

M.Sc STATISTICS  
(with effect from 2010-11 batch)

I SEMESTER

PAPER 1.1 - PROBABILITY AND DISTRIBUTIONS

UNIT I

Classes of sets, field, sigma field, minimal sigma field, Borel field. Limit of a sequence of sets. Measure on field, extension of measure to sigma field, Lebesgue measure, Lebesgue-Stieltjes measures, Measurable functions, Borel function, induced sigma field.

UNIT II

Random variable, convergence of random variables- convergence in probability, almost surely, in the rth mean and in distribution their relationships. Characteristic function, properties, inversion theorem, continuity theorem, Central Limit Theorem, Lindberg-Levy, Liaunoff forms.

UNIT III

Mathematical expectation, Moments of random variable, conditional expectation, problem of moments. Basic Markov's, Chebycheff's, Holder's, Minkovski's and Jensen's inequalities. Law of large numbers. Chebycheff's and Kinchin's forms of WLLN, Kolmogrov's SLLN. Convergence theorems relating to  $X_n + Y_n$ ,  $X_n Y_n$  and

$X_n / Y_n$

Where  $X_n \rightarrow X$  and  $Y_n \rightarrow C$

UNIT IV

Weibull and Laplace distributions, their m.g.f., c.f. and other properties. Compound distributions – Poisson-Binomial. Sampling distributions . Non-central chi-square, Non-central t and Non-central F distributions and their properties. Distribution of quadratic forms under normality and related distributions.

UNIT V

Multivariate normal, bi-variate as a particular case, moments, c.f., conditional and marginal distributions. Distributions of order statistics from rectangular, exponential and normal distributions. Empirical distribution function, distribution

of correlation coefficient, partial and multiple correlations, derivation formulae and inter relationships.

Text Books.

Bhat.B.R. . Modern probability theory. Wiley Eastern Ltd.

Rohatgi, V.K.(1984) . An introduction to Probability and Mathematical Statistics . Wiley Eastern

Goon, A.M., Gupta, M.K., Das Gupta, B. . An outline of statistical theory, Vol. I. The World Press Pvt. Ltd., Kolkata.

References.

Billingsley, P.(1986) . Probability and Measure. Wiley

Kingman, J.F.C., and Taylor, S.J. (1966) . Introduction to Measure and Probability. Cambridge University Press.

David, H.A. . Order Statistics

Feller, W. . Introduction to Probability Theory And Its Applications, Vol. II

Cramer, H. (1946). Mathematical Methods of Statistics. Princeton

Morrison, D. F.(1976). Multivariate Statistical Methods. 2<sup>nd</sup> ed., McGraw Hill

Mardia

Anderson, T.W. (1983) . An Introduction to Multivariate Statistical Analysis. 2<sup>nd</sup> ed., Wiley.

Jhonson, R. and Wichern (1992). Applied Multivariate Statistical Analysis. 3<sup>rd</sup> ed., Prentice Hall.

## PAPER 1.2 - ESTIMATION THEORY

### UNIT I

Point estimation. Concepts of unbiasedness, consistency, minimum variance unbiased estimation. Information in a sample, Cramer-Rao inequality, efficiency of an estimator, Chapman-Robin's inequality and Bhattacharya bounds, definition of CAN estimator.

### UNIT II

Concept of sufficiency, single parameter and several parameter cases. Fisher-Neyman Factorization theorem, minimal-sufficient statistic, exponential families and Pitman families. Invariance property of sufficiency under 1-1 transformation of sample space and parameter space.

### UNIT III

Distributions admitting sufficient statistics, Rao-Blackwell theorem, completeness, Lehman-Scheffe theorem, joint sufficiency (regular case).

### UNIT IV

Method of maximum likelihood, CAN estimatos for one-parameter Cramer family. Cramer-Huzurbazar theorem, solution of likelihood equations, method of scoring. Connection between MLEs and efficient estimators, MLEs and sufficient estimators.

### UNIT V

Censored and truncated distributions. Type I and Type II censoring for normal and exponential distributions and their MLEs. Interval estimation. confidence intervals using pivots, shortest expected length confidence intervals.

Text Books .

Goon, A.M., Gupta, M.K., Das Gupta, B. An Outline of Statistical Theory. Vol. II, The World Press PVT. Ltd., Kolkata.

Rohatgi, V. (1998). An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd., New Delhi.

Kale, B.K. (1999). A First Course on Parametric Inference. Narosa Publishing House.

References.

Lehmann, E.L.(1986). Theory of Point Estimation.

Rao, C.R. (1973). Linear Statistical Inference.

Dudewicz, E.J. and Misra, S.N(1988) . Modern Mathematical Statistics. Student's Edition, Wiley.

Lawless, J.F., Statistical Models and Methods for Lifetime Data. John Wiley & Sons.

### PAPER 1.3 – SAMPLING

#### UNIT I

Selection with varying probabilities, PPS sampling, Horvitz and Thomson estimator, Yates' and Grundy's estimator, Midzuno-Sen sampling scheme.

## UNIT II

Systematic sampling. Estimation of population mean and its variance, methods for populations with linear trend. Yates correction, modified systematic sampling, balanced systematic sampling, centrally located sampling, circular systematic sampling.

## UNIT III

Cluster sampling. Estimation of population mean and its variance, efficiency of cluster sampling, determination of optimal cluster size, estimation of proportion, cluster sampling with varying sizes. Two-stage sampling . Two-stage sampling with equal first stage units. Estimation of mean and its variance. Optimum allocation. Three –stage sampling with equal probabilities. Two-stage pps sampling.

## UNIT IV

Ratio estimation: Introduction. Bias and mean square error, estimation of variance, confidence interval, comparisons with mean per unit estimator, ratio estimator in stratified random sampling. Difference estimator and regression estimator: Introduction. Difference estimator, difference estimator in stratified sampling. Regression estimator, comparison of regression estimator with mean per unit estimator and ratio estimator. Regression estimator in stratified sampling.

## UNIT V

Multi-phase sampling: Introduction. Double sampling for difference estimation, double sampling for ratio estimation, double sampling for regression estimator , optimum allocation varying probability sampling. Non-sampling errors. Sources and types of non-sampling errors, non-response errors, techniques for adjustment of non-response, Hansen and Harvitz technique, Deming's model.

Text Books .

F.S.Chaudhary . Theory and Analysis of Sample Survey Designs, New Age International Publishers, Delhi.

Des Raj . Sampling Theory.

Cochran, W.G. . Sampling Techniques.

Murthy, M.N. . Sampling Theory Techniques.

Parimal Mukhopadhyay. Theory and Methods of Survey Sampling. Prentice-Hall of India Pvt. Ltd., New Delhi.

Sukhatme, P.V. and Sukhatme, B.V. . Sampling Theory of Survey with Applications.

## PAPER 1.4 - C – PROGRAMMING

### UNIT I

Identifiers and key words, data types, constants, variables and arrays, declarations, expressions, statements, symbolic constants. Operators and expressions .  
Arithmetic, unary, relational and logical, assignment ,conditional operators.  
Library functions.

### UNIT II

Data input and output. getchar, putchar functions, scanf, printf, gets, puts functions. Control statements. while, do-while, for nested loops, if-else, switch, break, continue, exit operator, goto statement. Functions. Definitions, accessing a function, passing arguments to a function, specifying argument types, function prototypes and recursion.

### UNIT III

Program structure. Storage classes, automatic, external and static variables. Arrays. Definition, processing an array, passing arrays to a function, multi-dimensional arrays, arrays and strings.

### UNIT IV

Pointers. Fundamentals, pointer declarations, passing pointers to a function, pointers and multi-dimensional arrays, operations on pointers arrays of pointers, passing functions to other functions.

### UNIT V

Structures and Unions. Definitions, processing, typedef, structures and pointers, passing structures to a function, self-referential structures. Data Files. Opening and closing a data file, creating, processing a data file, unformatted data files.

Text Books.

Balaguruswamy, E. . Programming in C. Tata McGraw Hill.

Somasekharan, M.T. . Programming in C. Prentice Hall, India.

Brain, W., Karnighan and Dennis, M. Reitech. Prentice Hall India Ltd.

Byron, S.Gottfried. Programming with C. Tata McGraw Hill.

Kochan, S.G. . Programming in C.

## SEMESTER II

### PAPER 2.1 – MULTIVARIATE ANALYSIS

#### UNIT I

Definition of Wishart matrix and its properties, Mahalanobis distance, null distribution of Hotelling's  $T^2$  statistic. Its Application . tests on mean vector for one and more multivariate normal populations , equality of the components of a mean vector in a multivariate population.

#### UNIT II

Classification and discrimination procedures: Procedures for discriminating between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, probability of misclassification and their estimation. Classification into more than two multivariate populations. K-nearest neighbour classification.

#### UNIT III

Principle components, dimension reduction. Canonical variables and canonical correlation. Definition, use, estimation and computation.

#### UNIT IV

Factor analysis: Orthogonal factor model, methods of estimating factor loadings – principle component method, principle factor method, iterated principle factor method. Maximum likelihood estimation. Factor rotation, orthogonal factor rotation – varimax, quartimax rotations, oblique rotation criteria for determining number of common factors. Factor scores.

#### UNIT V

Cluster analysis : Hierarchical clustering - single, complete and average linkage methods, centroid and Ward's methods. Non-hierarchical methods – K-means algorithm. Multi-dimensional scaling.

Note . Practical exercises must be based on statistical packages only.

## Text Books .

- Anderson, T.W. (1983) . An Introduction to Multivariate Statistical Analysis. 2<sup>nd</sup> ed., Wiley.
- Seber, G.A.F. (1984). . Multivariate observations. Wiley.
- Johnson, R. and Wichern (1992) . Applied Multivariate Statistical Analysis. Prentice-Hall, 3<sup>rd</sup> ed.

## References.

- Gin, N.C. (1977). Multivariate Statistical Inference. Academic Press.
- Kshirasagar, A.M. (1972). Multivariate Analysis. Marcel Dekker.
- Morrison, D.F. (1976). Multivariate Statistical Methods. 2<sup>nd</sup> ed. McGraw Hill.
- Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory. John Wiley.
- Rao, C.R. (1973). Linear Statistical Inference and its Applications. 2<sup>nd</sup> ed., Wiley.
- Sharma, S. (1996). Applied Multivariate Techniques. Wiley.
- Srivastava, M.S. and Khatri, C.G. (1979). An Introduction to Multivariate Statistics. North Holland.

## PAPER 2.2 – TESTING OF HYPOTHESIS

### Unit I

Neyman-Pearson theory. Lemma using critical functions. Uniformly most powerful tests, their relation with sufficient statistics,

### UNIT II

Monotone likelihood ratio and UMP tests for one-sided hypothesis, composite hypothesis. Unbiased tests, uniformly most powerful unbiased tests. Type-A and Type-A regions.

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### UNIT III

Likelihood ratio criterion, its asymptotic distribution, one sample, two sample and k-sample problems. Linear hypothesis. Wald's SPRT. Proof that it terminates in a finite number of steps with probability 1. O.C and A.S.N. functions. Examples of binomial and normal cases for testing hypothesis on  $\mu$  and  $\sigma^2$

### UNIT IV

Notion of non-parametric test, different NP tests. Run test, sign test, Wilcoxon and Mann-Whitney test, Median test, derivations of the mean and variance of the above test statistics when null hypothesis is true.

## UNIT V

Chi-square test for goodness of fit, its asymptotic distribution, description of Kolmogorov-Smirnov test, tests involving rank correlation (Kendall's and Spearman's).

Text Books .

Rohatgi, V.K. . Statistical Inference, John Wiley and Sons.

Gibbons, J.D. . Non-parametric Inference, McGraw Hill

Wald. Sequential Analysis, John Wiley and Sons.

Goon, Gupta and Das Gupta . An Outline of Statistical Theory. Vol. 2, The World Press Pvt. Ltd., Kolkata.

References.

Lehmann, E.L. . Testing of Statistical Hypothesis. John Wiley and Sons.

Rao, C.R.. Linear Statistical Inference and its Applications. John Wiley and Sons.

Sidney Siegel . Non-parametric Statistics for the Behavioural Sciences.

## PAPER 2.3 – STOCHASTIC PROCESSES

### Unit I

Introduction to stochastic processes(sps), classification of sps' according to state space and time domain. Countable state Markov Chains(MCs), Chapman-Kolmogorov equations, calculation of n-step transition probability and its limit. Classification of states, period of state, stationary distribution of MC.

### UNIT II

Random walk and gambler's ruin problem. Random walk in one and two dimensions. Gambler's ruin problem, probability of ultimate ruin, expected duration of the game.

### UNIT III

Discrete state space continuous time MC. Poisson process and its properties, birth process, death process, birth and death process.

### UNIT IV

Weiner process as a limit of random walk, elementary properties of Wiener process. Branching process. G-W branching process, probability of ultimate extinction, distribution of population size.



## UNIT V

Renewal Theory. Elementary renewal theorem and applications. Study of residual and excess life times and their distributions. Stationary process. Weakly stationary process and strongly stationary process.

Text Books.

Medhi, J. (1982). Stochastic Processes. Wiley Eastern.

Bhat, B.R.(2002). Stochastic Models- Analysis and Applications. New Age International, India.

Basu, A.K. . Introduction to Stochastic Process.

Srinivasan and Mehta. Stochastic Processes.

References.

Adke, S.R. and Manjunath, S.M. (1984). An introduction to Finite Markov Processes, Wiley Eastern.

Cinlar, E. (1975) . Introduction to Stochastic Processes. Prentice-Hall.

Feller, W. (1968). Introduction to Probability and Applications. Vol. I, Wiley Eastern.

Hoel, P.G., Port, S.G. and Stone, C.J. (1972). Introduction to Stochastic Processes. Houghton Mifflin and Co.

Karlin, S. and Taylor, H.M. (1975) . A First Course in Stochastic Processes. Vol. I

Parzen, E. (1962). Stochastic Processes. Holden-Day.

## PAPER 2.4 – DESIGN OF EXPERIMENTS

### UNIT I

Principles of designs, analysis of variance and analysis of co-variance, fixed and random effect models. Contrasts. Model adequacy checking. Test for normality, test for equality of variances (Bartlett test, Modified Levene method)

### UNIT II

C.R.D., R.B.D., estimation of parametric functions and tests of hypothesis, comparison of their efficiencies. Missing plot techniques, testing the equality of subsets of block effects or treatment effects. Multiple comparisons tests . Tukey's , Fisher's Least Significant Difference (LSD) method, Duncan's multiple range test.

### UNIT III

L.S.D., orthogonality in L.S.D. Missing plot technique, Analysis of split plot design.

## UNIT IV

Factorial designs. Analysis of  $2^n$  and  $3^2$  designs. Estimation of factorial effects, testing their significance. Total and partial confounding.

## UNIT V

Youdin design, intra block analysis . B.I.B.D., P.B.I.B.D., their analysis, estimation of parameters, testing of hypothesis.

### Text Books.

Das, M.N. and Giri, N.C.. Design and Analysis of Experiments. New Age International Pvt. Ltd.

Montgomery, D.C. . Design and Analysis of Experiments. John Wiley and Sons, New York.

### References.

Cochran and Cox . Experimental Designs. Asia Publishing House, Bombay.

Kemp Thorne. Design and Analysis of Experiments, Wiley Eastern Pvt. Ltd., New Delhi.

## SEMESTER III

### PAPER 3.1 – OPERATIONS RESEARCH I

#### UNIT I

Definition and scope of Operations Research (O.R). Phases in OR. Models and their solutions. Linear Programming (LP). Graphical, simplex, revised simplex methods. Duality and sensitivity analysis.

#### UNIT II

Transportation and assignment problems. Sequencing and scheduling problems. 2-machine n-job and 3-machine n-job problems with identical machine sequence for all jobs, 2-job n-machine problem with different routings.

#### UNIT III

Analytical structure of inventory problems, EOQ formula of Harris, its sensitivity analysis and extensions allowing quantity discounts and shortages. Multi- item inventory subject to constraints. Models with random demand, static risk model, P and Q systems with constant and random lead times.

## UNIT IV

S-s policy for inventory and its derivation in the case of exponential demand, multi-echelon inventory models. Queuing models : specifications and effectiveness measures. Steady state solutions of M/M/1 and M/M/C with associated distributions of queue length and waiting time.

## UNIT V

M/G/1 queue and Pollaczek –Kinchine result. Steady state solutions of  $M/E_k/1$  and  $E_k/M/1$  queues. Machine interference problem. Bulk queues (bulk arrival and bulk service), finite queues, queues in tandem, GI/G/1 queue and its solution, simulation of queues.

### Text Books.

Kanti Swarup, Gupta, P.K. and Man Mohan (1985) . Operations Research, Sultan Chand and Sons.

Sharma, J.K. (2003). Operations Research Theory and Applications. Macmillan, India.

Sharma, S.D. . Operations Research. Kedarnath Ramnath Publishers, Meerut.

### References.

Taha, H.A.(1982) .Operations Research: An Introduction. Macmillan.

Hillier, F.S. and Lieberman, G.J. . Introduction to Operations Research. Holden Dev.

Churchman, C.W., Ackoff, R.L., and Arnoff, E.L. (1957) . Introduction to Operations Research. John Wiley.

Gross, D. and Harris, C.M. (1974) . Fundamentals of Queuing Theory. John Wiley.

## PAPER 3.2 – COMPUTER-INTENSIVE STATITICAL METHODS

### UNIT I

Stochastic simulation. generating random variables, simulating multivariate distributions, simulating stochastic processes such as simple queues.

### UNIT II

Variance reduction: importance sampling for integration, control variates and antithetic variables.

### UNIT III

Markov Chain Monte Carlo methods. Gibbs sampling for multivariate simulation, simulated annealing for optimization.

### UNIT IV

Bootstrap methods: re-sampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression.

### UNIT V

Jackknife and cross-validation: jackknife in sample surveys, cross validation for tuning parameters.

#### Text Books.

Rubinstein (1981). Simulation and the Monte Carlo Method. Wiley.

Tanner, M.A. (1996). Tools for Statistical Inference. 3<sup>rd</sup> ed., Springer.

Efron, B. and Tibshirani, R.J. (1993). An introduction to Bootstrap. Chapman & Hall.

Shao, J. and Tu, D. (1995). The Jackknife and the Bootstrap. Springer Verlag.

Gnanadesikan, R. (1997). Methods for Statistical data Analysis of Multivariate Observations. 2<sup>nd</sup> ed., Wiley.

#### References.

Fishman, G.S. (1996). Monte Carlo . Concepts, Algorithms and Applications. Springer.

Belsley, D.A., Kuh, E., and Welsch, R.E.(1980). Regression Diagnostics. Wiley

McCullagh, P. and Nelder, J.A. (1999) . Generalized Linear Models. 3<sup>rd</sup> ed., Chapman and Hall.

Seber, G.A.F., and Wild, C.J.(1989).Non-linear Regression. Wiley.

McLachlan, G.J. and Krishnan, T.(1997). The EM algorithms and extensions. Wiley.

Simon off, J.S. (1996). Smoothing Methods.

### PAPER 3.3 – DEMOGRAPHY

#### UNIT I

Scope and content of population census of India. Population composition, dependency ratio. Brief coverage and content errors in demographic data.

Adjustment of age data-use of Whipple, Myer and UN indices. Chandrasekhar-Deming formula to check completeness of registration data.

#### UNIT II

Measures of fertility. Stochastic models for reproduction (Dandekar's modified binomial and Poisson distributions, William Brass model), distributions of time to first birth, inter-live birth intervals and number of births.

### UNIT III

Measures of mortality. Construction of abridged life tables( $l_x$  – linear, exponential, Reed and Merrell's, Greville's). Relation between functions of life tables. Distributions of life table functions.

### UNIT IV

Stable and quasi-stable populations, intrinsic growth rate. Methods for population projection. Use of Leslie matrix.

### UNIT V

Models for population growth and their fitting to population data. Linear, exponential, logarithmic, modified logarithmic, Gompertz and logistic curves. Stochastic models for population growth.(Pure birth model, simple birth and death model, birth, death and migration model).

Text Books.

Sudhendra Biswas (1995). Applied Stochastic Processes. New Age International Publishers Ltd.

Pathak, K.B. and Ram, F.(1998). Techniques of Demographic Analysis. Himalaya Publishers.

Srinivasan, K.(1998).Basic Demographic Techniques and Applications. Sage Publications.

Asha Abhande, Tara Kanitkar(2004).Principles of Population Studies. Himalaya Publishing House.

References.

Saxena, H.C and Surendran, P.U.. Statistical Inference

Bartholomew, D.J.(1982). Stochastic Models for Social Processes. John Wiley.

Benjamin, B. (1969). Demographic Analysis. George Allen and Unwin.

Chain, C.L. (1968). Introduction to Stochastic Processes in Biostatistics. John Wiley.

Cox, P.R.(1970). Demography. Cambridge Press.

Key Fitz, N.(1977). Applied Mathematical Demography. Springer Verlag.

Spiegel man, M.(1969). Introduction to Demographic Analysis. Harvard University Press.

## PAPER 3.4 – TIME SERIES ANALYSIS

### UNIT I

Time series as discrete parameter stochastic process. Auto covariance and auto-correlation function, their properties. Exploratory time series analysis. Tests for trend and seasonality.

## UNIT II

Exponential and moving average smoothing. Holt and Winters smoothing. Forecasting based on smoothing, adaptive smoothing.

## UNIT III

Detailed study of the stationary processes: Moving Average (MA), Auto Regressive (AR), ARMA and AR Integrated MA (ARIMA) models.

## UNIT IV

Box-Jenkins models: Discussion (without proof) of estimation of mean, auto covariance and auto-correlation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Forecasting, residual analysis and diagnostic checking.

## UNIT V

Spectral analysis of weakly stationary process. Periodogram and correlogram analyses. Computations based on Fourier transform.

Text Books.

Box, G.E.P. and Jenkins, G.M. (1976). Time Series Analysis – Forecasting and Control. Holden Day, San Francisco.

Anderson, T.W. (1971). The Statistical Analysis of Time Series. Wiley, N.Y.

Makridakis, Wheelwright and McGee. Forecasting. Methods and Applications. John Wiley & Sons.

Montgomery, D.C. and Johnson, L.A. (1977). Forecasting an Time Series Analysis. McGraw Hill.

References.

Fuller, W.A. (1976). Introduction to Statistical Time Series. John Wiley, N.Y.

Granger, C.W.J. and Newbold (1984). Forecasting Econometric Time Series. 3<sup>rd</sup> ed., Academic Press.

Priestley, M.B. (1981). Spectral Analysis and Time Series. Griffin, London.

Kendall, S.M. and Ord, J.K. (1990). Time Series Analysis. 3<sup>rd</sup> ed., Edward.

Kendall, M.G. and Stuart, A. (1966). The Advanced Theory of Statistics. Vol.3, Charles Griffin, London

Bloomfield, P.(1976). Fourier Analysis of Time Series-An Introduction, Wiley.  
Granger, C.W.J. and Hatanka, M.(1964). Spectral Analysis of Economic Time Series. Princeton Univ. Press, N.Y.

Koopmans, L.H.(1974). The Spectral Analysis of Time Series. Academic Press.

#### SEMESTER IV

#### PAPER 4.1- OPERATIONS RESEARCH II

##### UNIT I

Decision Theory: Decision theory approach, decision theory under uncertainty, under risk, posterior probabilities and Bayesian analysis, decision tree analysis, decision making with utilities.

##### UNIT II

Game theory: two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in  $2 \times 2$ ,  $2 \times m$  and  $m \times n$  games. Dynamic programming.

##### UNIT III

Integer programming: Branch and Bound algorithm and cutting plane algorithm. Multi-criterion and goal programming. Replacement problems: block and age replacement policies, replacement of items with long life.

##### UNIT IV

Project management: CPM, PERT, probability of project completion, crashing.

##### UNIT V

Information theory: Communication process, entropy, channel capacity, efficiency, redundancy. Shannon-Fano encoding procedures. Non-linear programming: Kuhn-Tucker conditions, Wolfe and Beale's algorithms for solving quadratic programming problems.

Text Books.

Kanti Swarup, Gupta, P.K. and Man Mohan (1985) . Operations Research, Sultan Chand and Sons.

Sharma, J.K. (2003). Operations Research Theory and Applications. Macmillan, India.

Sharma, S.D. . Operations Research. Kedarnath Ramnath Publishers, Meerut

## References.

- Taha, H.A.(1982) .Operations Research-An Introduction. Macmillan.  
Hillier, F.S. and Lieberman, G.J. . Introduction to Operations Research. Holden Dev.  
Churchman, C.W., Ackoff, R.L., and Arnoff, E.L. (1957) . Introduction to Operations Research. John Wiley.  
Gross, D. and Harris, C.M. (1974) . Fundamentals of Queuing Theory. John Wiley.

## PAPER 4.2 – ECONOMETRICS

### UNIT I

Nature and scope of econometrics. General Linear Model. assumptions, OLS method of estimation, tests of hypothesis, confidence intervals, prediction, estimation subject to linear restrictions, maximum likelihood estimation.

### UNIT II

Tests of structural change: dummy variables and seasonal adjustments, equality of two regression equations, specification errors. Estimation methods.

### UNIT III

Generalized least squares: Aitken estimators. Heteroscedasticity. Goldfeld-Quandt test, Park test, weighted least square method of estimation. Auto-correlation. detection by Durbin-Watson statistic, estimation methods. Cochran, Orcutt and Durbin's. SUR system of equations.

### UNIT IV

Lagged variables: distributed lag models- Koyck approach, adaptive expectations model, stock adjustments models, Almon's approach. Errors in variables.

### UNIT V

Simultaneous equation models: structural form, reduced form and recursive form. Identification problem, order and rank conditions. Methods of estimation. 1LS, 2SLS, IV, LIML and 3SLS.

## Text Books.

- Gujarathi, D.(1979). Basic Econometrics, McGraw Hill.  
Johnston, J.(1984). Econometric Methods. 3<sup>rd</sup> ed., McGraw Hill.



Koutsoyiannis, A.(1979). Theory of Econometrics. Macmillan Press.  
Theil, H.(1982). Introduction to the Theory and Practice of Econometrics. John Wiley.

References.

Apte, P.G. (1990). Text Book of Econometrics. Tata McGraw Hill.

Cramer, J.S. (1971). Empirical Econometrics. North Holland.

Intrilligator, M.D.(1980). Econometric Models-Techniques and Applications. Prentice Hall of India.

Klien, L.R. (1962). An Introduction to Econometrics. Prentice Hall of India.

Mallnvand, E (1966). Statistical Methods of Econometrics. North Holland.

Srivastava, V.K. and Gile, D.A.E. (1987). Seemingly Unrelated Regression Equation Models. Marcel and Dekker.

Walters, A. (1970). An Introduction to Econometrics. McMillan & co.

### PAPER-4.3 - COMPUTER PROGRAMMING - C++

#### UNIT I

Object oriented programming principles, declaration of classes, array of classes, pointer to classes, constructors and destructors.

#### UNIT II

Friend functions, inline function, static class members, this pointer. Single, multiple inheritance. Types of derivation such as public, private, protected inheritance and member access controls, ambiguity in inheritance.

#### UNIT III

Virtual base class, container classes. Function overloading. Operator Overloading. overloading of assignment, binary and unary operators.

#### UNIT IV

Polymorphism, early binding, virtual functions, late binding, pure virtual functions, abstract base classes, constructor under inheritance, destructor under inheritance, virtual destructors.

#### UNIT V

Templates and exception handling. Data file operations, structures and file operations, classes and file operations.

## Text Books.

Deital & Deital . C++. Prentice-Hall Inc.

Sinan Si Alhir . UML. Orielly.

Sarang . Object Oriented Programming with C++. Prentice-Hall.

Balaguruswamy, E. . Programming in C++. Tata McGraw Hill.

## References.

Decker, R. and Hirshfield, S. (1998). The Object Concept. An Introduction to Computer Programming using C++. PWS Publishing.

Lippmann, S.B. and Lajoie, J. (1998). C++ Primer. 3<sup>rd</sup> ed. Addison-Wesley.

Nauhaton, P.(1996). The Java Handbook. Tata McGraw Hill.

Sawitch, W.J. (2001). Problem Solving with C++ . The Object of Programming. 3<sup>rd</sup> ed. Addison-Wesley, Longman.

## PAPER-4.4 – ACTUARIAL STATISTICS

### UNIT I

Theory of interest rates: ate of interest, nominal rate of interest. Accumulation factors. Force of interest, present values, Stoodley formula for the force of interest, present value of cash flows, valuing cash flows. Basic compound interest function, equations of values and yield on transaction-annuities certain, present values and accumulation, concepts of different annuities, continuously payable annuities, varying annuities.

### UNIT II

Utility theory, insurance and utility theory, models for individual claims an their sums, approximations for the distribution of the sum. Application to insurance. Survival function, time until death for a person age  $x$ , curate future life time , force of mortality.

### UNIT III

Life table and its relation with survival function, examples, the deterministic survivorship group, recursion formulas, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

### UNIT IV

Life insurance: insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance an varying benefit insurance. Life annuities. single payment, continuous life annuities,

discrete life annuities, life annuities with monthly payments, recursions, complete annuities-immediate and apportionable annuities-due.

## UNIT V

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrements, central force assumptions for multiple decrements. Uniform distribution assumption for multiple decrements.

### Text Books.

Bowers, N.L., Gerber, H.U., Hickman, J.C, Jones, D.A., and Nesbitt, C.J. (1986) . Actuarial Mathematics. Society of Actuaries, Ithaca, Illinois, U.S.A. 2<sup>nd</sup> ed. (1997) CH. 1,2,3,4,5,9 & 10.

McCutcheon, J.J. and Scott, W.F. . An Introduction to Mathematics of Finance. Butter Worth & Heinemann.

### References.

Spurgeon, E.T. (1972). Life Contingencies. Cambridge University press.

Nall, A. (1977). Life Contingencies. Heinemann.

