VIDYASAGAR UNIVERSITY

Curriculum for 3-Year BSc (HONOURS)
in
Statistics

Under Choice Based Credit System (CBCS)
w.e.f 2017-2018

VIDYASAGAR UNIVERSITY

B Sc (Honours) in Statistics

[Choice Based Credit System]

Year	Semester	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
	Semester-I								
1	I	Core-1		CT1: Descriptive Statistics	6	4-0-0	15	60	75
				CP1: Descriptive Statistics - Lab		0-0-4			
		Core-2		CT2: Probability and Probability Distributions-I	6	4-0-0	15	60	75
				CP2: Probability and Probability Distributions-I - Lab		0-0-4			
		GE-1		Mathematics	6	5-1-0	15	60	75
		AECC-1		English/MIL	2	1-1-0	10	40	50
	Semester –I: total				**20**				**275**
	Semester-II								
	II	Core-3		CT3: Mathematical Analysis	6	5-1-0	15	60	75
		Core-4		CT4: Probability and Probability Distributions-II	6	4-0-0	15	60	75
				CP4: Probability and Probability Distributions-II - Lab		0-0-4			
		GE-2		TBD	6	4/5	15	60	75
				TBD		2/1			
		AECC-2		ENVS	4		20	80	100
	Semester-II : total				**22**				**325**

Year	Semester	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
	Semester-III								
2	**III**	Core-5		CT5: Linear Algebra and Numerical Analysis	6	5-1-0	15	60	75
		Core-6		CT6: Demography and Vital Statistics	6	4-0-0	15	60	75
				CP6: Demography and Vital Statistics - Lab		0-0-4			
		Core-7		CT7: Statistical Computing Using C/C++ Programming	6	4-0-0	15	60	75
				CP7: Statistical Computing Using C/C++ Programming - Lab		0-0-4			
		GE-3		TBD	6	4/5	15	60	75
						2/1			
		SEC-1		TBD	2	1-1-0	10	40	50
		Semester – III : total			**26**				**350**
	Semester-IV								
	IV	Core-8		CT8: Survey Sampling & Indian Official Statistics	6	4-0-0	15	60	75
				CP8: Survey Sampling & Indian Official Statistics - Lab		0-0-4			
		Core-9		CT9: Statistical Inference-I and Sampling Distributions	6	4-0-0	15	60	75
				CP9: Statistical Inference-I and Sampling Distributions - Lab		0-0-4			
		Core-10		CT10: Time Series Analysis	6	4-0-0	15	60	75
				CP10: Time Series Analysis - Lab		0-0-4			
		GE-4		TBD	6	4/5	15	60	75
						2/1			
		SEC-2		TBD	2	1-1-0	10	40	50
		Semester – IV : total			**26**				**350**

Year	Semester	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
		Semester-V							
3	**V**	Core-11		CT11: Statistical Inference-II	6	4-0-0	15	60	75
				CP11: Statistical Inference-II - Lab		0-0-4			
		Core-12		CT12: Linear Models	6	4-0-0	15	60	75
				CP12 : Linear Models - Lab		0-0-4			
		DSE-1		TBD	6	4-0-4	15	60	75
		DSE-2		TBD	6	4-0-4	15	60	75
		Semester –V : total			**24**				**300**
		Semester-VI							
	VI	Core-13		CT13: Design of Experiments	6	4-0-0	15	60	75
				CP13: Design of Experiments - Lab		0-0-4			
		Core-14		CT14: Multivariate Analysis and Nonparametric Methods	6	4-0-0	15	60	75
				CP14: Multivariate Analysis and Nonparametric Methods - Lab		0-0-4			
		DSE-3		TBD	6	4-0-4	15	60	75
		DSE-4		TBD	6	4-0-4	15	60	75
		Semester – VI : total			**24**				**300**
Total in all semester:					**142**				**1900**

CC = Core Course , **AECC** = Ability Enhancement Compulsory Course , **GE** = Generic Elective , **SEC** = Skill Enhancement Course , **DSE** = Discipline Specific Elective , **CA**= Continuous Assessment , **ESE**= End Semester Examination , **TBD**=To be decided , **CT** = Core Theory, **CP**=Core Practical , **L** = Lecture, **T** = Tutorial ,**P** = Practical , **MI**L = Modern Indian Language , **ENV**S = Environmental Studies ,

List of Core Course (CC)

CC-1: Descriptive Statistics
CC-2: Probability and Probability Distributions-I
CC-3: Mathematical Analysis
CC-4: Probability and Probability Distributions-II
CC-5: Linear Algebra and Numerical Analysis
CC-6: Demography and Vital Statistics
CC-7: Statistical Computing Using C/C++ Programming
CC-8: Survey Sampling and Indian Official Statistics
CC-9: Statistical Inference-I and Sampling Distributions
CC-10: Time Series Analysis
CC-11: Statistical Inference-II
CC-12: Linear Models
CC-13: Design of Experiments
CC-14: Multivariate Analysis and Nonparametric Methods

Discipline Specific Electives (DSE)

DSE-1: Statistical Quality Control
OR
DSE-1 : Econometrics
DSE-2: Stochastic Processes and Queuing Theory
OR
DSE-2: Survival Analysis
DSE-3: Actuarial Statistics
OR
DSE-3: Financial Statistics
DSE-4: Operations Research
OR
DSE-4: Project Work

Skill Enhancement Course (SEC)

SEC-1: Statistical Data Analysis using R
OR
SEC-1: Monte Carlo Method
SEC-2: Research Methodology
OR
SEC-2: Data Base Management Systems

Generic Electives (GE)

GE-1: Statistical Methods
GE -2 : Introductory Probability
GE-3: Basics of Statistical Inference
OR
GE-3: Research Methodology
GE-4: Introduction to Operations Research
OR
GE-4: Applied Statistics

Core Courses

CC-1 : Descriptive Statistics **Credits 06**

C1T : Descriptive Statistics **Credits 04**

Descriptive Statistics

Unit 1

Statistics: Definition and scope, concepts of statistical population and sample. Data: quantitative and qualitative,scales of measurement: nominal, ordinal, interval and ratio. Frequency distribution. Presentation: tabular and graphical, including histogram and ogives.

Unit 2

Measures of Central Tendency: Mean, Median, Mode. Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation, Gini's Coefficient, Lorenz Curve. Moments, skewness and kurtosis, Quantiles and measures based on them. Box Plot. Outlier Detection. Quantile-Quantile Plot.

Unit 3

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares.

Analysis of Categorical Data:Contingency table, association of attributes, odds ratio, Pearson's measure, Goodman-Kruskal's γ. Binary response and logistic regression. Spearman'sRank correlation.

Unit 4

Index Numbers: Weighted means, price and quantity index numbers, choice of weights, Laspeyres' and Paasche's index numbers. Tests of index numbers and Fisher's ideal index number.

Reference Books

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- 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.
- Tukey, J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Publishing Co.
- Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
- Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company.

C1P: Descriptive Statistics Lab **Credits 02**

Descriptive Statistics

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of quadratic and exponential function.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman's rank correlation.
11. Box Plot and Q-Q Plot.
12. Calculation of price and quantity index numbers.

CC-2: Probability and Probability Distributions-I Credits 06

C2T: Probability and Probability Distributions-I **Credits 04**

Probability and Probability Distributions-I

Unit 1
Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic.

Unit 2
Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Unit 3
Random variables: discrete random variables, p.m.f. and c.d.f., statement of properties of c.d.f, illustrations and properties of random variables. Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform.

Unit 4
Twodimensional random variables: discrete type, joint, marginal and conditional p.m.f and c.d.f., statement of properties of c.d.f, independence of variables, trinomial distribution.

Reference Books

- Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.

- Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.
- Goon, A.M., Gupta, M.K. & Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press.
- Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley .
- Uspensky, J.V. (1937): Introduction to Mathematical Probability,McGraw Hill.
- Cacoullos, T. (1973): Exercises in Probability. Narosa.
- Rahman, N.A. (1983): Practical Exercises in Probability and Statistics, Griffen.
- Ross, S. (2002): A First Course in Probability, Prentice Hall.

C2P: Probability and Probability Distributions-I Lab **Credits 02**

Probability and Probability Distributions-I

List of Practical

1. Application problems based on Classical Definition of Probability.
2. Application problems based on Bayes Theorem.
3. Fitting of binomial distributions for n and p = q = ½.
4. Fitting of binomial distributions for given n and p.
5. Fitting of binomial distributions after computing mean and variance.
6. Fitting of Poisson distributions for given value of lambda.
7. Fitting of Poisson distributions after computing mean.
8. Fitting of negative binomial distribution.
9. Fitting of suitable distribution.
10. Application problems based on binomial distribution.
11. Application problems based on Poisson distribution.
12. Application problems based on negative binomial distribution.

CC-3: Mathematical Analysis Credits 06

C3 T – Mathematical Analysis

Unit 1

Representation of real numbers as points on a line. Algebraic, Order and Completeness properties of R (Concepts only). Bounded and unbounded sets, neighbourhood of a point, Supremum and infimum. Functions, Countable, Uncountable sets and Uncountability of R. Sequences and their convergence, monotonic sequences, bounded sequences, squeeze theorem Limits of some special sequences such as $\boldsymbol{r^n}$, $(\mathbf{1}+\frac{\mathbf{1}}{\boldsymbol{n}})^{\boldsymbol{n}}$, $\boldsymbol{n^{\frac{1}{n}}}$. Infinite series, positive termed series and their convergence, Comparison test, ratio test and root test. Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

Unit 2

Review of limit, continuity and differentiability. Indeterminate form, L' Hospital's rule. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's form of remainder(without proof). Taylor's series expansions of sinx, cosx, e^x , $(1+x)^n$, log (1+x).Maxima and Minima of Functions. Successive Differentiation.

Unit 3

Integral Calculus: definite integral (definition). Statements of properties, Fundamental Theorem of Integral Calculus.

Improper Integral, Beta and Gamma functions: properties and relationship between them.

Unit 4

Functions of two variables and Partial Derivatives. Maxima and Minima of such Functions. Constrained Maximization and minimization, use of Lagrange Multiplier. Double Integral (intuitive-graphical approach),change of order of integration, transformation of variables and Jacobians (statement of relevant theoremsand their uses).

Reference Books

- Malik S.C. and Savita Arora (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
- Somasundram, D. And Chaudhary, B(1987).: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.
- Gupta S.L. and Nisha Rani(1995): Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi.
- Apostol, T.M(1987).: Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.
- Shanti Narayan(1987): A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
- Singa,l M.K. and Singal A.R (2003): A First Course in Real Analysis, 24th Edition, R. Chand& Co., New Delhi.
- Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
- Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
- Chakraborty, Arnab (2014): Real Analysis, volumes 1,2,3, second edition. Sarat Book House.

CC-4: Probability and Probability Distributions-II Credits 06

C4T: Probability and Probability Distributions-II Credits 04

Unit 1

Continuous random variables, p.d.f. and c.d.f., illustrations and properties, univariate transformations with illustrations. Two dimensional random variables: continuous type, joint, marginal and conditional, p.d.f., and c.d.f..Independence of two variables.

Unit 2

Mathematical Expectation (discrete and continuous): Single & bivariate random variables and their properties.Probability generating function. Moments.Moment generating function. Correlation coefficient, Conditional expectation and variance. Probability Inequalities: Markov & Chebyshev.

Unit 3

Standard continuous probability distributions: uniform, normal, exponential, Cauchy, beta, gamma, lognormal, logistic, double exponentialand Pareto along with their properties and limiting/approximation cases.

Unit 4

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Reference Books

- Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
- Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
- Ross, S. (2002): A First Course in Probability, Prentice Hall.
- Feller, W. (1968): An Introduction to Probability Theory & its Applications, Vol-I, John Wiley.

C4 P: Probability and Probability Distributions-II Lab **Credits 02**

List of Practical

1. Problems based on area property of normal distribution.
2. To find the ordinate for a given area for normal distribution.
3. Application based problems using normal distribution.
4. Fitting of normal distribution when parameters are given.
5. Fitting of normal distribution when parameters are not given.
6. Problems similar to those in 1 to 5 in cases of other continuous distributions.

CC-5: Linear Algebra and Numerical Analysis Credits 06

C5T:Linear Algebra and Numerical Analysis

Unit 1

Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, Adjoint and inverse of a matrix and related properties.

Unit 2

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

Unit 3

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Quadratic forms: Classification & canonical reduction. Linear transformation. Applications of Linear Algebra in Statistics.

Unit 4

Numerical Analysis: Polynomials and Difference Tables. Approximation of functions and Weierstrass Theorem (statement).Lagrange and Newton formulae for Interpolation. Trapezoidal and Simpson's 1/3 Rulesfor approximations of definite integrals. Approximate solutions of Numerical Equations by Fixed-point Iteration and Newton-Raphson methods. Conditions of convergence.

Reference Books

- Lay David C (2000).: Linear Algebra and its Applications, Addison Wesley.
- Schaum's Outlines (2006): Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition.
- Krishnamurthy, V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
- Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International.
- Gupta, S.C(2008).: An Introduction to Matrices (Reprint). Sultan Chand & Sons.
- Artin, M (1994): Algebra. Prentice Hall of India.
- Datta, K.B (2002): Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
- Hadley, G (2002) : Linear Algebra. Narosa Publishing House (Reprint).
- Searle, S.R (1982).: Matrix Algebra Useful for Statistics. John Wiley &Sons.
- Chakraborty, Arnab (2014): Linear Algebra, first edition. Sarat Book House.
- Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.

- Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
- Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Del.
- Scarborough, J.B. (1966): Numerical Mathematical Analysis. Oxford and IBH Publishing.

CC-6: Demography and Vital Statistics — Credits 06

C6T: Demography and Vital Statistics — Credits 04

Unit 1

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekaran-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Unit 2

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

Unit 3

Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR).

Unit 4

Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net
Reproduction Rate (NRR). Population Estimation, Projection and Forecasting: Use of A.P. and G.P. methods for population estimates,
Fitting of Logistic curve for population forecasting using Rhode's method.

Reference Books

- Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
- Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
- Keyfitz, N and Caswell. H (2005): Applied Mathematical Demography (3rd edition), Springer.
- Chattopadhyay, A.K. and Saha, A.K. (2012): Demography: Techniques and Analysis, Viva Books.

➢ Ramakuar, R. and Gopal, Y.S. (1986):Technical Demography. Wiley Eastern Ltd.

C6P: Demography and Vital Statistics Lab **Credits 02**

List of Practical

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:-
    a. Direct method
    b. Indirect method
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. To calculate GRR and NRR for a given set of data and compare them.
8. Population Estimation.

CC-7: Statistical Computing Using C/C++ Programming Credits 06

C7T: Statistical Computing Using C/C++ Programming **Credits 04**

Unit 1

Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data

Unit 2

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional (?) operator. Looping in C/C++: for, nested for, while, do…while, and jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

Unit 3

User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values , arguments with return

values, no arguments but returns a value, functions that return multiple values. Recursion function. Passing arrays to functions, Storage class of Variables.

Unit 4

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers

Structure: Definition and declaring, initialization, accessing structure members, copying and comparison of structure variables, array of structures, structure pointers. Dynamic memory allocation functions: malloc, calloc and free.

Pre-processors: Macro substitution, macro with argument

File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

Reference Books

- Kernighan, B.W. and Ritchie, D.(1988): CProgramming Language,2nd Edition, Prentice Hall.
- Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition Tata McGraw Hill.
- Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, TataMcGraw Hill.

C7P: Statistical Computing Using C/C++ Programming Lab **Credits 02**

List of Practical

1. Plot of a graph y = f(x).
2. Roots of a quadratic equation (with imaginary roots also).
3. Sorting of an array and hence finding median.
4. Mean, Median and Mode of a Grouped Frequency Data.
5. Variance and coefficient of variation of a Grouped Frequency Data.
6. Preparing a frequency table.
7. Random number generation from uniform, exponential, calculate sample mean and variance and compare with population parameters.
8. Matrix addition, subtraction, multiplication, Transpose and Trace.
9. Fitting of Binomial, Poisson distribution.
10. Compute ranks and then calculate rank correlation (without tied ranks).
11. Fitting of lines of regression.
12. Numerical methods: Solving one-variable equations using Newton-Raphson method.
13. Trapezoidal rule for numerical integration.
14. Solving a linear system of equation.

CC-8: Survey Sampling and Indian Official Statistics Credits 06

C8T: Survey Sampling and Indian Official Statistics Credits 04

Survey Sampling and Indian Official Statistics

Unit 1

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, 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 their variances and sample size determination.

Unit 2

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, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nxk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Unit 3

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), MSE of these estimates and estimates of these variances, MSE in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Concept of sub sampling. Two-stage Sampling, Estimation of Population mean and variance of the estimate.

Unit 4

An outline of present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Registered General Office and National Statistical Commission. Government of India's Principal publications containing data on the topics such as Agriculture, price, population, industry, finance and employment.

Consumer price Index, Wholesale price index number and index of industrial production.

National Income: Basic idea and a brief description of income, expenditure and production approaches.

Reference Books

- Cochran, W.G. (1984): SamplingTechniques (3rd Ed.), Wiley Eastern.

- 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
- Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
- Goon A.M., Gupta M.K. and Dasgupta B. (2008): Fundamentals of Statistics, Vol-II, World Press.
- Guide to current Indian Official Statistics, Central Statistical Office, GOI, and New Delhi. http://mospi.nic.in/

C8P: Survey Sampling and Indian Official Statistics Lab **Credits 02**

Survey Sampling and Indian Official Statistics

List of Practical

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.
9. Two-stage Sampling.
10. Tabular and graphical exercises based on available official statistics.
11. Construction of Consumer and wholesale price index numbers.

CC-9: Statistical Inference-I and Sampling Distributions Credits 06

C9T: Statistical Inference-I and Sampling Distributions **Credits 04**

Statistical Inference-I and Sampling Distributions

Unit 1

Problems of Statistical Inference: Population & parameter, random sample & statistic, Point and Interval Estimation, Confidence level, Testing of Hypothesis, Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Sampling distribution of a statistic.

Unit 2

Derivation of the sampling distribution of sample mean and variance for a normal population, standard errors of sample mean, sample variance and sample proportion.

Exact sampling distribution: Definition and derivation of p.d.f. of χ^2 with n degrees of freedom (d.f.), nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., additive property of χ^2 distribution.

Exact sampling distributions: Student's and Fisher's t-distributions, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance and limiting form of t distribution.

Snedecor's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance. Distribution of 1/F (n1, n2). Relationship between t, F and $\chi 2$ distributions. Distribution of sample correlation coefficient in the null case.

Unit 3

Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

Unit 4

Exact tests and confidence intervals: classical and p-value approaches.Binomial proportion(s), Poisson mean(s),Univariate Normal mean (s), standard deviation(s), Standard tests related to Bivariate normal parameters.

Reference Books

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
- Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) 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 McGraw-Hill Pub. Co. Ltd.
- Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics, Prentice Hall.
- Casella , G. and Berger R.L (2002).: Statistical Inference, 2nd Edn.Thomson Learning.

C9P: Statistical Inference-I and Sampling Distributions Lab **Credits 02**

Statistical Inference-I and Sampling Distributions lab

List of Practical

1. Testing of significance for single proportion and difference of two proportions.
2. Testing of significance for single Poisson mean and difference of two Poisson means.
3. Testing of significance and confidence intervals for single mean and difference of two means.
4. Testing of significance and confidence intervals for single standard deviation and difference of two standard deviations.
5. Testing of parameters under bivariate normal distribution.

CC-10 : Time Series Analysis Credits 06

C10T: Time Series Analysis **Credits 04**

Time Series Analysis

Unit 1

Introduction to time series data, application of time series from various fields. Modelling time series as deterministic function plus IID errors: Components of a time series (trend, cyclical and seasonalpatterns, random error) Decomposition of time series. Estimation of trend: free hand curve method, method of moving averages, fitting various mathematical curves and growth curves.

Unit 2

Effect of elimination of trend on other components of the time series. Estimation of seasonal component by Method of simple averages, Notions of multiplicative models: ratio to Trend.

Unit 3

Introduction to stochastic modelling: Concept of stationarity. Illustration of how a stationary time series may show temporal patterns. Stationarity in mean.

Box-Jenkins modelling: Moving-average (MA) process and Autoregressive (AR) process of orders one and two.ACF, PACF and their graphical use in guessing the order of AR and MA processes. Estimation of the parameters of AR (1) and AR (2) using Yule-Walker equations.

Unit 4

Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression,

Reference Books

- Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
- Kendall M.G. (1976): Time Series, Charles Griffin.
- Brockwell and Davis (2010):Introduction to Time Series and Forecasting (Springer Texts in Statistics) ,2nd Edition.

C10P: Time Series Analysis Lab **Credits 02**
Time Series Analysis

List of Practical

1. Plotting a real life time series, and detecting various features (trend, periodic behaviours etc). Suggested data sets:
   a) Sun spot data
   b) Dollar-Rupee exchange rates
   c) Stock market data
2. Fitting and plotting of mathematical curves:
   a) modified exponential curve
   b) Gompertz curve
3. Fitting of trend by Moving Average Method.
4. Plotting detrended series.
5. Measurement of Seasonal indices Ratio-to-Moving Average method.
6. Plotting ACF and PACF of a given time series.
7. Using Yule-Walker equation to fit AR (1) and AR (2) models to real life data.
8. Forecasting by shortterm forecasting methods.
9. Forecasting by exponential smoothing.

CC-11: Statistical Inference-II Credits 06

C11T: Statistical Inference-II **Credits 04**

Statistical Inference-II

Unit 1
Limit laws: Sequence of random variables, convergence in probability, convergence in mean square and convergence in distribution and their interrelations, W.L.L.N. and their applications, De-Moivre Laplace Limit theorem, Statement of Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T.

Unit 2
Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality (statement and applications) and MVB estimators.
Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square and statements of their properties

Unit 3

Principlesof test of significance: Null and alternative hypotheses (simple and composite),Type-I and Type-II errors, critical region, levelof significance, size and power,Most powerful test, uniformly most powerful test, Neyman- Pearson Lemma (statement and proof of sufficiency part only) and its applications to construct uniformly most powerful test, unbiased test (definition only). Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit 4

Large Sample Theory:

Transformations of Statistics to stabilize variance: derivation and uses of Sin^{-1}, square root. Uses of logarithmic and z-transformations. Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients. Large Sample distribution of Pearsonian $\chi 2$ –statistic and its uses.

Reference Books

- Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Outline of Statistics, Vol. I & II, World Press, Calcutta.
- Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
- Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price 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 T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
- Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Lowa State University Press.
- Casella , G. and Berger R.L. (2002).: Statistical Inference, 2nd Edn. Thomson Learning.

C11P: Statistical Inference II Lab **Credits 02**

Statistical Inference II

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. Estimation by the method of moments, minimum Chi-square.
5. Type I and Type II errors.
6. Most powerful critical region.

7. Uniformly most powerful critical region.
8. Power curves.
9. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis.
10. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis.
11. Large sample tests.

CC-12: Linear Models — Credits 06

C12T: Linear Models — Credits 04

Linear Models

Unit 1
Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance. Fundamental Theorems on least squares (statements only).

Unit 2
Regression analysis: Multiple Regression. Estimation and hypothesis testing in case of simple and multiple regression models. Tests for parallelism and identity, linearity of simple regression.

Unit 3
Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance (with one concomitant variable) in two-way classified data with equal number of observations per cell, for fixed effect models. Analysis of variance one-way classified data for random effect models.

Unit 4
Regression Diagnostics: Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots.

Reference Books

- 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.
- Scheffe, H. (1959): The Analysis of Variance, John Wiley.
- Goon, A.M., Gupta, M.K.: Das Gupta, B. (2005), Outline of Statistics, Vol.II, World Press, Calcutta.

C12P: Linear Models Lab **Credits 02**

Linear Models

List of Practical

1. Simple Linear Regression.
2. Multiple Regression.
3. Tests for Linear Hypothesis.
4. Lack of fit.
5. Analysis of Variance of a one way classified data.
6. Analysis of Variance of a two way classified data with one observation per cell.
7. Analysis of Covariance of a one way classified data with one concomitant variable.
8. Analysis of Covariance of a two way classified data with one concomitant variable.
9. Analysis of Variance of a one way classified data for random effect model.

CC-13: Design of Experiments Credits 06

C13T: Design of Experiments **Credits 04**

Design of Experiments

Unit 1

Experimental designs: Role, historical perspective, terminology: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher). Uniformity trials, fertility contour maps, choice of size and shape of plots and blocks in Agricultural experiments. Uses in Industrial Experiments.

Unit 2

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

Unit 3

Factorial experiments: advantages, notations and concepts. 2^nexperiments: design and analysis. Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate.

Unit 4

Split Plot Design and Strip arrangements.

Reference Books

- 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.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
- Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
- Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
- Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
- Dean, A.M. and Voss, D. (1999):Design and Analysis of Experiments.Springer Texts in Statistics.

C13P: Design of Experiments Lab **Credits 02**

Design of Experiments

List of Practical

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 and2^3 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.
10. Analysis of a single replicate of a 2^n design.
11. Analysis of Split Plot and Strip Plot designs.

CC-14: Multivariate Analysis and Nonparametric Methods Credits 06

C14T: Multivariate Analysis and Nonparametric Methods **Credits 04**

Multivariate Analysis and Nonparametric Methods

Unit 1

Multivariate Data: multiple regression, multiple and partial correlation coefficients.
Random Vector: Probability mass/density functions, Distribution function, mean vector & Dispersion matrix, Marginal & Conditional distributions. Multiple and partial correlation coefficient.

Unit 2

Multivariate Normal distribution and its properties. Multinomial Disrtribution and its properties.Tests forMultiple and partial correlation coefficients.

Unit 3

Applications of Multivariate Analysis: Principal Components Analysis and Factor Analysis (Application Oriented discussion, derivations not required)

Unit 4

Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, One Sample Tests: Kolmogrov - Smirnov, Sign, Signed rank.Wilcoxon-Mann-Whitney test. Kruskal-Wallis test.

Reference Books

- Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
- Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
- Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
- Johnson, R.A. And Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
- Mukhopadhyay, P.: Mathematical Statistics.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
- Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
- Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

C14P: Multivariate Analysis & Nonparametric Methods Lab **Credits 02**

Multivariate Analysis and Nonparametric Methods

List of Practical

1. Test for Multiple Correlation.
2. Test for Partial Correlation.
3. Multivariate Normal Distribution.
4. Principal Components Analysis.
5. Factor Analysis.
6. Test for randomness based on total number of runs.
7. Kolmogorov -Smirnov test for one sample.
8. Sign test .
9. Signed rank test.
10. Wilcoxon-Mann-Whitney test.
11. Kruskal-Wallis test.

Discipline Specific Electives (DSE)

DSE-1: Statistical Quality Control — Credits 06

DSE1T: Statistical Quality Control — Credits 04

Statistical Quality Control

Unit 1

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.

Unit 2

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 3

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

Unit 4

Acceptance sampling plan: Principle of acceptance sampling plans. Single 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. Introduction to Six-Sigma: Overview of Six Sigma. Lean Manufacturing and Total Quality Management (TQM).

Reference Books

- Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. 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, Heinemann Publication. 2nd Edition, Butterworth .

DSE1P: Statistical Quality Control Lab **Credits 02**

Statistical Quality Control

List of Practical

1. Construction and interpretation of statistical control charts
    a. X-bar & R-chart
    b. X-bar & s-chart
    c. np-chart
    d. p-chart
    e. c-chart
    f. u-chart
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. Calculation of process capability

OR

DSE-1 : Econometrics Credits 06

DSE1T: Econometrics **Credits 04**

Econometrics

Unit 1

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. Estimation under linear restrictions. Dummy variables, Qualitative data.

Unit 2

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity,

Unit 3

Autocorrelation: Concept, consequences of auto correlated disturbances, detection and solution of autocorrelation. Generalized least squares estimation.

Unit 4

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Errors in variables: Correlation between error and regressors. Instrumental variable method (Single-equation model with one explanatory variable)

Reference Books

- Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition McGraw Hill Companies
- Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
- 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.

DSE1P: Econometrics Lab **Credits 02**

Econometrics Lab **Credits 02**

List of Practical

1. Problems related to consequences of Multicollinearity.
2. Diagnostics of Multicollinearity.
3. Problems related to consequences of Autocorrelation (AR(I)).
4. Diagnostics of Autocorrelation.
5. Problems related to consequences Heteroscedasticity.
6. Diagnostics of Heteroscedasticity.
7. Estimation of problems of General linear model under Heteroscedastic distance terms.
8. Problems on Autoregressive models.
9. Problems on Instrumental variable.

DSE-2: Stochastic Processes and Queuing Theory Credits 06

DSE2T: Stochastic Processes and Queuing Theory **Credits 04**

Stochastic Processes and Queuing Theory

Unit 1

Stochastic Process: Introduction, Stationary Process.

Unit 2

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Higher transition probabilities. Generalization of independentBernoulli trials, classification of states and chains, stability of Markov system

Unit 3

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

Unit 4

Queuing System: General concept, steady state distribution, queuing model, M/M/1 withfinite and infinite system capacity, waiting time distribution (without proof).

Reference Books

- Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
- Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
- Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New AgeInternational Publishers.
- Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
- Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I,3rd Edition, Wiley International.

DSE2P: Stochastic Processes and Queuing Theory Lab **Credits 02**

Stochastic Processes and Queuing Theory Lab

List of Practical

1. Calculation of transition probability matrix.
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes.
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain.
6. Computation of probabilities in case of generalizations of independent Bernoulli trials.
7. Calculation of probabilities for given birth and death rates and vice versa.
8. Calculation of probabilities for Birth and Death Process.
9. Calculation of probabilities for Yule Furry Process.
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behavior of queue as N tends to infinity.
12. Calculation of generating function and expected duration for different amounts of stake.

OR

DSE-2: Survival Analysis **Credits 06**

DSE2T: Survival Analysis **Credits 04**

Survival Analysis

Unit 1

Survival Analysis: Functions of survival times, survival distributions and their applications- exponential, gamma, Weibull, Rayleigh, lognormal distributions, and distribution having bath-tub shaped hazard function. Mean Residual Time.

Unit 2

Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples.

Unit 3

Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

Unit 4

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.

Reference Books

- Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.
- Kleinbaum, D.G. (1996): Survival Analysis, Springer.
- Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
- Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.

DSE2P: Survival Analysis Lab **Credits 02**

Survival Analysis Lab

ist of Practical

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.
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 Non-parametric methods with Actuarial methods.
10. To estimate the survival function and variance of the estimator using Non-parametric methods with Kaplan-Meier method.

DSE-3: Actuarial Statistics — Credits 06

DSE3T: Actuarial Statistics — Credits 04

Actuarial Statistics

Unit 1
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 2
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 3
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 4
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.

Reference Books

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

DSE3P: Actuarial Statistics Lab — Credits 02

Actuarial Statistics Lab

List of Practical

1. Risk computation for 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

OR

DSE-3: Financial Statistics — Credits 06

DSE3T: Financial Statistics — **Credits 04**

Financial Statistics

Unit 1

Probability review: Real valued random variables, expectation and variance, skewness and kurtosis, conditional probabilities and expectations. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models with state dependent increments.

Unit 2

Tools Needed For Option Pricing: Wiener process, stochastic integration, and stochastic differential equations. Introduction to derivatives: Forward contracts, spot price, forward price, future price. Call and put options, zero-coupon bonds and discount bonds

Unit 3

Pricing Derivatives: Arbitrage relations and perfect financial markets, pricing futures, put-call parity for European options, relationship between strike price and option price. Stochastic Models in Finance: Discrete time process- binomial model with period one.

Unit 4

Stochastic Models in Finance: Continuous time process- geometric Brownian motion. Ito's lemma, Black-Scholes differential equation, Black-Scholes formula for European options, Hedging portfolios: Delta, Gamma and Theta hedging. Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends.

Reference Books

- Franke, J., Hurdle, W.K. And Hafner, C.M. (2011): Statistics of Financial Markets: An Introduction, 3rd Edition, Springer Publications.

- Stanley L. S. (2012): A Course on Statistics for Finance, Chapman and Hall/CRC.

DSE3P: Financial Statistics Lab **Credits 02**

Financial Statistics

List of Practical

1. To verify "no arbitrage" principle
2. To verify relationship between spot price, forward price, future price
3. To price future contracts
4. To verify put-call parity for European options
5. To construct binomial trees and to evaluate options using these trees
6. To price options using black – Scholes formula
7. To hedge portfolios using delta and gamma hedging
8. To hedge portfolios theta hedging
9. Pricing of call options using binomial model
10. Computation of dividends on call options as a percentage of stock price.
11. Computation of dividends on call options as a fixed amount of money.
12. Pricing of put options using binomial model
13. Call-put parity for options following binomial models.
14. Effect of dividends on put options.

DSE-4: Operations Research Credits 06

DSE4T: Operations Research **Credits 04**

Operations Research

Unit 1

Introduction to Operations Research, 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 2

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, special cases of assignment problem.

Unit 3

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game

matrixand solution to rectangulargame with mixed strategy.

Unit 4

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

Reference Books

- Taha, H. A. (2007): Operations Research: An Introduction, 8 Hall of India.
- KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
- 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.

DSE4P: Operations Research Lab **Credits 02**

Operations Research Lab

List of Practical (Using TORA/WINQSB/LINGO)

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.
2. Identifying Special cases by Graphical and Simplex method and interpretation
    a. Degenerate solution
    b. Unbounded solution
    c. Alternate solution
    d. Infeasible solution
3. Allocation problem using Transportation model.
4. Allocation problem using Assignment model.
5. Problems based on game matrix.
6. Graphical solution to mx2 / 2xn rectangular game.
7. Mixed strategy.
8. To find optimal inventory policy for EOQ models and its variations.
9. To solve all-units quantity discounts model.

OR

DSE-4: Project Work **Credits 06**

Project Work

Analysing Social Change in Historical Perspective

Objective: The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

Skill Enhancement Course (SEC)

SEC-1: Statistical Data Analysis using R **Credits 02**

SEC1T: Statistical Data Analysis using R

Unit 1

Introduction to R: Installation, commandline environment, overview of capabilities, brief mention of open source philosophy.

R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers.Standard functions, e.g., sin, cos, exp, log.

Unit 2

The different types of numbers in R: Division by zero leading to Inf or -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c(), seq() and colon operator. How functions map overvectors. Functions to summarise a vector: sum, mean, sd, medianetc. Extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting. Plot(), lines(), abline(). No detailsabout the graphics parameters except colour and line width.Barplot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x).

Unit 3

Matrix operations in R: Creation. Basic operations. Extracting submatrices. Loading data from a file: read.table() and read.csv(). Mention of head=TRUE and head=FALSE. Dataframes. Mention that these are like matrices, except that different columns may be of different types.

Unit 4

Problems on discrete and continuous probability distributions.

Reference Books

- Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
- Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York
- A simple introduction to R by Arnab Chakraborty (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis (freely available at ftp://cran.r-project.org/pub/R/doc/contrib/Paradis-rdebuts_en.pdf)

OR

SEC-1: Monte Carlo Method — Credits 02

SEC1T: Monte Carlo Method

Monte Carlo Method

Unit 1

Using the computer for random number generation. (treated as a black box). A brief look at some popular approaches (nomathematical justification needed). Simulating a coin toss, a die roll and a card shuffle.

Unit 2

CDF inversion method. Simulation from standard distributions. Finding probabilities and moments using simulation.

Unit 3

Monte Carlo integration. Basic idea of importance sampling. MCMC not included.

Unit 4

Generating from Binomial and Poisson distributions, and comparing the histograms to the PMFs. Generating from Uniform(0,1) distribution, and applying inverse CDF transforms. Simulating Gaussian distribution using Box-Muller method. Approximating the expectation of a given function of a random variable using simulation. Graphical demonstration of the Law of Large Numbers. Approximating the value of pi by simulating dart throwing.

Reference Books

- Shonkwiler, Ronald W. and Mendivil, Franklin (2009):Explorations in Monte Carlo Methods (Undergraduate Texts in Mathematics)
- Carsey,Thomas M. and Harden, Jeffrey J. (2014):Monte Carlo Simulation and Resampling Methods for Social Science.

SEC-2: Research Methodology — Credits 02

SEC2T: Research Methodology

Research Methodology

Unit 1

What is Research? Role of Research in important areas. Characteristics of Scientific Method. Process of research: Stating Hypothesis or Research question, Concepts & Constructs, Units of analysis & characteristics of interest, Independent and Dependent variables, Extraneous or Confounding variables. Measurements and scales of Measurements. Types of research:

Qualitative & Quantitative Research, Longitudinal Research, Survey & Experimental Research.

Unit 2
Survey Methodology and Data Collection, sampling frames and coverage error, non-response.

Unit 3
Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

Unit 4
Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), questions and answers in surveys, Internal & External validity, , interpret the results and draw inferences. Formats and presentations of Reports – an overview.

Reference Books

- Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
- Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.

OR

SEC-2: Data Base Management Systems Credits 02

SEC2T : Data Base Management Systems

Data Base Management Systems

Unit 1
Introduction: Overview of Database Management System, Introduction to Database Languages, advantages of DBMS over file processing systems.

Unit 2
Relational Database Management System: The Relational Model, Introduction to SQL: Basic Data Types, Working with relations of RDBMS: Creating relations e.g. Bank, College Database (create table statement).

Unit 3
Modifying relations (alter table statement), Integrity constraints over the relation like Primary Key , Foreign key, NOT NULL to the tables, advantages and disadvantages of relational Database System.

Unit 4

Database Structure: Introduction, Levels of abstraction in DBMS, View of data, Role of Database users and administrators, Database Structure: DDL, DML, Data Manager (Database Control System).Types of Data Models Hierarchical databases, Network databases, Relational databases, Object oriented databases.

Reference Books

- Gruber, M(1990): Understanding SQL, BPB publication.
- Silberschatz, A, Korth, H and Sudarshan, S(2011) "Database System and Concepts", 6th Edition McGraw-Hill.
- Desai, B. (1991): Introduction to Database Management system, Galgotia Publications.

General Elective (GE)

[Interdisciplinary for other department]

GE-1: Statistical Methods — Credits 06

GE1T: Statistical Methods — Credits 04

Statistical Methods

Unit 1

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. Frequency distribution, Presentation: tabular and graphic, including histogram and ogives.

Unit 2

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 3

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation (Spearman). Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

Unit 4

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

Reference Books

- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- Mood, A.M. Graybill, F.A. AndBoes, D.C. (2007): Introduction to theTheory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
- Goon A.M., Gupta M.K. and Dasgupta B. : Basic Statistics. The World Press, Kolkata.
- Chakraborty, Arnab (2016) : Probability and Statistics. Sarat Book House.

GE1P: Statistical Methods **Credits 02**

Statistical Methods Lab

List of Practical

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Partial and multiple correlations
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

GE-2: Introductory Probability Credits 06

GE2T:Introductory Probability **Credits 04**

Unit 1

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 2

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f., c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

Unit 3

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T).

Unit 4

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

Reference Books

- Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi
- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
- Chakraborty, Arnab (2016) : Probability and Statistics. Sarat Book House.
- Ross, S. (2002): A First Course in Probability, Prentice Hall.

GE2P: Introductory Probability (Lab) **Credits 02**

List of Practical

1. Fitting of binomial distributions for n and p = q = ½ given
2. Fitting of binomial distributions for n and p given
3. Fitting of binomial distributions computing mean and variance
4. Fitting of Poisson distributions for given value of lambda
5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Problems based on area property of normal distribution
9. To find the ordinate for a given area for normal distribution
10. Application based problems using normal distribution
11. Fitting of normal distribution when parameters are given
12. Fitting of normal distribution when parameters are not given

GE-3: Basics of Statistical Inference Credits 06

GE3T: Basics of Statistical Inference **Credits 04**

Unit 1

Population and Sample, Parameter and Statistic, Population distribution and Sampling distribution.

Statistical Inference: Point Estimation, Interval Estimation and Testing of Statistical Hypothesis. Four useful distributions for statistical Inference; Normal, χ^2 , t and F (Statement of the pdf's & shape of the curves). Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I& Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

Unit 2

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test.

Unit 3

Tests for the significance of correlation coefficient. Sign test. Wilcoxon two-sample test.

Unit 4

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, Statistical concepts of "treatment", "plot" and "block". Analysis of completely randomized design, randomized complete block design.

Reference Books

- Daniel, Wayne W., Bio-statistics (2005): A Foundation for Analysis in the Health Sciences. John Wiley .
- Goon, A.M., Gupta M.K. & Das Gupta (2005):Fundamentals of statistics, Vol.-I & II.
- Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
- Dunn, O.J (1977): Basic Statistics: A primer for the Biomedical Sciences. John Wiley.
- Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.
- Goldstein, a Biostatistics-An introductory text (1971). The Macmillion New York.

GE3P: Basics of Statistical Inference Lab **Credits 02**

List of Practical

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

OR

GE-3: Research Methodology — Credits 06

GE3T: Research Methodology — Credits 04

Research Methodology

Unit 1

What is Research? Role of Research in important areas. Characteristics of Scientific Method. Process of research: Stating Hypothesis or Research question, Data Collection, Analysis and Interpretation, Internal & External validity, Presenting Results. Units of analysis & characteristics of interest. Concepts & Constructs, Independent and Dependent variables, Extraneous or Confounding variables. Measurements and scales of Measurements. Types of research: Qualitative & Quantitative Research, Longitudinal Research, Survey & Experimental Research.

Sampling Techniques: Introduction to sampling, advantage of sampling over census, simple random sampling, sampling frame, probabilistic aspects of sampling, stratified random sampling, other methods of sampling, sampling design, non-probability sampling methods.

Unit 2

Data: Introduction, primary and secondary data, methods of collecting primary data, merits and demerits of different methods of collecting primary data, designing a questionnaire, pretesting a questionnaire, editing of primary data, technique of interview, collection of secondary data, scrutiny of secondary data,

Data Processing: Introduction, editing of data, coding of data, classification of data, tables as data presentation devices, graphical presentation of data

Unit 3

Data Analysis: An overview on techniques in univariate, bivariate and multivariate data Models and Model Building: role of models, types of models, objectives of modelling, model building/ model development, model validation, simulation models

Unit 4

a. Formats of Reports: introduction, parts of a report, cover and title page, introductory pages, text, reference section, typing instructions, copy reading, proof reading.
b. Presentation of a report: introduction, communication dimensions, presentation package, audio-visual aids, presenter's poise.

Reference Books

- Kotahri, C.R (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed. Reprint, New Age International Publishers.
- Kumar, R (2011): Research Methodology: A step-by-step guide for beginners; SAGE publications.
- Lilien, Gary L. and Philip Kotler (1983): Marketing Decision Making; a Model Building Approach, Harper & Row, New York.
- Shenoy, GVS, et al., (1983). Quantitative Techniques for Managerial Decision Making, Wiley Eastern.
- Wimmer, R.D. and Dominick, J.R (2011). : Mass Media Research, Ninth Edition, CENGAGE Learning.

GE3P: Research Methodology Lab **Credits 02**

Research Methodology Lab

List of Practical

Submit a Research Report based on empirical study on some real life situation. The student will personally collect, analyse, interpret the data and prepare a report under the supervision of a faculty.

GE-4: Introduction to Operations Research Credits 06

GE4T: Introduction to Operations Research **Credits 04**

Introduction to Operations Research

Unit 1

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Unit 2

Optimum solution to a L.P.P: Simplex method, concept of artificial variables and Charne's big M-technique. Graphically identifying special cases of L.P.P. Concept of duality in L.P.P.

Unit 3

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. Assignment problem: Hungarian method to find optimal assignment.

Unit 4

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

Reference Books

- Taha, H. A. (2007): Operations Research: An Introduction 8th Edition, Prentice Hall of India.
- SwarupKanti, Gupta, P.K. and Manmohan (2007): Operations Research, 13 Edition Sultan Chand and Sons
- Ravindran, a, Phillips, D.T., Solberg, J.J. (2005): Operations Research- Principles and Practice, John Wiley & Sons.

GE4P: Introduction to Operations Research Lab **Credits 02**

Introduction to Operations Research Lab

List of Practical

1. Mathematical formulation of L.P.P and solving the problem using graphical method
2. Simplex technique to solve L.P.P and reading dual solution from the optimal table
3. Charne's Big M method involving artificial variables.
4. Identifying Special cases: Degenerate solution, Unbounded solution, Alternate solution and Infeasible solution by Graphical method and interpretation
5. Allocation problem using Transportation model
6. Allocation problem using Assignment model
7. Networking : Shortest route problem
8. Problems based on game matrix: mx2 / 2xn rectangular and Mixed strategy

OR

GE-4: Applied Statistics **Credits 06**

GE4T: Applied Statistics **Credits 04**

Applied Statistics

Unit 1

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).Measurement of seasonal

variations by method of ratio to trend.

Unit 2

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number & wholesale price index number. Index of Industrial Production and rate of inflation. Uses and limitations of index numbers.

Measures of Inequality and Development: Gini's coefficient and Lorenz curve, Human Development Index.

Unit 3

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts.

Unit 4

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates.

Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Reference Books

- Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9th Edition World Press, Kolkata.
- Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons
- Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition Wiley India Pvt. Ltd.

GE4P: Applied Statistics Lab **Credits 02**

Applied Statistics Lab

List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.

4. Construction of Consumer and wholesale price index numbers, fixed base index number and consumer price index number with interpretation.
5. Gini's coefficient, Lorenz curve, Human Development Index.
6. Construction and interpretation of X bar & R-chart.
7. Construction and interpretation p-chart (fixed sample size) and c-chart.
8. Computation of measures of mortality.
9. Completion of life table.
10. Computation of measures of fertility and population growth.

END