful in every field of human activities. Thus, it attempts to resolve the conflicts of interest among the components of organization in a way that is best for the organization as a whole. Main fields where OR is extensively used are: 1. National Planning and Budgeting 2. Defense Services 3. Industrial Establishment and Private Sector Units 4. Research & Development and Engineering. To develop the optimization techniques that will be useful in the personal and professional life. To learn the mathematical formulation of complex decision-making problems and arrives at optimal or near-optimal solutions using different techniques of operations research.

Unit I

Introduction to Operations Research (O.R.), phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P, Simplex method for solving L.P.P, Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method.

Unit II

Transportation Problem: Initial solution by North West corner rule, least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment problem.

Unit III

Game theory: rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.

Unit IV

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

Text Books

- ✓ *Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.*
- ✓ *D S Hira: Operation Research S Chand*

Suggested Readings

- ✓ *Taha, H.A. (2007): Operations Research: An Introduction, 8thEdition, Prentice Hall of India.*
- ✓ *Hadley, G:(2002):Linear Programming, Narosa Publications*
- ✓ *Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research Concepts and cases, 9th Edition, Tata McGraw Hill*
- ✓ *Kalavathy: Operation Research, Vikas Publishing*

List of Practicals

1. Mathematical formulation of L.P. P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables Identifying Special cases by Graphical and Simplex method and interpretation (Unbounded, Infeasible and alternate solution)
2. Allocation problem using Transportation model
3. Allocation problem using Assignment model

4. Problems based on game matrix

Semester VI
MAJOR-I (Paper-XIV)
Non-Parametric Statistical Inference

COURSE OUTCOMES

CO1: Reinforce and supplement prior knowledge of fundamental statistical topics such as the goals of a statistical analysis; elements andprinciples of hypothesis testing and confidence intervals; comparative studies. Understand and apply the general concept of nonparametric statistics

CO2: Perform a variety of nonparametric statistical analyses such as: One and two sample tests (e.g. binomial test, Wilcoxon test, etc.), K-sample methods (Kruskal-Wallis test, etc.)

CO3: Can understand modern use of computing in nonparametric statistics

CO4: Understand the data management and performance of basic nonparametric statistical analyses

CO5: Explain findings with others using appropriate statistical and non- statistical language

LEARNING OUTCOMES

The essential ideas and implementations of both traditional and contemporary nonparametric statistical methods of data analysis are covered. Allows students to investigate nonparametric methods on a more in-depth level than in previous courses and apply it to data in their particular disciplines. Students will understand the general concept of nonparametric statistics and performs variety of nonparametric statistical analyses. Students will communicate findings with others in a global environment using appropriate statistical and non-statistical language.

Unit I

Some tests based on Binomial Distribution: The Binomial Test, The quantile Test, Tolerance limits, The Sign Test and some variations, The Mc Nemar Test for Significance of changes.

Unit II

The contingency Tables: The 2× 2Contingencytable,The $r \times c$ Contingency table, The Chi-square Test for differences in Probabilities, The Chi-Square Test for independence, The Chi-Square Test for Fixed Marginal Totals, The median Test, Measures of Dependence, Cramer's and Pearson's Contingency Coefficient, The Phi Coefficient, A Goodness of Fit Test, Cochran's test for correlated Observations

Unit III

The Use of Ranks: The One Sample or Matched pairs case, The Wilcoxon Signed Ranks Test, Confidence interval for the median, Two independent Samples: The Mann-Whitney Test, Measures of Rank Correlation, Spearman's Rho, Kendall's Tau, Kendall's partial correlation coefficient, Several Independent Samples: Kruskal-Walis Test

Unit IV

Statistics of the Kolmogorov-Smirnov Type: Kolmogorov goodness of fit test, Confidence band for population distribution function, The Lilliefors Test, The Cramer-von Misses Goodness of fit test, Tests for two independent samples: The Smirnov test, The Cramer-von Misses two sample test, Tests for several independent samples —The Birnbaum-Hall Test

Text Books

- ✓ *Conover, W.J., Practical Non-parametric Statistics, John Wiley & Sons.*

Suggested Readings

- ✓ *Nonparametric Statistical Methods, 3rd Edition, Myles Hollander, Douglas A. Wolfe, Eric Chicken, Wiley Series in Probability and Statistics*

List of Practicals

1. The Binomial Test, The quantile Test
2. The Sign Test, The Mc Nemar Test for Significance of changes
3. The Chi-square Test for differences in Probabilities, The Chi-Square Test for independence, The Chi-Square Test for Fixed Marginal Totals,
4. The median Test,
5. Cramer's and Pearson's Contingency Coefficient
6. The Wilcoxon Signed Ranks Test
7. Measures of Rank Correlation

MAJOR-I (Paper-XV)

Multivariate Analysis

COURSE OUTCOMES

CO1: The understanding of basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.

CO2: Analysing Multivariate data using multiple and partial correlation coefficient.

CO3: Understand Wishart distribution, Hotelling T^2 and Mahalanobis D^2 Statistic.

CO4: Implement dimension reduction techniques using software on real life problems.

CO5: Demonstrate knowledge and understanding of the basic ideas behind discriminant, clustering analysis and ANN techniques with applications.

LEARNING OUTCOMES

The learning objectives include: Study of theoretical concepts of Bivariate Normal and Multivariate Normal Distributions along with their properties. Analyzing Multivariate data using data reduction techniques like Principal Component Analysis, Factor Analysis. To learn and develop scientific view to deal with multidimensional data sets and its uses in the analysis of research data. To understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in the data analysis.

Unit I

Bivariate Normal Distribution (BVND): probability density function (p.d.f.) of BVND, properties of BVND, marginal and conditional p.d.f. of BVND. Multivariate Data: Random Vector: Probability mass / density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions. Characteristic Function

Unit II

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance —covariance matrix. Hotelling's T^2 Statistic for one sample and two samples (detailed derivations excluded), Optimum properties of T^2 test, Multiple and partial correlation coefficient and their properties.

Unit III

Principal Component Analysis: Method of extraction, graphical presentation, Properties of principal components. Canonical Correlation Analysis: Population correlation analysis, sample canonical correlation analysis, interpretation from canonical correlation analysis .Cluster Analysis: Basic steps – Distance-type measures, matching type measures, Forming clusters – Agglomerative method.

Unit IV

Discriminant Analysis: Scope, Assumptions, justification and selection of variables, importance of variables, methods of discrimination–maximum likelihood method, discrete discriminant analysis, idea about artificial neural network and its application.

Text Books

- ✓ *Bhuyan, K C., Multivariate Analysis and its Applications, New Central Book Agency(P) Limited*
- ✓ *Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II, (4th ed.), World Press.*

Suggested Readings

- ✓ *Johnson, R. A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edn. Pearson & Prentice Hall Kshirsagar, A.M.(1972): Multivariate Analysis, 1st Edn. Marcel Dekker.*
- ✓ *Anderson, T. W. (2003). An Introduction to Multivariate statistical Analysis (3rd ed.), Wiley.*
- ✓ *Bilodeau, M. & Brenner, D.(1999). Theory of Multivariate Statistics, Springer*
- ✓ *Härdle, W.K. & Simar, L. (2007). Applied Multivariate Statistical Analysis(2nd ed.), Springer*
- ✓ *Rencher, A.C.(2002). Methods of Multivariate Analysis (2nded.),Wiley*
- ✓ *Timm, N.H.(2002). Applied Multivariate Analysis, Springer.*

List of Practicals

1. Multiple Correlation
2. Partial Correlation
3. Bivariate Normal Distribution
4. Mean vector and variance–covariance matrix
5. Hotelling's T^2 Statistic.
6. Principal Component Analysis.
7. Canonical Correlation Analysis

Semester VII

MAJOR-I (Paper-XVI)

Time Series Analysis

COURSE OUTCOMES

CO1: Understand the concept of time series with its components and able to compute ACVF and ACF Remove trend and seasonality using different methods to convert the time series into stationary

CO2: Apply auto-regressive, moving average, ARMA, ARIMA models, Box- Jenkins approach

to forecast time-series data empirically

CO3: Check and validate models with its residual analysis and diagnostic checking. Analyze the nature of data and interpret the measures

CO4: Analyze the data and predict the future values using curve fitting and exponential smoothing techniques

LEARNING OUTCOMES

Students of this course are taught to understand and predict the changes in economy. Areas of learning include Profit of experience, Safety from future, Utility Studies, Sales Forecasting, Budgetary Analysis, Stock Market Analysis, Yield Projections, Economic Forecasting, Census Analysis, Risk Analysis & Evaluation of changes. To learn and develop scientific view to understand the time series data and its analysis. To learn stationary and non-stationary, and seasonal and non seasonal time series models. Learn to estimate model parameters and compare different models developed for the same dataset in terms of their estimation and prediction accuracy.

Unit I

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, growth curves.

Unit II

Trend Cont: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to (Linear) Trend.

Unit III

Seasonal Component: Ratio to Moving Averages and Link Relative method, Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR(1) and AR(2)–Yule-Walker equations.

Unit IV

Stationary Time series: Weak stationarity, autocorrelation function and correlogram of moving average; its applications. Random Component: Variate component method. Forecasting: Exponential smoothing methods.

Text Books

- ✓ *Kendall M.G.(1976): Time Series, Charles Griffin.*
- ✓ *Brockwell,P.J.andDavis,R.A.(2003).IntroductiontoTimeSeriesAnalysis, Springer*

Suggested Readings

- ✓ *Gupta ,S.C. and Kapoor,V.K.(2008):Fundamentals of Applied Statistics, 4th Edition(Reprint), Sultan Chand &Sons*
- ✓ *Chatfield C.(1980):The Analysis of Time Series–An Introduction, Chapman & Hall.*
- ✓ *Mukhopadhyay P.(2011): Applied Statistics, 2nded. Revised reprint, Books and Allie d*

List of Practicals

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Forecasting by exponential smoothing

MAJOR-I (Paper-XVII)
Optimization Techniques

COURSE OUTCOMES

CO1: Comprehend the techniques and applications of Engineering optimization

CO2: Analyze characteristics of a general linear programming problem

CO3: Apply basic concepts of mathematics to formulate an optimization problem

CO4: Analyze various methods of solving the unconstrained minimization problem

CO5: Analyze and appreciate variety of performance measures for various optimization problems

LEARNING OUTCOMES

At the end of this unit, the student will be able to explain importance of optimization. List out the design variables, constraints and objective function for optimization techniques. can analyze Kuhn Tucker conditions and method of multipliers. Analyze solution of nonlinear programming problems and also analyze various optimization methodologies.

Unit I

Convex sets: Open and closed sets in E_n, convex linear combinations, convexsets, intersection of convex sets, convex hull of a set, Vertices or extreme points of a convex set, convex polyhedron, Hyperplanes, half-spaces and polytopes, separating and supporting hyperplanes, vertices of a closed bounded convex set.

UnitII

Flow and potential in networks: Graphs — definition and notation, minimum path problem, spanning tree of minimum length, problem of minimum potential difference, scheduling of sequential activities, maximum flow problem, duality in maximum flow problem.

UnitIII

- Integer Programming: ILP in two-dimensional space, General ILP and MILP problems, cutting planes, Branch and bound method, The 0-1 variable.
- Sensitivity analysis: changes in b_i, $c_j$and in a_{ij}, introduction of new variables, introduction of new constraints, deletion of variables and deletion of constraints

Unit IV

- Kuhn-Tuker Theoryandnonlinear programming:Lagrangianfunction,saddlepoint, relation between saddle point and minimal point, Kuhn-Tucker conditions
- Geometric programming: Examples, general method, generalizationthrough Kuhn- Tucker theory.

Text Books

✓ *Mital, K.V. and Mohan, C. Optimization methods in operations research and system analysis, New age international.*

Suggested Readings

- ✓ *Aoki, M.; Introduction to Optimization Techniques, Fundamentalsand applications of Nonlinear Programming, Macmillan*
- ✓ *Bazaraa, M.S. and Shetty, C.M. Foundations of Optimization, Lecture Notes in Economics and Mathematical Systems, Springer-Verlag.*
- ✓ *Rao S.S,"Optimization–Theory and applications",WileyEasterLtd.,1979.*
- ✓ *David G. Luerbeggan, "Introduction to Linear and Non Linear Programming", Addison Wesley Publishing Co. 1973.*
- ✓ *Hadley G."Nonlinear and –dynamic programming" Addis on Wesley Publishing Co. 1964.*
- ✓ *Cordan C.C. Beveridge and Robert S. Schedther, "Optimization, Theory and Practice" McGraw Hill Co.1970.*
- ✓ *Harndy A. Tahh."Operations Research, An Introduction", Macmillan Publishers Co. New York, 1982.*
- ✓ *Beightfer and S. others ,"Foundations of Optimization Pill", New Delhi, 1979.*

List of Practicals

1. Integer Programming Problem
2. Vertices or extreme points of a convex set.
3. Minimum path problem, spanning tree of minimum length
4. Sensitivity analysis: changes in b_i, c_j and in a_{ij}
5. Saddle point
6. Minimal point
7. Geometric programming

MAJOR-I (Paper-XVIII)
Econometrics

COURSE OUTCOMES

CO1: Know the scope and objectives of Econometrics

CO2: Detect theabsence of homoscedasticity, Autocorrelation and Multicollinearity

CO3: Derive the reduced form of a simultaneous equation model

CO4: Remove the autocorrelation effect in the data

CO5: Understand Autocorrelation

LEARNING OUTCOMES

Econometrics deals with the measurement of economic relationships. It is an integration of economics, mathematical economics and statistics with an objective to provide numerical values to the parameters of economic relationships. It may be pointed out that the econometric methods can be used in other areas like engineering sciences, biological sciences, medical sciences, geosciences, agricultural sciences etc. In simple words, whenever there is a need of finding the stochastic relationship in mathematical format, the econometric methods and tools help. After completing this course, students should have developed a clear understanding of 1. The fundamental concepts of econometrics. 2. Specification of the model. 3. Multiple Linear Regression. 4. Multicollinearity. 5. Heteroscedasticity. 6. Autocorrelation.7. Autoregressive and Lag models 8.Use of Dummy Variables 9. Specification Errors.

Unit I

- Nature of Econometrics and Economic Data, Definition of Econometrics – Steps in Empirical Economic Analysis-Econometric Model–The Role of Measurement in Economics—The Structure of Economic Data:Cross-Sectional data,TimeSeries data, Pooled Cross Section data, Panel Data.
- Linear model and estimation of parameter and related tests, Estimation under linear restrictions.

Unit II

- Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.
- Heteroscedastic disturbances: OLS estimator under heteroscedasticity. Consequences of heteroscedasticity.

Unit III

- Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.
- Auto-regressive and Distributed Lag Models :Introduction–Types of Lag schemes Koyck's lag model, Almon's Lag scheme,Partial Adjustment and Expectations models-Causality in Economics—TheGranger Causality Test.

Unit IV

Functional forms of Regression models – Log linear models, Semi log- models and Reciprocal models – Choice of Functional Form.

Text Books

- ✓ *Johnston, J: Econometric Methods, McGraw-Hill Book Co., New York.*

Suggested Readings

- ✓ *Maddala, G.S: Econometrics, McGraw-Hill Book Co., New York, 3rd Rd.*
- ✓ *Gujarathi, D.N: Basic Econometrics, Fourth Edition, Tata Mc Graw-Hill, New Delhi.*
- ✓ *Tintner, G: Econometrics, John Wiley &Sons, New York.*
- ✓ *Wooldridge, Jeffery M: Econometrics, Cengage Learning India Pvt.Ltd, New Delhi.*
- ✓ *Koutsoyiannis ,A. (2004):Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited,*
- ✓ *Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics,4th Edition, John Wiley & Sons.*

List of Practicals

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems concerning specification errors
5. Problems related to consequences of Multicollinearity
6. Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Diagnostics of Autocorrelation
9. Estimation of problems of General linear model under Autocorrelation
10. Problems related to consequences Heteroscedasticity
11. Diagnostics of Heteroscedasticity
12. Estimation of problems of General linear model under Heteroscedastic distance terms
13. Problems related to General linear model under(Aitken Estimation)
14. Problems on Autoregressive and Lag models.

MAJOR-I (Paper-XIX)
Stochastic Process

COURSE OUTCOMES

CO1: Identify the situations which require stochastic modelling

CO2: Identify the states and model the situation using Markovian approach

CO3: Study and interpret the characteristics of queuing environment using stochastic

modelling

CO4: Apply Renewal Process to real time problems

CO5: Apply Birth-Death Process to Queuing problems

LEARNING OUTCOMES

After completing this course, students should have developed a clear understanding of the fundamental concepts of stochastic processes, tools needed to analyze stochastic processes, Markov chains, Stability of Markov chains, Poisson process and its variations, Queuing systems, Random walk and ruin theory, and to identify the real-life applications of stochastic processes. To learn and to understand stochastic processes predictive approach. To develop an ability to analyze and apply some basic stochastic processes for solving real life situations.

Unit I

Stochastic Process: Definition and specification Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains.

Unit II

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, pure death process, birth and death process.

Unit III

Stationary Processes: Stationarity, Gaussian processes, Time series: Introduction, White noise process, First order Markov process, moving average(MA) process, autoregressive(AR) process, Yule Process, ARMA process

Unit IV

Simulation: Generation of pseudorandom numbers, evaluation of integrals using random numbers, evaluation of multiple integrals, generation of continuous random variables: inverse transform method, rejection method, generation of Bernoulli, Binomial and Geometric random variables.

Text Books

- ✓ *Medhi, J.(2009):Stochastic Processes, New Age International Publishers.*

Suggested Readings

- ✓ *Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.*

- ✓ *Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.*
- ✓ *Karlin, Sand Taylor H.M, A first course in Stochastic Process. Academic Press;*

List of Practicals

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Calculation of probabilities for given birth and death rates and vice-versa
5. First order Markov process
6. Moving average(MA) process, autoregressive(AR)process, Yule Process
7. Generation of pseudo random numbers

Semester VIII
MAJOR-I (Paper-XX)
Scientific Computing Using Matlab(NPTEL)

COURSE OUTCOMES

CO1: Use MATLAB effectively to analyze and visualizedata

CO2: Apply numeric techniques and simulations to solve engineering-related problems

CO3: Apply a top-down, modular, and systematic approach to design, write, test, and debug sequential MATLAB programs to achieve computational objectives

CO4: Have indepth understanding and use of Matlab fundamental data structures (classes).

CO5: Create and control simple plot and user-interface graphics objects in MATLAB

CO6: Be able to understand and use Matlab Toolboxes for solving real life problems

LEARNING OUTCOMES

After completion, a student can introduce the MATLAB software environment and fortify an organized, top-down way to define and solve big problems. He will be able to introduce common approaches, structures, and conventions for creating and evaluating computer programs, primarily in a procedural paradigm with an introduction to object-oriented concepts and terminology. He can apply a variety of

common numeric techniques to solve and visualize engineering-related computational problems. He will be familiar with various toolboxes to solve real life applications

Unit I

Introduction: What is MATLAB? Use and requirements, basics of MATLAB: windows, online help, input-output, File types, platform dependence, some general commands, creating and working with arrays of numbers, creating and printing simple plots, creating, saving and executing with a script file, creating and executing a function file, working with files and directories.

Unit II

Interactive computation: Matrices and vectors — inputs, indexing, matrix manipulation, creating vectors, matrix and array operations —arithmetic ,logical, elementary math operations, vectorization, command line functions, built-in functions.

Unit III

Saving and loading data in MATLAB, Plotting Graphs, Programming in MATLAB: scripts and functions—script files, function files, language specific features. Basic statistical functions and descriptive analysis.

Unit IV

- Applications: Linear Algebra—solving linear equations, Gaussian elimination, finding eigen values and vectors
- Curve fitting and interpolation—Polynomial curve fitting on the fly, least square curve fitting, interpolation.
- Data analysis and statistics

Text Books

- ✓ *Rudra Pratap(2006). Getting started with MATLAB 7: A quick introduction for Scientists and Engineers, Oxford University Press.*

Suggested Readings

- ✓ *Stephen J. Chapman (2005). Essentials of MATLAB Programming, Cengage Learning.*
- ✓ *Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg (2001) A Guide to MATLAB: For Beginners and Experienced Users, Cambridge University Press*

List of Practicals

1. Solving linear equations, Gaussian elimination, finding eigen values and vectors
2. Curve fitting and interpolation—Polynomial curve fitting on the fly, least square curve fitting, interpolation.
3. Data analysis and statistics

For details please visit

https://nptel.ac.in/courses/111102137

MAJOR-I (Paper-XXI)
Actuarial Statistics

COURSE OUTCOMES

CO1: Understand the utility theory, insurance products and life tables

CO2: Understand the concept of interest

CO3: Understand the concept of life insurance

CO4: Understand the concept of existing insurance products of different insurance company

CO5: Know life annuities, net premium and net premium reserves

LEARNING OUTCOMES

To learn the life tables used in insurance products. To learn the concept of interest, different life insurance products, life annuities, net premiums. To motivate students to prepare for exams required for employment in the actuarial science profession.

Unit I

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

Unit II

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

Unit III

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time-until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

Unit IV

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

Text Books

- ✓ *Dickson, C.M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.*

Suggested Reading

- ✓ *Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. And Nesbitt, C.J. (1997): Actuarial Mathematics, Society Of Actuaries, Itasca, Illinois, U.S.A.*

List of Practicals

1. Risk computation f or different utility models
2. Discrete and continuous risk calculations
3. Calculation of aggregate claims for collective risks
4. Calculation of aggregate claim for individual risks
5. Computing Ruin probabilities and aggregate losses
6. Annuity and present value of contract
7. Computing premium for different insurance schemes
8. Practical based on life models and tables

MAJOR-I (Paper-XXII)

Bayesian Parametric Inference

COURSE OUTCOMES

CO1: Can use relative frequencies to estimate probabilities

CO2: Can calculate conditional probabilities

CO3: Can calculate posterior probabilities using Bayes' theorem and also can calculate

simple likelihood functions

CO4: Can describe the role of the posterior distribution, the likelihood function and the posterior distribution in Bayesian inference about a parameter

LEARNING OUTCOMES

Bayesian *statistics*, as well as being able to 'understand the key ideas of Bayesian statistics' you should also find that your skills and confidence in tackling questions on probability are improving.

Unit I

- Subjective interpretation of probability in terms of fair-odds- Evaluation of subjective probability of an event of an event using a subjectively unbiased coin- Subjective prior distribution of a parameter-Bayes theorem and computation of the posterior distribution.
- Natural Conjugate family of priors for a model –Hyper parameter of a prior from conjugate family- Conjugate family for exponential family models-admitting sufficient statistics of fixed dimensions-Enlarging the natural conjugate family by enlarging hyper parameter space, Mixtures from conjugate family-choosing an appropriate member of conjugate prior family, Non-informative, improper and invariant priors-Jerffrey‟s invariant priors, Maximum entropy priors.

Unit II

Bayesian point estimation: Prediction problem from posterior distribution-Bayes estimates for absolute error loss, squared error loss and Linex loss and Entropy loss function -Generalization to convex loss functions-Evaluation of the estimate in terms of the posterior risk.

Unit III

- Bayesian interval estimation: Credible intervals-Highest posterior density regions interpretation of the confidence coefficient of an interval.
- Bayesian testing of hypothesis: Prior and posterior odds-Bayes factor for various types of testing hypothesis problem-Jeffery approach, Linley‟s paradox for testinga point hypothesis for normal mean.

Unit IV

- Bayesian prediction problem: Standard Predictive distributions, Prediction for exponential family of distributions- predictive distributions and Reliabilityestimation-predictiveinterval,IdeasonBayesianRobustness,Monte-Carlo

- Integration and Markov Chain Monte Carlo Technique (Without Proof).

Text Books

- ✓ *Bansal ,A.K.(2007): Bayesian Parametric Inferences, Narosa Publications.*

Suggested Reading

- ✓ *Sinha, S.K.(1998):Bayesian Estimation, New Age International(P)Ltd., New Delhi.*
- ✓ *Berger, J.O.(1985):Statistical Decision Theory and Bayesian Analysis,2/e Springer Verlag.*
- ✓ *Christian P. Robert: The Bayesian Choice, 2nd Edition, Springer*
- ✓ *Robert, C.P. and Casella, G.(2004): Monte Carlo Statistical Methods, 2/e Springer Verlag.*
- ✓ *Degroot, M.H.(2004):Optimal Statistical Decisions, Welly Inter science.*
- ✓ *Gamerman, D. And Lobes, N.F. (200): Stochastic Simulation for Bayesian Inference, Taylor and Francis.*
- ✓ *Box, G.P. and Tiao, G.C.(1973): Bayesian Inference in Statistical Analysis, Adison Wesley..*

List of Practicals

1. Bayes theorem and computation of the posterior distribution
2. Non-informative, improper and invariant priors
3. Credible intervals
4. Bayesian testing of hypothesis
5. Prediction for exponential family of distributions
6. Monte-Carlo Integration and Markov Chain Monte CarloTechnique

MAJOR-I (Paper-XXIII)
Strategy: An Introduction To Game Theory
(NPTEL)

BYDR.VIMALKUMAR&PROF.ADITYAK.JAGANNATHAM, IITKANPUR

COURSE OUTCOMES

- Identify strategic situations and represent the mas games
- Solve simple games using various techniques
- Analyze economic situations using game theoretic techniques
- Recommend and prescribe which strategies to implement
- Model any strategic interaction as a game and critically analyse the potential

outcomes

LEARNING OUTCOMES

Games or 'Strategic Interactions' can be found in all walks of life. Examples of such scenarios are two firms competing for market share, politicians contesting elections, different bidders participating in an auction for wireless spectrum, coal blocks etc. Game theory provides a convenient framework to model and interpret the behaviour of participants in such strategic interactions. Hence it can be applied to solve a wide variety of problems involving diverse areas such as Markets, Auctions, Online Retail, Cold War, Paying Taxes, Bargaining, Elections, Portfolio Management etc. Therefore, both undergraduate and postgraduate students and professionals from diverse backgrounds such as Scientists, Engineers, Managers, Politicians and Political Scientists, Economists, Mathematicians etc. will find the course content useful. Examples and exercises will be motivated by problems close to real life scenarios.

Unit I

Normal Games and Nash Equilibrium, Mixed Strategies.

Unit II

- Sequential Games.
- Games with Incomplete Information

Unit III

- Auctions, Repeated Games

Unit IV

- Cooperative Games, Bargaining and Negotiation.

Text Books

- ✓ *T. Ferguson, Game Theory, Web Notes.*

Suggested Reading

- ✓ *Karlin and Peres, Game Theory, Alive, AMS.*
- ✓ *De Vos and Kent, Game Theory: A Playful Introduction,AMS*

For details please visit:
https://nptel.ac.in/courses/110104063

MINOR-I (Paper-I)
Descriptive Statistics

COURSE OUTCOMES

CO1: Understand the scope and necessity of Statistics
CO2: Tabulate and represent the data in diagrams and graphs
CO3: Apply the formula and calculate descriptive measures of statistics
CO4: Analyze the nature of data and interpret the measures

CO5: Analyze the data and predict the future values using curve fitting

LEARNING OUTCOMES

The learning objectives include summarizing the data and to obtain its salient features from the vast mass of original data. After completing this course, the students should have developed a clear understanding of Concepts of statistical population and sample, variables and attributes.

Unit I

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram, stem and leaf diagram and Ogives, consistency and independence of data with special reference to attributes.

Unit II

Measures of Central Tendency: mean, median and mode, Measures of Dispersion: Range, Inter Quartile Range, Quartile Deviation, Mean Deviation, Variance and Standard Deviation, Coefficient of Variation, Moments, Absolute Moments, Skewness and Kurtosis, Sheppard's Corrections.

Unit III

Bivariate data: Definition, Scatter Diagram, Simple, Partial and Multiple Correlation (3variablesonly), Rank Correlation. Simple linear regression, Principle of least squares and fitting of polynomials and exponential curves.

Unit IV

Index Numbers: Definition, construction of index numbers and problems there off or weighted and unweighted index numbers including Laspeyer's, Paasche's, Edgeworth-Marshall and Fisher's Ideal Index numbers. Errors in Index numbers. Chain base index numbers, conversion of fixed based to chain-based index numbers and vice-versa. Consumer price index numbers, Cost of living index number, Uses and limitations of index numbers.

Text Books

- ✓ *P. N Arora, Sumeet Arora: Comprehensive Statistical Methods, S Chand*
- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, The World Press, Kolkata.*
- ✓ *Gupta, S.C. and Kapoor,V.K.(2008): Fundamentals of Mathematical Statistics, 4th*

Edition, Sultan Chand & Sons

Suggested Readings

- ✓ *Miller, Irwin and Miller, Mary lees (2006): John E. Freund's Mathematical Statistics with Applications, (7thEdn.), Pearson Education, Asia.*
- ✓ *Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.*
- ✓ *R S N Pillai & Bagavathi :Practical Statistics, S Chand*
- ✓ *C B Gupta: An Introduction to Statistical Methods, Vikas Publishing*

List of Practicals

Emphasis should be given on interpretation of results.

8. Graphical representation of data–Simple Bar Diagram, Multiple Bar Diagram and Divided Bar Diagram, Histogram, Stem and leaf diagram, Pie diagram, Frequency polygon and frequency curve.
9. Problems based on Measures of Central Tendency.
10. Problems based on Measures of Dispersion.
11. Problems based on Moments, Skewness and Kurtosis.
12. Scatter Diagram, Karl Pearson correlate on coefficient and rank correlation coefficient (with and without tie).
13. Lines of regression, angle between lines and estimated values of variables.
14. Calculate price, quantity and cost of living index numbers.

MINOR-II (Paper-I)
Probability and Probability Distributions

COURSE OUTCOMES

CO1: Concept of probability, different approaches to the theory of probability. Concept of events, mutually exclusive independent and exhaustive events. Sample space and its properties. Use the basic probability rules including addition and multiplicative laws, conditional probability and Bayes theorem.

CO2: Gain knowledge on random variables. Distinguish between discrete and continuous random variables. Probability mass function and probability density function.

CO3: Understand Mathematical expectation of a random variable. Conditional expectation and variance and conditional expectations.

CO4: Understand the most common discrete and continuous probability distributions

and their real-life applications. Identify their characteristics.

CO5: Identify the type of statistical situation to which different distributions can be applied. Use the different distributions in solving statistical problems.

LEARNING OUTCOMES

To present the general theory of statistical distributions as well as the standard distributions found in statistical practice. To train students with essential tools for statistical analyses at the post graduate level. Fostering understanding through real-world statistical applications. A probability distribution is a statistical model that shows the possible outcomes of a particular event or course of action as well as the statistical likelihood of each event. Probability distribution functions are quite important and widely used in actuarial science (insurance), engineering, physics, evolutionary biology, computer science and even social sciences such as psychiatry, economics and even medical trials.

Unit I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability —classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Unit II

Random variables: discrete and continuous random variables, probability mass function (p.m.f.), probability density function (p.d.f.) and cumulative distribution function (c.d.f.), illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables.

Unit III

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, Cumulants generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

Unit IV

Standard discrete probability distributions: Uniform, Bernoulli, Binomial, Poisson, Geometric, along with their properties and limiting/approximation cases. Standard continuous probability distributions: Uniform, Normal, Exponential, Beta and Gamma along with their properties and limiting/approximation cases.

Text Books

- ✓ Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- ✓ Ravish R Singh & Mukul Bhatt: Probability and Statistics, S Chand
- ✓ Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Mathematical Statistics, 4th Edition (Reprint), Sultan Chand & Sons

Suggested Readings

- ✓ *Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7thEdn.), Pearson Education, Asia.*
- ✓ *Iyengar: Probability and Statistics S Chand*
- ✓ *Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint),Tata McGraw-Hill Pub. Co. Ltd.*
- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8thEdn. The World Press, Kolkata.*
- ✓ *Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi*

List of Practicals

1. Fitting of Binomial and Geometric distributions
2. Fitting of Poisson distributions
3. Fitting of Normal and One-parameter exponential distributions
4. Application problems based on Binomial, Geometric, Poisson, One-parameter exponential and Normal distributions.

MINOR-I (Paper-II)
Survey Sampling & Indian Official Statistics

COURSE OUTCOMES

CO1: Understand the basic principles underlying survey design and estimation

CO2: Apply the different sampling methods for designing and selecting a sample from a population.

CO3: Implement Cluster sampling, Ratio and Regression estimation in real life Problems.

CO4: Apply unequal probability sampling designs viz. PPSWR, PPSWOR including

Lahiri's method and Murthy's estimator for survey. Analyze the nature of data and interpret the measures.

CO5: Understand the structure and functioning of Indian Official Statistical System

LEARNING OUTCOMES

Survey Sampling provides the tolls/ techniques for selecting a sample of elements from a target population keeping in mind the objectives and nature of population. Most of the research work is done through Sample Survey. The students are able to know about Indian Official Statistical System. After completing the course, students should have developed clear understanding of: Basic concepts of survey sampling, Principles of survey sampling and main steps involved in selecting a sample, Simple random sampling, Stratified random sampling, Systematic sampling, Ratio and Regression method of estimation, Cluster sampling (equal cluster size), Concepts of sub sampling, Indian Official Statistical System.

Unit I

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: probability and non-probability samplings, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of the in variances and sample size determination.

Unit II

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Systematic Sampling: Technique($N = nk$), estimates of population mean and total, variances of these estimates. Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Unit III

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, comparison with SRSWOR. Cluster sampling(equal clusters only) estimation of population mean and its variance.

Unit IV

Present official statistical system in India, methods of collection of official statistics, its quality and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), National Statistical Office (NSO) and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

Text Books

- ✓ *Sukhatme, P.V., Sukhatme, B. V. Sukhatme, S. Asok, C.(1984). Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics.*
- ✓ *Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.*
- ✓ *http://mospi.nic.in/*

Suggested Readings

- ✓ Cochran W.G.(1984):Sampling Techniques(3rdEd.),Wiley Eastern.
- ✓ Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- ✓ DesRajandChandhokP.(1998):SampleSurveyTheory,NarosaPublishingHouse
- ✓ Goon A.M., Gupta M.K. and Dasgupta B.(2001):Fundamentals of Statistics(Vol.2), World Press.
- ✓ J K Sharma(2014) Business Statistics, Vikas Publication.

List of Practicals

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods. Compare the efficiencies of above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra- class correlation coefficient, efficiency as compared to SRS.

MINOR-II (Paper-II)
Statistical Quality Control

COURSE OUTCOMES

CO1: Understand the concept of quality, specification limits and tolerance limits

CO2: Construct and draw control charts for variables ,attributes and interpret them

CO3: Understand basic of production process monitoring and apply concept of control charts on it. Apply various sampling plans for product control

CO4: Analyze the nature of data and interpret the quality of product. Apply the acceptance and continuous sampling plans in production process. Compute capability indices

CO5: Apply reliability and other related measures based on standard distributions. Know and apply the concept of weighted control charts, six sigma, ISO: 9000 series standards and Taguchi design.

LEARNING OUTCOMES

Acquire knowledge and develop analysis skills and industrial experimentation. Acquire knowledge on acceptance sampling principles and methods. Develop skills to analyse quality related data using advanced statistical methods. To develop scientific view to analyze the industrial data about specific perspective. To learn the statistical quality control techniques used in industries such as control charts, acceptance sampling plans etc. To learn some advanced control charts, capability indices and the concept of six-sigma.

Unit I

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts-Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.

Unit II

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Analysis of patterns on control chart, estimation of process capability. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

Unit III

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD,AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling

inspection plan tables.

Unit IV

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM).Organizational Structure and Six Sigma training Plans-Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection.

Text Books

- ✓ *Montogomery, D.C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.*

Suggested Readings

- ✓ *Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.*
- ✓ *Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.*
- ✓ *Montogomery, D.C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.*
- ✓ *Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.*
- ✓ *Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.*

List of Practicals

1. Construction and interpretation of statistical control charts
2. X-bar & R-chart
3. X-bar & s-chart
4. np-chart, p-chart, c-chart and u-chart
5. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves

MINOR-I (Paper-III)

Operations Research

Course Outcomes

CO1: Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.

CO2: Apply simplex method to solve real life problems.

CO3: Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems

CO4: Understand the concept of Game theory, PERT/ CPM, simulation, investment analysis with real life applications. Understand the concept and solving the problem of game theory

CO5: Understand the concept of inventory model and solving the problem of inventory models

LEARNING OUTCOMES

The Operations Research is not only confined to any specific agency like defense services but today it is widely used in all industrial organizations. It can be used to find the best solution to any problem be it simple or complex. It is useful in every field of human activities. Thus, it attempts to resolve the conflicts of interest among the components of organization in a way that is best for the organization as a whole. Main fields where OR is extensively used are: 1. National Planning and Budgeting 2. Defense Services 3. Industrial Establishment and Private Sector Units 4. Research & Development and Engineering. To develop the optimization techniques that will be useful in the personal and professional life. To learn the mathematical formulation of complex decision-making problems and arrives at optimal or near-optimal solutions using different techniques of operations research.

Unit I

Introduction to Operations Research (O.R.), phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P, Simplex method for solving L.P.P, Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method.

Unit II

Transportation Problem: Initial solution by North West corner rule, least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment problem.

Unit III

Game theory: rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.

Unit IV

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

Text Books

- ✓ *Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.*
- ✓ *D S Hira: Operation Research S Chand*

Suggested Readings

- ✓ *Taha, H.A. (2007): Operations Research: An Introduction, 8thEdition, Prentice Hall of India.*
- ✓ *Hadley, G:(2002):Linear Programming, Narosa Publications*
- ✓ *Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research Concepts and cases, 9th Edition, Tata McGraw Hill*
- ✓ *Kalavathy: Operation Research, Vikas Publishing*

List of Practicals

5. Mathematical formulation of L.P. P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables Identifying Special cases by Graphical and Simplex method and interpretation (Unbounded, Infeasible and alternate solution)
6. Allocation problem using Transportation model
7. Allocation problem using Assignment model
8. Problems based on game matrix

MINOR-II (Paper-III)
Non-Parametric Statistical Inference

COURSE OUTCOMES

CO1: Reinforce and supplement prior knowledge of fundamental statistical topics such as the goals of a statistical analysis; elements andprinciples of hypothesis testing and confidence intervals; comparative studies. Understand and apply the general concept of nonparametric statistics

CO2: Perform a variety of nonparametric statistical analyses such as: One and two sample

tests (e.g. binomial test, Wilcoxon test, etc.), K-sample methods (Kruskal-Wallis test, etc.)

CO3: Can understand modern use of computing in nonparametric statistics

CO4: Understand the data management and performance of basic nonparametric statistical analyses

CO5: Explain findings with others using appropriate statistical and non- statistical language

LEARNING OUTCOMES

The essential ideas and implementations of both traditional and contemporary nonparametric statistical methods of data analysis are covered. Allows students to investigate nonparametric methods on a more in-depth level than in previous courses and apply it to data in their particular disciplines. Students will understand the general concept of nonparametric statistics and performs variety of nonparametric statistical analyses. Students will communicate findings with others in a global environment using appropriate statistical and non-statistical language.

Unit I

Some tests based on Binomial Distribution: The Binomial Test, The quantile Test, Tolerance limits, The Sign Test and some variations, The Mc Nemar Test for Significance of changes.

Unit II

The contingency Tables: The 2× 2Contingencytable,The $r \times c$ Contingency table, The Chi-square Test for differences in Probabilities, The Chi-Square Test for independence, The Chi-Square Test for Fixed Marginal Totals, The median Test, Measures of Dependence, Cramer's and Pearson's Contingency Coefficient, The Phi Coefficient, A Goodness of Fit Test, Cochran's test for correlated Observations

Unit III

The Use of Ranks: The One Sample or Matched pairs case, The Wilcoxon Signed Ranks Test, Confidence interval for the median, Two independent Samples: The Mann-Whitney Test, Measures of Rank Correlation, Spearman's Rho, Kendall's Tau, Kendall's partial correlation coefficient, Several Independent Samples: Kruskal-Walis Test

Unit IV

Statistics of the Kolmogorov-Smirnov Type: Kolmogorov goodness of fit test, Confidence band for population distribution function, The Lilliefors Test, The Cramer-von Misses Goodness of fit test, Tests for two independent samples: The Smirnov test, The Cramer-von Misses two sample test, Tests for several independent samples —The Birnbaum-Hall Test

Text Books

- ✓ *Conover, W.J., Practical Non-parametric Statistics, John Wiley & Sons.*

Suggested Readings

- ✓ *Nonparametric Statistical Methods, 3rd Edition, Myles Hollander, Douglas A. Wolfe, Eric Chicken, Wiley Series in Probability and Statistics*

List of Practicals

1. The Binomial Test, The quantile Test
2. The Sign Test, The Mc Nemar Test for Significance of changes
3. The Chi-square Test for differences in Probabilities, The Chi-Square Test for independence, The Chi-Square Test for Fixed Marginal Totals,
4. The median Test,
5. Cramer's and Pearson's Contingency Coefficient
6. The Wilcoxon Signed Ranks Test
7. Measures of Rank Correlation

MULTIDISCIPLINARY COURSE (MDC-I)

Statistical Methods for Scientists and Engineers

By Prof. Somesh Kumar (NPTEL)

Course Outcomes:

CO1: The overall course objective is to understand basic concepts of probability and statistics and to be able to use them to solve engineering problems.

CO2: Understand basic techniques for data summary and data presentation.

CO3: Understand and be able to use basic probability rules and common probability distributions.

CO4: Be able to estimate population parameters from random samples and perform error analyses.

CO5: Be able to understand and apply the basic concepts of statistical inference, confidence limits and hypothesis testing.

CO6: Be able to develop empirical linear models from data and evaluate their statistical properties.

CO7: Be able to understand and apply the concepts of design of experiments and analysis of variance.

CO8: Understand the theory and practice of statistical quality control and quality control charts.

UNIT-I

Review of Probability and Distributions: Rules for probability, random variables and their distributions, moments, special discrete and continuous distributions, laws of large numbers and central limit theorem, sampling distributions.

UNIT-II

Parametric Methods: Point estimation – unbiasedness, consistency, UMVUE, sufficiency and completeness, method of moments, maximum likelihood estimation and method of scoring. Bayes, minimax and admissible estimators. Interval estimation - confidence intervals for means, variances and proportions. Testing of Hypotheses - tests for parameters of normal populations and for proportions, goodness of fit test and its applications.

UNIT-III

Multivariate Analysis: Multivariate normal, Wishart and Hoteling's T 2 distributions and their applications in testing of hypotheses problems. Classification of observations, principal component analysis, canonical correlations and canonical variables.

UNIT-IV

Nonparametric Methods: Empirical distribution function, asymptotic distributions of order statistics, single sample problems, problems of location, prediction intervals, Kolmogorov Smirnov one sample statistics, sign test, Wilcoxon signed rank statistics, two sample problems, Mann-Whitney-Wilcoxon tests, scale problems, Kolmogorov Smirnov two sample criterions.

Text Books

- ✓ *An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md.E.Saleh.*
- ✓ *Modern Mathematical Statistics by E.J. Dudewicz & S.N. Mishra*
- ✓ *Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross*
- ✓ *An Introduction to Multivariate Analysis by T. W. Anderson*
- ✓ *Nonparametric Statistical Inference by J.D. Gibbons & S. Chakraborti*

Suggested Readings

- ✓ *Statistical Inference by G. Casella &R.L.Berger*
- ✓ *Applied Multivariate Statistical Analysis by R.A. Johnson & D.W. Wichern*
- ✓ *Nonparametric Inference by Z. Govindarajulu*

For details please visit:

https://nptel.ac.in/courses/111105077

MULTIDISCIPLINARY COURSE (MDC-II)

SURVIVAL ANALYSIS AND BIOSTATISTICS

COURSE OUTCOMES

CO1: Understand survival data and censoring and truncation mechanisms
CO2: Estimate survival curves for censored survival data
CO3: Fit survival models using the Cox proportional hazards model
CO4: Evaluate the validity of assumptions underlying the Cox model and modify the Cox model to accommodate time-dependent variables and multiple outcomes
CO5: Understand how to accommodate competing risks and determine thepower and sample size requirements for a survival analysis study.

LEARNING OUTCOMES

This course emphasizes concepts and applications used in public health studies. The product limit estimator, the Cox proportional hazard model, and parametric models will be discussed. Censoring and truncation patterns will also be studied. Model building and checking will be discussed throughout.

UNIT-I
Survival Analysis: Functions of survival times, survival distributions and their application,Gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function. Censoring Schemes: Type I, Type II and progressive or random censoring with 70 biological examples. Estimation of mean and median survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Nonparametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT-II
Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model.

UNIT-III
Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

UNIT-IV
Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array, relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials: Planning and design of clinical trials, Phase I, II and III trials. Single and double blind experiments.

TEXTBOOKS

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival dataAnalysis, 3rd Edition, John Wiley and Sons.
2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.

SUGGESTEDREADINGS

1. Kleinbaum, D.G. (1996): Survival Analysis, Springer.
2. Chiang, C.L. (1968): Introduction to Stochastic Processes in Biostatistics, John Wiley and Sons.
3. Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.

LISTOFPRACTICALS

1. To estimate survival function
2. To determine death density function and hazard function
3. To identify type of censoring and to estimate survival time for type I censored data
4. To identify type of censoring and to estimate survival time for type II censored data
5. To identify type of censoring and to estimate survival time for progressively type I censored data 71
6. Estimation of mean survival time and variance of the estimator for type I censored data
7. Estimation of mean survival time and variance of the estimator for type II censored data
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data
9. To estimate the survival function and variance of the estimator using Nonparametric methods with Actuarial methods
10. To estimate the survival function and variance of the estimator using Nonparametric methods with Kaplan-Meier method
11. To estimate Crude probability of death
12. To estimate Net-type I probability of death
13. To estimate Net-type II probability of death
14. To estimate partially crude prob.

MULTIDISCIPLINARY COURSE (MDC-III)

Demography

Unit-1:

LO. *Understand of key concepts of demography as a discipline*

Introduction: Demography - Its Definition, Nature and Scope; Relationship with other disciplines; Demographic Balancing Equation; Sources of Demographic Data in India: Salient Features of Census, Civil Registration System, National Sample Survey, National Family Health Survey; Population Distribution and Growth – Measures and Determinants; Concepts of Rate, Ratio and Proportion.

Unit -II:

LO . *Examine population dynamics and resultant socioeconomic issues and problems.*

World Population Growth; Doubling time; Population Growth in India; Population Dynamics: Fertility, Mortality and Migration - Measures, Determinants and Implications; Theories of Population - Malthusian Theory and theory of Demographic Transition, Population policies and programmes in India.

Unit-III: Practical

LO. *Compare and relate population growth and distribution of developed and developing countries*

1. Arithmetic and Geometric Projection - Calculation and Graphical display;
2. Construction of population pyramid,
3. Construction of Lorenz Curve
4. Calculation and presentation of Population Growth Rate, Crude Birth Rate, Age-Specific Fertility Rate, Infant and Neonatal Mortality Rate, Maternal Mortality Ratio Based on Supplied Data.
5. Practical Record and Viva-Voce.

Text Books:

- ✓ *Chandna, R. C. (2015). An Introduction to Population Geography, Kalyani Publishers.*
- ✓ *Hassan, M.I (2020). Population Geography: A Systematic Exposition, Routledge, London and New York.*

Reference Books:

- ✓ *Bhende, A. and Kanitkar T. (2000). Principles of Population Studies, Himalaya Publishing House.*
- ✓ *Pathak, K.B and F. Ram (2016). Techniques of Demographic Analysis, Himalaya Publishing House, Mumbai.*
- ✓ *Srinivasan, K (1998). Basic Demographic Techniques and Applications, Sage Publications, New Delhi.*

SEC-I

INTRODUCTION TO STATISTICS AND DATA ANALYSES

COURSE OUTCOMES

CO1: To understand the fundamental concepts and scope of statistics.

CO2: To identify and classify different types of data and scales of measurement.

CO3: To acquire knowledge and skills in data collection, classification, and tabulation.

CO4: To apply appropriate statistical measures of central tendency and dispersion.

CO5: To give an idea about the relationship between the variables.

CO6: To know more about categorical data and to understand the process of hypothesis testing.

LEARNING OUTCOMES

1. Exhibit a clear understanding of the principles and limitations of statistics.
2. Classification of data based on their type and scale of measurement.
3. Collection of data from primary and secondary sources.
4. Interpret measures of central tendency, dispersion, Skewness, Kurtosis and moments.
5. Correlation and regression.

6. Clear concept of categorical data and its analysis.
7. Basic concepts of hypothesis testing, including framing of null and alternative hypothesis.

Unit I: Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

Unit II: Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation. Moments, skewness and kurtosis.

Unit III: Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression.

Unit IV: Tests of proportions, tests of association and goodness-of-fit using Chi square test, Yates' correction. Testing of Hypothesis: Statistical Hypothesis, null and alternative hypotheses, simple and composite hypotheses, Level of significance.

SUGGESTED READING: 1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

2. Miller, Irwin and Miller, Marylees (2006): John E. Freund‟s Mathematical Statistics with Applications,(7th Edn.), Pearson Education, Asia.

3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

PRACTICALS

1. Graphical representation of data

2. Problems based on measures of central tendency

3. Problems based on measures of dispersion

4. Problems based on moments, skewness and kurtosis

6. Karl Pearson correlation coefficient

7. Partial and multiple correlations

8. Lines of regression, angle between lines and estimated values of variables.

9. Chi-square test of proportions and goodness of fit

SEC-II

DATA ANALYTICS-I

COURSE DESCRIPTION

This paper helps students to learn the fundamental elements of Data Analytics and to gain proficiency in working with SPSS. Upon Completing the Course, students will be able to identify advanced techniques of data analytics using Statistical Package for Social Sciences (SPSS), use Exploratory data analysis to visualize the data, analyses survey and other data sets using statistical methods

COURSE OUTCOMES

CO1: This course is designed to help students learn fundamental elements of Data Analytics and to gain proficiency in working with SPSS.

CO2: Upon Completing the Course, students will be able to identify advanced techniques of data analytics using Statistical Package for Social Sciences (SPSS) software.

CO3: They will be exposed to exploratory data analysis techniques.

CO4: This course shall enable them to use statistical tools to visualize and analyze surveys and other data sets.

Unit I: Introduction to Data Analytics

Concept of data analytics; Role of data analyst; Classification of Data- Structured, Semi-Structured, Unstructured data; Scale of measurement of data; Various Data sources, Modern Data collection Methods.

LO: This module shall help the students to understand the basics of data analytics and identify, understand, and deal with different types of data sets.

Unit II: Data Visualisation and Basic Statistics

Data presentation and visualization, Types of Diagrams; Descriptive statistics like measure of central tendency, Dispersion, Skewness, Correlation etc.; Univariate, Bivariate, Multivariate Analysis.

LO: Students shall develop proficiency in data visualization to identify patterns, trends, and outliers in data sets; and be able to understand applied statistics to develop suitable concepts and methods that will help to analyse data and solve research problems in this module.

Unit III: Introduction to SPSS

Different Menu‘s in SPSS, creating a data file, opening excel files, variables and labels, selecting cases by filtering, recoding of data, merging of files, Sorting of Cases and Variable, SPSS Output and its transfer to excel and word.

LO: This module shall enable the students to calculate/recode variables and prepare data for analysis using SPSS.

Unit IV: Exploratory Data Analysis using SPSS

Data visualization using frequency tables and charts, descriptive statistics, cross tabulations, Compare-Means, ANOVA, Independent Sample t-test, Paired Sample t-test, One-way ANOVA, chi square tests. Simple and Partial correlation; General Linear Model

LO: Upon completion of this module, the learners shall be able to carry out exploratory data analysis using SPSS that can test hypotheses.

Text Books

1. *Brian C. Cronk (2018), How to use SPSS: A Step-By-Step Guide to Analysis and Interpretation, Tenth edition, Routledge.*
2. *Nancy L. Leech et. al. (2005), SPSS for Intermediate Statistics: Use and Interpretation, Second edition, Lawrence Erlbaum Associates, Inc.*

Additional Reading

1. *William E. Wagner (2015), Using IBM SPSS statistics for research methods and social science statistics, Fifth edition, SAGE Publications, Inc.*
2. *IBM 2016, IBM Knowledge Center: SPSS Statistics, IBM, viewed 18 May 2016, https://www.ibm.com/support/knowledgecenter/SSLVMB/ welcome/ 2.*

SEC-III

Analytical Ability and Logical Reasoning

Course Objectives

- To cover various forms of reasoning including deductive, inductive, and abductive, and integrate these with critical thinking skills.
- To explore logical sequences, coding-decoding, and arrangements as key elements of logical reasoning.
- To delve into complex logical reasoning constructs such as alphanumeric series, reasoning analogies, and calendars.
- To engage with arguments involving two or more premises and utilize connectives effectively.

Learning Outcomes

- To be acquainted with using facts, evidence, rules, and principles to draw valid conclusions and make sound judgments.
- Able to practice pattern recognition, spatial reasoning, and decision-making as fundamental components of analytical reasoning.
- Able to apply logical reasoning to practical scenarios involving cause and effect, dices, directions, and visual reasoning.
- Able to master logical constructs such as statements and assumptions, conclusions, and syllogisms.

Unit-I: Analytical Reasoning

Deductive Reasoning, Inductive Reasoning, Abductive Reasoning, Critical Thinking, Pattern Recognition- Data, Sequences, Structures, Logical Reasoning, Spatial Reasoning, Causal Reasoning, Decision Making.

Unit-II: Basic Logical Reasoning Concepts

Logical Sequence Series- patterns and sequences in reasoning. Coding- Coding decoding. Arrangements-Seating arrangements and data arrangement. Blood Relations-problems related to blood relations. Input and Output Patterns. Binary Logic Problems

Unit-III: Logical Reasoning

Alphanumeric series, Reasoning Analogies, Calendars, Cause and Effect, Clocks, Cubes and cuboids, Data Sufficiency, Decision Making, Deductive Reasoning/Statement Analysis, Dices, Directions, Mirror and Water Images,

Unit-IV: Logical Statements

Two premise argument. More than two premise argument using connectives. Statement and Assumptions. Statement and Conclusions. Syllogism.

VALUE ADDED COURSE
Environmental Studies
&
Disaster Management

SEMESTER-I
(VAC-I)
For Under Graduate Compulsory Courses for Arts, Science and Commerce

FULL MARK-100 (Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources : World food problems, changes caused by agriculture and Overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.

e) Energy resources : Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:-
Introduction-Definition; Biogeographically classification of India
India as a mega diversity nation. Hot sports of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-so conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. **Disaster Management:** Types of disasters (natural and Man-made) and their causes and effect)
2. **Vulnerability Assessment and Risk analysis:** Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)
3. **Institutional Framework:** Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. **Preparedness measures:** Disaster Management cycle, Early Warning System, Pre-Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stakeholders participation, Corporate Social Responsibility (CSR)
5. **Survival Skills:** Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)
A.
a) Environmental Ethics: Issues and possible solutions.
b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
c) Environment Protection Act
d) Air(Preservation Control of Pollution) Act
e) Water(Preservation Control of Pollution) Act
f) Wildlife Protection Act
g) Forest Conservation Act
h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
B. Human Population and the Environment
Population Ecology: Individuals, species, population, community Human population growth, population control method Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.

- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge ,etc.

VALUE ADDED COURSE-II

Ethics and Value
SEMESTER-III

Credit point: 3 **Full mark -100** **Total Hours: 45**

- Development of a good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior
- Inculcating a positive attitude and healthy work culture
- To equip the students to prepare themselves national and state level civil service and other competitive examination.

COURSE CONTENTS
UNIT-I- ETHICS AND HUMAN INTERFACE [5 Hours]
Learning Outcome-

- ✓ Understand the basic ethics and its relevance in life
- Ethics and Human Interface: Essence, Determinants and consequence of ethics and human action.
- Dimensions of Ethics in private and public relationship
- Human Values: Tolerance, Compassion, Rationality, Objectivity, Scientific Attitude Integrity, Respecting conscience and Empathy etc.
- Mahatma Gandhi and Ethical Practices: Non-Violence, Truth, Non-hatred and love for all, concern for the poorest, objective Nationalism and Education for man making. Relation between Ends and Means.

Subject Teacher: Philosophy/Political Science or Any other Teacher.
UNIT-II- ETHICS AND MAJOR RELIGIONS AND CIVILIZATIONS [7 hours]
Learning Outcome-

✓ *Be familiar with ethical principles and values promoted by major religious traditions and civilization*

- Hinduism- Dharma and Mokhya (out of 4 goals of life Dharma, Artha, Kama and Mokhya), Concept of Purusartha, Nisakama Karma(work without attachment to results), Concept of Basudev Kutumba and Peace (Whole world including all animals, plants, inanimate beings and human form one world)
- Ten Commandments: (Christianity and Judaism Tradition)
- Islamic Ethics: Justice, Goodness, Kindness, Forgiveness, Honesty, Purity and Piety
- Egyptian- Justice, Honesty, Fairness, Mercy, Kindness and Generosity
- Mesopotian-Non-indulgence in lying, stealing, defrauding, maliciousness, adultery, coveting possession of others, unworthy ambition, misdemeanors and injurious teaching.

- Buddhism-Arya Astangika Marg: Right View, Thought, Speed, Action, Livelihood, Efforts, Attention and Concentration.
- Jainism-Right faith, knowledge and conduct(Triralna)
- Chinese-Confucianism- Respect for Autonomy, Beneficence, non-maleficence and justice. Taoism: No killing, No stealing, No sexual misconduct, No false Speech and No taking of intoxicants.

Subject Teacher: History/Philosophy/Political Science or Any other Teacher.
UNIT-III- CONSTITUTIONAL VALUES, GOOD CITIZENSHIP, PATRIOTISM AND VOLUNTEERISM [10 Hours]
Learning Outcome-
✓ *Students Learns about constitutional values of India, Civic Sense and good Citizenship (both National and International) Patriotism and need for Volunteerism*

- Salient Values of Indian Constitution: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity
- Patriotic values and ingredients of National Building, Examples of great Patriots, Rani Laxmi Bai, Bhagat Singh, Mangal Pandey, Birsa Munda, Laxman Naik, Subhas Chandra Bose and Khudiram Bose.
- Law abiding citizenship
- Concept of Global citizenship in contemporary world
- Volunteerism- concept and facts of Volunteerism, building a better society through Volunteerism, Blood Donation, Social work, Helping the Aged, Promotion of Green Practices and Environment protection.

Subject Teacher: Philosophy/Political Science /History/ or Any other Teacher.
UNIT-IV- WORK ETHICS [6 hours]
Learning Outcome-
✓ *Understand the concept of work ethics, ethics in work place and ethical practices to be adopted by various professionals*

- The concept of professionalism.
- Professional ethics at work place
- Core values needed for all professionals. Reliability, Dedication, Discipline, Productivity, Co-operation , Integrity, Responsibility, Efficiency, Professionalism, Honesty, Purity and Time Management, Accountability, Respect Diversity, Gender Sensitivity, Respect for others, Cleanliness, Rational Thinking, Scientific Attitude, Clarity in Thinking . Diligence, cleanliness and Environment Consciousness.
- Codes of conduct for Students(both in College and Hostels),Teachers, Business professional, Doctors, Lawyers, Scientist, Accountants, IT professionals and Journalist.
- Practical ethics in day to day life.

Subject Teacher: Commerce/Philosophy/Education/History/ or Any other Teacher.
UNIT-V-ETHICS AND SCIENCE AND TECHNOLOGY [7 Hours]
Learning Outcome-

✓ *Understand how Science is related to ethics and values has ethical implications.*

- Ethics of Science and Technology. Are science and Technology ethically neutral? Are Science and Technology Value Free?
- Ethics of scientific Research ,Innovation and Technology
- Ethics of Social Media, Modern Gadgets
- AI and Ethics

.Subject Teacher: Philosophy or Any Science Teacher

UNIT-VI- ETHICS AND VULNERABLE SECTIONS OF SOCIETY [10 hours]

Learning Outcome-

✓ *Understand how various vulnerable sections of our society are treated unequally and what needs to be done to address their inequality*

✓ *Understand dimensions of substance abuse*

1. Women and family-Gendered practices in the family, marriages (dowry, child marriage, women's consent).

Women and work- women's work at home and at work place, pay gap, gendered roles, harassment at work place and working women and role conflict.

Women and Society- Gender sensitive language, property right, marriage-divorce/Separation and women's right; violence against women

2. Issues Relating to Children: Nutrition and health , Child Exploitation: Child labour ,trafficking, sexual exploitation

3. Issues Relating to Elderly Persons : Abuse of Elders, Financial insecurity, Loneliness and Social insecurity, Health Care Issues, Needs for a happy and Dignified Ageing

4. Issues Relating to persons with disability: Rights of PWD, affirmative action, prevention of discrimination, providing equal opportunity, various scheme for empowering PWD and social justice for PWD.

5. Issues Relating to Third Gender: Understanding LGBTQ, Social justice for them, Removal of discrimination, Affirmative action and Acceptance of diversity of gender.

Subject Teacher: Sociology/political Science /Anthropology or Any Science Teacher

Sample Questions-

1. Birsa Munda belongs to which state of India?[1 mark]
2. Recall at least 4 constitutional values from the preamble to India constitution.[2 marks]
3. **Explain utility of being Punctual.[5 marks]**
4. Explain the ethical principles a scientist should follow.[8 marks]

Course material: To be developed by OSHEC and DDCE, Utkal University. Video Lectures will be also prepared by OSHEC and VTP, Utkal University. There shall be no internal examination for this course. The Term End Examination shall be conducted by the respective Universities. Student would engage in self-study and colleges shall conduct at least 4 doubt clearing session for each unit by engaging subject teachers as indicated above. The Principal may assign responsibility to any teacher.

VALUE ADDED COURSE-IV

Research Methodology
SEMESTER-VI

Credit point: 3 **Full mark 100** **Total Hours: 45**

COURSE OUTCOMES

After completion of this course, students will be able to

- Understand the need and importance of research
- Develop skills to identify samples for various types of research
- Differentiate between different types of research
- Explore relevant literature review using primary and secondary sources
- Acquire proficiency to develop research proposal

COURSE CONTENTS

UNIT-I Introduction To Research Methodology [12 Hours]

Learning Outcome-

✓ *The students will be able to gain insight about the meaning, purpose and types of research.*

- Meaning, Significance, Objectives of research, Research methods v/s research methodology, Ethics for research
- Types of research -Pure and applied research, Qualitative and Quantitative research Exploratory, Descriptive, Experimental, Analytical, Action research. Case Study.Field Studies,Surveys.
- Criteria of good research , Planning of research –Selection of a problem for research, Formulation of selected problem, Hypothesis, Research design

Unit II Research Methods [11 Hours]

Learning Outcome-

✓*The students will understand various methods of research and their applicability*

- **Review of Literature** – Need for reviewing literature, what to review and for what purpose, Literature search procedure, Sources of literature, Note taking, Identification of Research Gap.
- **Data Collection Method**- Choice of methods for data collection, Observation-Types of observation. Experimentation- Planning and conducting experiment, Types of experiment- Laboratory and field, Interview – Definition, Characteristics and Types of Interviews-Structured, Unstructured, Focused, Clinical, Depth , Interviewing Process-Preparation, Introduction, Developing rapport ,Carrying the interview forward, Recording interview and Closing interview. Content Analysis-Meaning, Procedure, Recording units and applications.

- **Tools for Data collection**-Tools-Observation schedule, Interview guide, Interview schedule, Questionnaire, Rating scale, Check List, Opinionnare, Data Sheet, Schedule for institutions, Inventories.

UNIT-III Sampling Techniques, Field Work and Report Writing [11 Hours]

Learning Outcome-

✓ *The students will be able to understand various sampling techniques in research*

✓ *The students will develop skills of preparing research proposal and writing research report scientifically.*

- **Sampling**- Concept of population and sample, Characteristics of a good sample design. Basis of sampling, Sampling Techniques and Methods- Probability sampling - Simple Random sampling, Stratified sampling ,Systematic random sampling, Cluster, Area sampling ,Multi-stage sampling. Non- Probability Sampling–Convenience sampling, Purposive sampling, Quota sampling and Snow-ball sampling.
- **Field Work**- Nature of field work, Selection and training of investigators, Sampling frame, Field operations and Field administration.
- **Report Writing** – Research report format- Report outline, Prefatory items. Body of the report-Introduction Design of the study, Result ,Findings and Discussion, Summary, Conclusions and Recommendations, Terminal items- Bibliography ,Appendix , Style sheet- APA .

UNIT-IV Activities to Be Conducted [11 Hours]

Learning Outcome-

✓ *Students will gain hands-on experience on application of research methodology*

- Identify the research gap through the review of literature.
- Collect data on a researchable topic through schedule questionnaire.
- Prepare a project report within one thousand words.
- Visit any organization and prepare a report by using case study method.
- Prepare a list of references on a topic by following APA style sheet.

Text books

1. C. R Kothari and Garg G, Research Methodology: Methods and Techniques , New Age International Publishers, Pvt ltd , New Delhi.

2. C. R Kothari and Garg G ,Research Methodology: Methods and Techniques , New Age International Publishers .,Pvt ltd , New Delhi

3. O. R Krishnaswami and M .Ranganatham, Methodology of research in Social Sciences. Himalaya Publishing House.

Reference Books:

1. Kumar R , Research Methodology,

2. Education and Communication for Development , O.P Dahama, O.P . Bhatnager.

E-resources:

1. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf

2. https://ebooks.inflibnet.ac.in/antp13/chapter/research-process-and-design/

Subject Teacher- Any Teacher with Ph.D.

Sample Question

1. What do you mean by research? [1 mark]
2. Differentiate between fundamental and applied research? [2 mark] [Within 50 words]
3. Explain various steps of research proposal. [5 mark] [within 300 word]
4. Discuss the characteristics of good sampling and briefly explain about various types of probability sampling. [8 mark] [within 500 to 800 words]