Syllabus of M.A./M.Sc. Programme in statistics under Choice Based Credit System (CBCS) (Semester wise) from the academic year 2018-2019 Course structure and Scheme of Examination for Semester I, II, III and IV

SEMESTER – I

Theory							
Sl. No.	Paper Code No. and Title	Credits	No. of hrs / Week Theory / Practical	Duration of Exam hrs Theory / Practical	Internal Assessment Marks Theory / Practical	Exams Marks	Total Marks
1.	HCT: 1.1: Linear Algebra	4	4	3	30	70	100
2.	HCT: 1.2: Real Analysis	4	4	3	30	70	100
3.	HCT: 1.3: Probability Theory & Distributions - I	4	4	3	30	70	100
4.	SCT: 1.1: Sample Surveys & Statistics for National Development, women's statistics	4	4	3	30	70	100
Practical's							
1.	HCP: 1.1: Statistical Computing	4	8	3	30	70	100
2.	HCP: 1.2: (Based on HCT 1.1 and SCT1.1)	4	8	3	30	70	100

SEMESTER – II

Theory							
Sl. No.	Paper Code No. and Title	Credits	No. of Hrs / Week Theory / Practical	Duration of Exam Hrs Theory / Practical	Internal Assessment Marks Theory / Practical	Exams Marks	Total Marks
1.	HCT: 2.1: Probability Theory & Distributions – II	4	4	3	30	70	100
2.	HCT: 2.2: Theory of Point Estimation	4	4	3	30	70	100
3.	HCT: 2.3: Linear Models & Regression Analysis	4	4	3	30	70	100
4.	SCT: 2.1: Operations Research	4	4	3	30	70	100
Practical's							
1.	HCP: 2.1: (Based on HCT 2.2 and SCT 2.1)	4	8	3	30	70	100
2.	HCP: 2.2: (Based on HCT 2.3)	4	8	3	30	70	100

SEMESTER – III

Sl. No.	Paper Code No. and Title	Credits	No. of Hrs / Week Theory / Practical	Duration of Exam Hrs Theory / Practical	Internal Assessment Marks Theory / Practical	Exams Marks	Total Marks
Theory							
1.	HCT: 3.1: Multivariate Analysis	4	4	3	30	70	100
2.	HCT: 3.2: Testing of Hypotheses	4	4	3	30	70	100
3.	HCT: 3.3: Design and Analysis of experiments	4	4	3	30	70	100
4.	SCT: 3.1: Bio- Statistics	4	4	3	30	70	100
5.	OEP 3.1: Quantitative techniques for research	4	4	3	30	70	100
Practical's							
1.	HCP: 3.1: (Based on HCT 3.1 and HCT 3.2)	4	8	3	30	70	100
2.	HCP: 3.2: (Based on HCT 3.3 And SCT 3.1)	4	8	3	30	70	100

SEMESTER – IV

Sl. No.	Paper Code No. and Title	Credits	No. of Hrs / Week Theory / Practical	Duration of Exam Hrs Theory / Practical	Internal Assessment Marks Theory / Practical	Exams Marks	Total Marks
Theory							
1.	HCT: 4.1: SQC & Reliability Theory	4	4	3	30	70	100
2.	HCT: 4.2: Elementary Stochastic Process	4	4	3	30	70	100
Optionals (Any two)							
3.	SCT: 4.1(a): Demography	4	4	3	30	70	100
4.	SCT: 4.1(b): Time series analysis	4	4	3	30	70	100
5.	SCT: 4.1(c): Actuarial Statistics	4	4	3	30	70	100
6.	SCT: 4.1(d):Statistical genetics	4	4	3	30	70	100
7.	OEP 4.1: Demography	4	4	3	30	70	100
Practical							
1.	Project (Primary and secondary)	8	Dissertation 100	Presentation 50	Viva 50	--	200

M.A / M.SC PROGRAMME IN STATISTICS UNDER CBCS SYSTEM
FROM THE ACADEMIC YEAR 2018 – 2019

SYLLABUS

SEMESTER I

HCT1.1: LINEAR ALGEBRA (4 Credits – 4 hours of Theory teaching per week)

Unit 1: Fields, vector spaces, subspaces; linear dependence and independence; basis and dimension of a vector space, finite dimensional vector spaces completion theorem. Examples of vector spaces over real and complex fields. Linear equations. Vector spaces with an inner product, Gram-Schmidt orthogonalization process. Orthonormal basis and orthogonal projection of a vector.

Unit 2: Linear transformations, algebra of matrices, row and column spaces of a matrix. Elementary matrices, determinants, rank and inverse of a matrix. null space and nullity; partitioned matrices; Kronecker product. Hermite canonical form, generalized inverse, Moore- Penrose Inverse, Idempotent matrices. Solutions of matrix equations.

Unit 3: Triangular reduction of a positive definite matrix. Characteristic roots and vectors, Cayley- Hamilton thoorem, minimal polynomial, similar matrices. Algebraic and geometric multiplicity of characteristic roots, spectral decomposition of a real symmetric matrix, reduction of a pair of real symmetric matrices, Hermitian matrices.

Unit 4: Real quadratic forms, reduction and classification of quadratic forms, index and signature. Singular values and singular decomposition, Jordan decomposition, extrema of quadratic forms. Vector and matrix differentiation.

Books for Reference:

Bellman, R. (1970): Introduction to Matrix Analysis, Second Edition, McGraw Hill.
Biswas, S. (1984): Topics in Algebra of Matrices, Academic Publications.
Graybill, F. A. (1983): Matrices with Applications in Statistics, Second Edition, Wadsworth..
Hadley, G. (1987): Linear algebra, Narosa.
Halmos, P. R. (1958): Finite Dimensional Vector Spaces, Second Edition, D. Van Nostrand Company.
Hoffman, K. and Kunze, R. (1971): Linear Algebra, Second Edition, Prentice Hall.
Rao, A. R. and Bhimasankaram, P.(1992): Linear Algebra, Tata McGraw Hill.
Rao, C. R (1973): Linear Statistical Inference and its Applications, Second Edition, Wiley.
Rao, C. R. and Mitra, S. K (1971): Genera1ized Inverse of Matrices and its Applications, Wiley.
Searle, S. R (1982): Matrix Algebra Useful for Statistics, Wiley.

HCT 1.2: REAL ANALYSIS (4 Credits – 4 hours of Theory teaching per week)

Unit 1: Elements of set theory, Sets in Euclidean space of k-dimensional R^k rectangles, neighbourhood, interior point and limit point, open and closed sets, Bolzano-Weierstrass theorem in R^2, Real valued functions continuity and uniform continuity.

Unit 2: Sequences and Series of constants- Limit superior, limit inferior and limit - properties. Cesaro sequences. Series of positive terms - Tests for convergence, divergence. Integral and Order tests and

Kummers' test (statement only of all the tests)- Ratio and Raabe's tests as special cases of Kummers' test. Series of arbitrary terms - absolute and conditional convergence.

Unit 3: Sequences of functions-Uniform convergence and point wise convergence, Series of functions-uniform convergence-Weierstrass' M test. Power series and radius of convergence. Riemann-Stieltjes integration-continuous integrand and monotonic /differentiable integrator.

Unit 4: Functions of two variables-partial and directional derivatives. Maxima and minima of functions, maxima-minima under constraints (Lagrange's multipliers).

Unit 5: Parametric functions. Uniform convergence of improper integrals, Differentiation under integrals. Double integrals and repeated integrals. Change of variables under double integration-statement of the theorems without proof and solution of problems.

Books for reference:

Apostol, T.M. (1985): Mathematical Analysis, Narosa India Ltd.
Courant, R. and John, F. (1965): Introduction to Calculus and Analysis, Wiley.
Goldberg, R.R.(1970): Methods of Real Analysis, Oxford Publishing Co.
Khuri, A.T. (1993): Advanced Calculus with Applications in Statistics, John Wiley.
Rudin, W. (1976): Principles of Mathematical Analysis, Mc Graw Hill.
Shantinarayan (1950) : A course on Mathematical analysis, Sultan Chand and Co.

HCT: 1.3: PROBABILITY THEORY AND DISTRIBUTIONS – I

Unit 1: Classes of sets, sequence of sets, limit superior and limit inferior of a sequence of sets, fields, sigma fields, minimal sigma field, Borel sigma field on the real line. Events, Sample space, Probability measure, Additive property, properties related to sequences of events, Independent events, Conditional probability and Bayes' theorem.

12 Hrs

Unit 2: Measurable functions, random variables, sums, product and functions of random variables, sequence of random variables. Induced Probability measure, Distribution function Jordan decomposition theorem. Bivariate distributions-joint marginal and conditional distributions. Expectations and conditional Expectations.

8 Hrs

Unit 3: Standard discrete and continuous univariate distribu1lons and their properties, Probability generating function and moment generating function. Bivariate normal and Multinomial distributions

10 Hrs

Unit 4: Transformation technique. Sampling distributions, Chi-square, 1, F and Non-central chi-square and their properties. Bivariate Negative Binomial, Beta and Gamma distributions.

10 Hrs

Unit 5: Markov, Chebyshev, Hoelder, Minkowski, Jensen and Liapunov inequalities. Relationship between tail of distributions and moments.

10 Hrs

Books for Reference:

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

Jolmson, S. and Kotz. (1972); Distributions in Statistics, Vols.I, II and III, Houghton and Miffin.
Mukhopadhyaya, P. (1996): Mathematical Statistics, Calcutta Publishing House.
Pitman, J. (1993): Probability, Narosa.
Lukacs C (1970)' Characteristic functions, Griffin Publications.

SCT: 1.1: SAMPLE SURVEYS AND STATISTICS FOR NATIONAL DEVELOPMENT, WOMEN'S STATISTICS

A. SAMPLE SURVEYS

Unit 1: Basic finite population sampling techniques (SRS WR/ WoR, stratified, systematic), related problems of population mean estimation, allocation problems in stratified sampling.

10 Hrs

Unit 2: Unequal probability sampling: PPS WR / WoR methods (including Lahiri's scheme) and related estimators of a finite population mean (Hansen-Hurvitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2).

10 Hrs

Unit 3: Ratio and regression estimators based on SRS WoR method of sampling, two-stage sampling with equal. number of second stage units, double sampling, cluster sampling.

10 Hrs

B. STATISTICS'FOR NATIONAL DEVELOPMENT

Unit 4: Economic development: growth ip. per capita income distributive justice. Indices of development, Human Development Index. Estimation of National Income - product approach, income approach and expenditure approach. Population growth in developing and developed countries. Population projection using Leslie matrix. Labour force projection.

10 Hrs

Unit 5: Measuring inequality of incomes, Gini coefficient, Theil's measure. Poverty measurement- different issues, measures of incidence and intensity, combined measures, eg. Indices due to Kakwani, Sen. etc.

10 Hrs

C. WOMEN'S STATISTICS

Women's Empowerment Index: 1) Determinants of empowerment like education, employment, access to health, access to media, access to finance, involvement in decision making process at family and at office/organization . 2) Various measures of women's empowerment index based on sex, geographical region and time etc.

Books for Reference:

Choudhary, A and Mukherjee, R (1989): Randomized Response techniques, Marcel Decker.
Cochran, W. G. (1977): Sampling techniques, Third Edition, Wiley.
Des Raj and Chandok (1998): Sampling Theory, Narosa.
Murthy, M. N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
Singh,D. and Choudhary, F. S. (1986): Theory and Analysis of Sample Survey Designs, New Age International.
Sukhatme et al. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press.
C.S.O. (1980): National Accounts Statistics- Sources and Health.

Keyfitz, N. Mathematical Demography.
UNESCO: Principles of Vital Statistics Systems, Series M-12.
Sen, A(I997): Poverty and Inequality.

HCP 1.1: STATISTICAL COMPUTING (PRACTICAL PAPER - I)

Unit 1: A general overview of R . Numeric/Character/logical; real /integer/complex string and the paste command matrices, dataframes, lists, setwd,read.table,read.csv.write. matrix, write.csv, creation of new variables, catergorization cut, factor,round, apply, creation of pattern variables, saving output files; source;print saving work space/ history. R-help command; help. search(), r mailing list, contributed documentation on cran. Descriptive statistics and Graphics in R: summary statistics for single group, the plot-command, histogram, box plot bar plot, lines, points, segments, arrows, paste, inserting math. symbols in a plot, pie diagram, customization of plot- setting graphical parameters text and m-text the pairs command. Graphical parameters such as mar/mai/mfrow/xlab/ylab/las/xaxp/xlim/ylim/cex/axis/tck/srt/main/title/legend/locator/ identity.

Unit 2: One and two sample t-tests, chi-squared tests, F- test for equality of variance, nonparametric tests, regression analysis, checking the assumptions of normality, Q-Q plots, P-P plots. ANOVA. Matrix operations, addition, subtraction, multiplication, linear equation and eigenvalues, finding rank, inverse, g-inverse, determinant. R –functions; some useful built in r functions, attach, detach, sort, order, rank, ceiling, floor, round, trunc, signif, apply, lapply, by. Programming in R;fro/while/loops, functions, the source command.

Unit 3: Numerical analysis and statistical applications. Numerical integration, root extraction, random number generation, Monte Carlo integration, matrix computations, drawing random samples from known univariate probability distributions -both discrete and continuous and bivariate normal distribution - the inverse method, the accept- rejection method, decomposition of discrete mixtures, Classical Monte Carlo integration. R-functions for generating random variables and simulations; rnorm, rbinom, rpiosson, runif,rchisq,rt, etc.,; sample, set.seed.

Unit 4: Writing / performing programs using MATLAB /MINITAB/ SPSS/ Excel on problems from the following topics: Descriptive statistics and Graphs, One and two sample parametric and nonparametric tests, Chi-square tests, Regression and correlation analysis, Analysis of Variance and Kruskal-Wallis Test.

References:

1. Dalgaard, P. (2002). Introductory Statistics with R. Springer Verlag, New York.
2. Kerns, G.J. (2010). Introduction to Probability and Statistics Using R. Free Software Foundation.
3. Kunte, Sudhakar (1999). Statistical Computing: 1. Understanding Randomness and Random Numbers,Resonance, Vol.4, No.10, pp.16-21.
4. Kunte. Sudhakar (2000). Statistical Computing: 2. Technique of Statistical *Simulation, Resonance,* Vo1.5, No.4, pp.18-27.
5. Robert, C. and Casella, G. (2010). Introducing Monte Carlo Methods with R. Springer Verlag, New York.
6. Sudha G Purohit, Sharad D Gore, Shailaja R Deshmukh (2010) Statistics Using R, Alpha Science Intl. Publ.
7. Verzani, J. (2005). Using R for Introductory Statistics. Taylor & Francis

HCP 1.2: (PRACTICAL PAPER – II) Practical's based on HCT: 1.1 AND SCT 1.1

SEMESTER II

HCT: 2.1: PROBABILITY THEORY AND DISTRIBUTIONS – II

Unit 1: Lebesgue and Lebesgue Stieltjes measure on the real line. Integration of measurable functions with respect to measures. Monotone convergence theorem, Fatou's lemma and dominated convergence theorem.

10 Hrs

Unit 2: Convergence in distribution, in Probability and with probability 1 and their implications. Slutsky's theorem. Weak law of large numbers- Ko1mogorov's generalized WLLN (proof of sufficient condition only), Khintchine's WLLN as special case, Chebyshev's WLLN.

10 Hrs

Unit 3: Borel-Cantelli lemma, Kolmogorov's inequality. Strong law of large numbers - Kolmogorov's SLLN's for independent sequences and deduction for the ii.d. Case. Definitions and examples of Markov dependent, exchangeable and Stationary sequences. Characteristic function - properties, Inversion theorem (statement only and proof for density version), Uniqueness theorem, Continuity theorem (statement only). Central limit theorem- lindberg-Feller form (statement only). Deductions of Levy-Lindberg and Liapunov's forms

15 Hrs

Unit 4: Order Statistics- their distributions and properties, Joint and marginal distributions. Extreme value distributions and their properties. Extreme value distributions as limit laws for the case of exponential, Norma, Uniform and Pereto.

15 Hrs

Books for Reference:

Cramer, H. (1946): Mathematical Methods of Statistics, Princeton.
Johnson, S. and Kotz, (1972): Distributions in Statistics, Vols.I, II and III, Houghton and Miffin.
Mukhopadhyaya, P. (1996): Mathematical Statistics, Calcutta Publishing House.
Pitman, J. (1993): Probability ;Narosa.
Rao, C. R. (1973): Linear Statistical Inference and its Applications, 2 nd Ed., Wiley Eastern.
Rohatgi, V. K (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
Lukacs C (1970): Characteristic functions, Griffin Publications.

HCT: 2.2: THEORY OF POINT ESTIMATION

Unit 1: Likelihood Function, Group Families, Exponential class of densities and it's properties, Fisher Information, Sufficiency, Neyman – Fisher factorization Theorem, Minimal sufficient statistics and their construction, Completeness, bounded completeness and relation with minimal sufficiency, ancillary statistics, Basu's Theorem and it's Applications.

20 Hrs

Unit 2: Unbiased Estimators, Characterization of UMVUE, Rao – Blackwell and Lehmann – Scheffe Theorem and their uses.

8 Hrs

Unit 3: Cramer- Rao inequality for single parameter case, Chapman - Robbins bounds and Bhattacharya bounds.

7 Hrs

Unit 4: Methods of Estimation: Method of moments, method of minimum chi-square, method of maximum likelihood and it's properties, Method of scoring and it's applications. Asymptotic effiency of MLE, CAN and BAN estimators.

15 Hrs

Books for Reference:

Kale B.K (1999) A first course on parametric inference. Narosa.
Lehmann E. L (1988) Theory of point estimation. John wiley & Sons
Rohatgi V.K (1984) An introduction to probability theory mathematical Statistics. Wiley eastern, New Delhi.
Zacks, S (1971) Theory of Statistical Inference. Wiley, Newyork.

HCT: 2.3: LINEAR MODELS AND REGRESSION ANALYSIS

Unit 1: Gauss-Markov setup, normal equations and least squares estimates, error and estimation space, variance and covariance of least squares estimates, estimation of error variance, estimation with correlated observations, least squares estimates with restriction and parameters. Simultaneous estimates of linear parame1ric functions.

10 Hrs

Unit 2: Test of hypothesis for one and more than one parametric functions. Confidence intervals and regions, analysis of variance fable, power of F-test, multiple comparison test like Tukey and Scheffe, simultaneous confidence interval.

10 Hrs

Unit 3: One way linear models when parameters are random and estimation of variance components. Simple linear regression, multiple regression - estimation, testing linear hypotheses, confidence interval, confidence region, prediction of new observations, prediction interval, fit of polynomials and use of orthogonal polynomial Introduction to non-linear models.

10 Hrs

Unit 4: Model adequacy - residuals and their plot for examining the departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers and remedies. Hat-matrix, leverages and detection of influential observations.

10 Hrs

Unit 5: Multicollinearity, ridge and principal component regression. Validation of regression model: analysis of estimated coefficients and predicted values, collecting fresh data, data splitting. Subset selection of explanatory variables and Mallow's C_p statistic, all possible regressions, stepwise, forward and backward regressions.

10 Hrs

Books for Reference:

Cook, RD. and Weisberg, S. (1982); Residual 'and Influence in Regression. Chapman and Hall, London.
Draper, N.R and Smith, H (1998): Applied Regression Analysis. Third Edition, Wiley, New York.
Gunst, R.F. and Mason, R.L. (1980) ; Regression Analysis and its Application - A Data Oriented Approach, Marcel-Dekker.
Montgomery,D.C, Peck, E.A. and Vining,G.G.(2003). Introduction to Linear Regression, John Wiley.
Rao, C. R (1913): Linear statistical Inference, Wiley Eastern.
Ryan,T.P.(1997). *Modern Regression Methods*, John Wiley, NY
Searle,S.R.(1971). *Linear Models*, John Wiley, NY.

Seber, G.A.F.(1997): *Linear Regression Analysis*. John Wiley, NY.
Seber, G.A.F. and Lee (2003): *Linear Regression Analysis*. 2/e John Wiley, NY
Weisberg, S. (1985): Applied Linear Regression, Wiley.

SCT: 2.1: OPERATIONAL RESESARCH

Unit 1: Definition and scope of Operational research; phases in Operational research; models and their solutions; decision-making under uncertainty and risk, use of different criteria; sensitivity analysis.

10 Hrs

Unit 2: LP Problem - Simplex method, Karmarkar's algorithm, duality theorem; transportation and assignment Problems; Wolfe's and Beale's algorithms for solving quadratic programming problems. Dynamic programming, Bellman's principle of optimality, general formulation, computational methods and applications of dynamic programming.

10 Hrs

Unit 3: Analytical structure of inventory problems; EOQ formula of Ranis and its sensitivity analysis and extensions allowing quantity discounts and shortages. Multi-item inventory subject to constraints. Models with random demand, the static risk model. P and Q -systems with constant and random lead times, (t-S) po1icy.

10 Hrs

Unit 4: Queueing .models - specifications; and effectiveness measures, steady-state solutions of M/M/I and M/M/C models with associated distributions of queue-length and waiting time. Queues with truncation Machine interference problem. M/G/I queue and Pollaczek-Khinchine result Steady - state solution of. M/E_k/I.

10 Hrs

Unit 5: PERT and CPM Probability of project completion; PERT - crashing.

10 Hrs

Books for Reference:

Churchman, C.W., Ackoff, R.L. and Amoff, E.L. (1957). Introduction to Operations Research.
Hillier, F.R and Leibennan, G (1962). Introduction to Operations Research
Kanti Swarup and Gupta, M.M. (1985); Operations Research.
Philips, D.T., Ravindran, A. and Solberg, J. Operations Research, Principles and Practice.
Taha, HA. (1982). Operational Research

HCP 2.1: (PRACTICAL PAPER – I) Practicals based on HCT: 2.2 AND SCT 2.1
HCP 2.2: (PRACTICAL PAPER – II) Practicals based on HCT: 2.3

SEMESTER III

STCT: 3.1: MULTIVARIATE ANALYSIS

Unit 1: Random sampling :limn multivariate normal distribution, maximum likelihood estimators of parameters, distribution of sample mean vector Wishart distribution (statement only) and its properties; distribution of sample generalized variance. Null distributions of sample correlation coefficient, partial. And multiple Correlation coefficients, distribution of sample regression coefficients. Application in testing and interval estimation.

10 Hrs

Unit 2: Hotellings- T^2, Null distribution of Hotelling's T^2 statistic, Application in test on mean vectors for single and several multivariate normal populations.

10 Hrs

Unit 3: Multivariate linear regression model, estimation of parameters, testing linear hypothesis about regression coefficients. Likelihood ratio test criterion. Multivariate analysis of variance of one and two way classified data.

10 Hrs

Unit 4: Classification and discrimination procedures for discrimination into one of two multivariate normal populations. Sample discriminant function, tests associated ,with discriminant function, probabilities of misclassification and their estimation, classification into more than two mul1ivariate normal populations.

10 Hrs

Unit 5: Principal components. Dimension reduction, canonical correlations and canonical variable - definition, use, estimation and computation.

10 Hrs

Books for Reference:

Anderson, T.W. (1983): An. Introduction to Multivariate Statistical Analysis, Second Edition, Wiley.
Giri, N. C. (1977): Multivariate Statistical Inference, Academic Press.
Johnson and Wichern (1986) : Applied Multivariate Analysis, Wiley.
Kshirsagar,. A.M. (1972): .Multivariate Analysis, Marcel-Dekker. .
Morrison, D.F. (1976): Multivariate Statistical Methods, Second Edition, McGraw Hill.
Muirhead, R.J. (1982): Aspects of Multivariate Stalistica1 Theory, Wiley.
Rao, C. R. (1973). Linear Statistical Inference and its Applications, Second Edition, Wiley Eastern.
Seber, G.A.F. (1984) : Multivariate Observations, Wiley.
Sharma, S. (1996). Applied Multivariate Techniques, Wiley.
Srivastava, M.S. and Khattree, C. G. (1979). An Introduction to Multivariate Statistics, North Holland.

STCT: 3.2: TESTING OF HYPOTHESES

Unit 1: Introduction to testing of hypotheses: size and power of a test. Neyman-Pearson lemma, MP test, MLR Property and UMP test.

10 Hrs

Unit 2: Generalization of NP-lemma, UMPU tests, Bounded completeness, Similar regions. Tests with Neyman structure, UMPU test for multi-parameter exponential families. Comparison of two binomial and Poisson populations.

10 Hrs

Unit 3: Confidence intervals and their connection with the tests of hypotheses. UMA, UMAU confidence intervals, shortest length confidence intervals.

Likelihood ratio tests, large sample properties. Chi-square goodness-of-fit tests for simple and composite hypothesis.

10 Hrs

Unit 4: Nonparametric methods-run test, sign test, signed-rank test, median test, Wilcoxon-Mann-Whitney test, Kolmogorov – Smirnov tests, Tests involving rank correlation, Linear rank statistics, Large sample properties and applications.

10 Hrs

Unit 5: Sequential analysis, need for sequential tests, SPRT and its properties, termination property, fundamental identity and Wald's equation, OC and ASN functions. SPRT for testing hypothesis in binomial, Poisson, normal and exponential distribution-computation of OC and ASN functions.

10 Hrs

Books for Reference:

Lehmann E.L. (1986)Testing Statistical Hypothesis, Wiley, New York.
Rohatgi V.K. (1984). An Introduction to Probability Theory and Mathematical Statistics. Wiley Eastern, New Delhi.
Dudewicz E.J. and Mishra S.N. (1988) Modern Mathematical Statistics, Wiley and Sons, New York.
Ferguson T.S. (1967), Mathematical Statistics- Decision Theoretic Approach. Academic Press, New York.
Kendall M.G. and Stuart A (1968) Advanced Theory of Statistics, Vol II, Charles Griffin and Co., London.
Rao C.R (1973). Linear Statistical inference. Wiley Eastern, New Delhi.
Wald A (1947) Sequential Analysis, Wiley New York.
Gibbons J.D. (1985). Non Parametric Statistical inference. Marcel Dekkar, New York.
Randles R.H. and Wolfe D.A. (1979) Introduction to Theory of Non-Parametric Statistics. Wiley, New York.
Cramer H. (1957) Mathematical Methods of Statistics. Princeton University Press, New Jersey.

HCT: 3.3: DESIGN AND ANALYSIS OF EXPERIMENTS

Unit 1: Gauss-Markov setup, estimability of linear parametric functions, normal equations and least squares estimation. Error and estimation spaces, variance and covariance of least square estimates. Estimation of Error variance, Linear Estimation in the correlated setup. Least squares Estimates with restriction on the parameters, simultaneous estimates of linear parametric functions.

14 Hrs

Unit 2: Tests of hypotheses for one and more than one linear parametric functions. confidence intervals and regions, ANOVA table, power of F – Test, multiple compararion procedures of Tukey and Scheffe, simultaneous confidence intervals.

8 Hrs

Unit 3: Application of Gauss – Markov theory to the analysis of two – way and three – way classification models. CRD, RCBD, LSD and Missing Plot techniques.

8 Hrs

Unit 4: Incomplete bock designs – BIBD and PBIBD. Balance, connectedness and orthogonality in relation to two – way designs. Analysis of Covariance.

8 Hrs

Unit 5: Factorial experiments, confounding in 2^n factorial experiments, Split – Plot design, Random effects models: one – way and two – way classification.

12 Hrs

Books for Reference:

Chakravarthy M.C. (1971) Mathematics of Design and Analysis of Experiments. Asia Publishing House.
Joshi, D.D. (1987) Linear Estimation and Design of experiments. Wiley Eastern.
Kshirsagar, A.M. (1983) Linear Models, Marcel Dekker.
Das M.N. and Giri, N.C. (1988) Design and Analysis of experiments. Wiley Eastern. Ltd.
Montgomery D.C. (1991) Design and Analysis of experiments, John Wiley and sons.
Ogawa, J (1974) Statistical Theory of the analysis of the experimental design. Marcel Dekker.
Rao C.R. (1985) Linear Statistical Inference and its applications. Wiley Eastern.
Searle S.R. (1971) Linear Models. John Wiley & Sons.

SCT 3.1: BIO-STATISTICS

Unit 1: Definition, agent, host and environment, mode of transmission; incubation period, spectrum of disease, herd immunity, classification of cause, of death, measures of mortality, studies of mortality. Measures of morbidity, I1lOIbidity surveys, issues and problems. Risk, cause and bias. Observational studies: retrospective, cross sectional and prospective studies.

10 Hrs

Unit 2: Clinical trials: Methods of randomization, ethical issues, cross over trials. Sequential and group sequential trials. Interim analysis, multiple testing and stopping rules. Equivalence trials.

10 Hrs

Unit 3: Clinical Epidemiology: Definition, reliability, validity, sensitivity, specificity, predictive values, likelihood ration test, selection and interpretation of diagnostic test. Deciding on the .best therapy.

10 Hrs

Unit 4: ROC curves, multiple and parallel test. Screening for disease, critical appraisal, Meta analysis. Epidemiologic Models - Epidemometric studies- Deterministic epidemic models: Simple, General, Recurrent.

10 Hrs

Unit 5: Time Series (Epidemic or others) Applications of Time series analysis in epidemiology - Simple descriptive techniques for detecting seasonal, Cyclical, secular and random variations

10 Hrs

Books for Reference:

Lilienfeld, A.M. and Lilienfeld, D.C. Foundations of epidemiology, Second Edition, Oxford Univ. Press, New York, 1980.
Fletcher, R.H., Fletcher, S. W. and Wagner, E.H. Clinical Epidemiology - the essentials, Second Edition, 1982.
Harold A Hahn, Christopher T. Sempos. Statistical Methods in Epidemiology, Oxford Univ. Press, New York, 1989.

David G.Kleinbaum, Lawrence L.Kupper and Hall Morgenstem. Epidemiologic Research, Van Nostrand, USA, 1982.
Chatfield, C. The Analysis of Time Series - An Introduction. Third Edition, Chapman and Hall, London, 1984.
Bailey N.T.J. The Mathematical Approach to Biology and Medicine. - Chapters 1, 2, and 9, John Wiley, 1967.

HCP 3.1: (PRACTICAL PAPER – I) Practicals based on HCT: 3.1 AND HCT 3.2
HCP 3.2: (PRACTICAL PAPER – II) Practicals based on HCT: 3.3 AND SCT 3.1

OEP 3.1 QUANTITAIVCE TECHNIQUES FOR REASERACH

Unit 1: Descriptive Statistics: Data presentation by charts and tables, measures of central tendency, Measures of dispersion, Skewness and kurtosis.

Unit 2: Correlation and regression Analysis , Scatter plot, Karl-pearson's coefficient of correlation, Spearman's rank correlation, Simple regression Analysis.

Unit 3: Test of Significance

Basic s of testing of hypothesis, Test for proportions (one sample and two sample problems), Test for mean, test for variance (one sample and two sample problems), Chi-Square test of independence, ANOVA.

Unit 4: Operations Research

Linear programming problems(LPP), Solution by graphical method, Transportation , Assignment and sequencing (Feasible solutions only).

Books for Reference:

Medhi J (1994), Stochastic Processes, 2nd edn., Wiley Eastern Ltd., New Delhi.
Bhattacharya, G.K. and Johnson, R.A. Statistical concepts and methods. Wiley Eastern. Calcutta, Bombay and Delhi.
Goon A.M., Gupta, M.K. and Das Gupta B: Fundamental of Statistics Vol.1 and II. World Press Pvt. ltd., Calcutta.
Levin, R.I. : Statistics for Management, Prentice Hall of India, New Delhi.

SEMESTER IV

HCT: 4.1: SQC AND RELIABILITY THEORY

Unit 1: Process Control: Control charts for $\bar{x}$ and s, demerits, extreme values. Moving average control charts, geometric moving average control charts, group control charts, multivariate quality control charts, sloping control lines.

Use of sequential runs in constructing control limits, CUSUM charts and its relation with SPRT. Control charts versus ANOVA and Chi-square tests.

12 Hrs

Unit 2: Product Control: single, double and multiple sampling plans for attributes, curtailed sampling plans. OC, AOQ, ASN and ATI functions for these plans. Designing single and double sampling plans. Chain sampling plans. Sampling plans by variables, Continuous sampling plans CSP1, CSP2, CSP3 and multilevel sampling plans.

10 Hrs

Unit 3: Reliability Theory: Life distributions, survival functions, failure rate, Integrated hazard function, residual life time, mean residual life time. Common Life Distributions: binomial, negative binomial, Poisson, exponential, Weibull, gamma, Pareto and log-normal distributions. Notion of aging: IFR, IFRA, DMRL, NBU, NBUE classes of life distributions and their dual.

10 Hrs

Unit 4: System reliabilities: Series, parallel, k-out-of-n, standby redundant systems and their reliabilities. Maintenance policies: Age replacement policy and Block replacement policies and their characteristics. Reliability modeling: Introduction to shock models, stress-strength models and proportional hazard models.

6 Hrs

Unit 5: Inference in Reliability: Type I and Type II Censoring schemes, likelihood functions based on these sampling schemes for exponential distribution. Reliability estimation (complete and censored samples) for exponential distribution, testing reliability hypotheses (exponential distribution).

12 Hrs

Books for Reference:

Montgomery D.C. (1996) Introduction to Statistical Quality Control, Wiley, New York.

Grant E.L. (1980) Statistical Quality Control McGraw Hill, New York.

Weetherhill G.B. and Brow D.W. (1991) Statistical Process Control. Chapman and Hall, London.

Barlow R.E. and Proschan F (1975) Statistical Theory of Reliability and Life Testing. Holt-Rinhart and Winston, New York.

Sinha S.K. and Kale B.K. (1990) Life Testing and Reliability Estimation. Wiley Eastern, New Delhi.

Mann N.R, Schaffer R.F and Singpurwalla N.D. (1974) Methods for Statistical Analysis of Reliability and Life Data. Wiley New York.

Zacks S (1992) Introduction to Reliability Analysis. Springer - Verlag, New York.

J.V. Deshpande and Sudha G. Purohit (2005) Life time data: Statistical Models and Methods. World Scientific.

HCT: 4.2: ELEMENTARY STOCHASTIC PROCESS

Unit 1: Introduction to stochastic processes (SP), classification of SP according to state space and time domain. Finite and countable state Markov chains (MC), Chapman – Kolmogorov's equations, calculation of

n-step transition probabilities and their limits, stationary distribution, classification of states, transient MC, random walk and gambler's ruin problems.

16 Hrs

Unit 2: Continuous time Markov processes: Kolomgorov-Feller differential equation, Poisson process, pure birth process, Yule – Furry process, birth and death processes, Weiner process as a limit of random walks, first passage time and other problems, diffusion process.

14 Hrs

Unit 3: Renewal Theory: Elementary renewal theorem and applications, key renewal theorem and its uses, study of residual life time process, discrete time renewal theory. Stationary process: weakly stationary and strongly stationary processes, spectral decomposition, moving average and auto regressive processes.

14 Hrs

Unit 4: Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, and statistical inference in MC and Markov process.

6 Hrs

Books for Reference:

Medhi J (1994), Stochastic Processes, 2nd edn., Wiley Eastern Ltd., New Delhi.
Bhat U.N. (1984), Elements of Applied Stochastic processes, 2nd edn., Wiley, New York.
Basawa I.V. and Prakash Rao B.L.S. (1980) Statistical Inference for stochastic processes, Academic press, New York.
Karlin S and Taylor H.M. (1975), A first course in stochastic processes, 2nd edn., Academic press, New York.

Elective Papers: ***Any two***

SCT: 4.1(a): DEMOGRAPHY (*OPTIONAL*)

Unit 1: Demography and its interdisciplinary nature, sources of demographic data, Coverage and Content errors. The use of balancing equation, Chandrasekaran and Deming formula to check completeness of registration data. Use of Whipple's, Myers's and UN Indices.

10 Hrs

Unit 2: Measures of Mortality: Various measures of mortality, infant mortality rate, cause specific death rates and standardized death rates. Measures of Fertility: Period and cohort fertility measures, use of birth order statistics, child – women ratio, Brass P/F ratio to estimate current levels of fertility, Measures of reproduction and replacement. Sheps and Perrin stochastic human reproductive process.

15 Hrs

Unit 3: Life Tables: Types of life tables, inter – relationships between life table functions, construction of life tables using Reed – merrel and Greville's Method. Probability distribution of life table functions and their optimum properties. Population estimation and Projections: Mathematical, Statistical and Demographic Methods, Component method.

15 Hrs

Unit 4: Stable and Quasi – stable population: Derivation of Lotka's stable population model and its properties, Intrinsic growth rate and its derivation, age structure and birth rate of a stable population, mean

length of generation, momentum of population growth, Quasi – stable population under changing fertility and mortality situations.

10 Hrs

Books for Reference:

Shryock, Henry S, Jacob S, Siegel and Associates (1964)- Methods and materials of demography (condensed edition) Academic press, London.
Barclay, George W. (1968) Techniques of population analysis, John Wiley and sons, New York.
Keyfitz N. (1968). Introduction to the Mathematics of Population. Addision-Wesley Publishing Co, Reading, Messachusetts.
Chiang C.L. (1968) Introduction to stochastic processes in Biostatistics, John Wiley and sons, New York.
R. Ramkumar (1986) Technical Demography, Wiley Eastern, New Delhi.
Sudhendu Biswas (1988), Stochastic Processes in Demography and Applications, Wiley Eastern, New Delhi.

SCT: 4.1(b): TIME SERIES ANALYSIS *(OPTIONAL)*

Unit 1: Time series as discrete parameter stochastic process, auto-covariance and auto-correlation functions and ,their properties.

Unit 2: Detailed study of the stationary processes: (i) moving average (MA), (ii) auto-regressive (AR), (iii) ARMA, and, (iv) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto-covariance and auto-correlation functions under large sample theory.

Unit 3: Choice of AR and MA orders. Estimation of ARIMA model parameters. Forecasting. Residual analysis and diagnostic checking.

Unit 4: Spectral analysis of weakly stationary process, periodogram and correlogram analysis, computation based on Fourier transforms, Spectral decomposition of weakly AR process and representation as a one-sided MA process -necessary and sufficient conditions.

Unit 5: Implication of spectral decomposition in prediction problems. State space representation of time series. Kalman filter techniques.

Books for Reference:

Anderson. T.W. (1971). The Statistical Analysis of Time Series. Wiley.
Bloomfield, P. (2000). Fourier Analysis of Time Series: An Introduction. Second Edition, Wiley.
Box, G.E.P., Jenkins, G. W. and Reinsel, G.C. (1994). Time Series Analysis:Forecasting and Control Prentice Hall.
Box, G.E.P. and Jenkins, G.M (1976). Time Series Analysis - Forecasting and Control Holden-day, San Francisco.
Chatfield, C. Analysis of Time Series - Theory and Practice, Chapman and Hall.
Chow, C.G. (1985). Econometrics.. Mc Graw Hill.
Findley, D.F..ed., (1981). Applied Time Series Analysis II. Academic. Press.
Fuller, W.A. (1976). Introduction to Statistical Time series. Wiley.
Granger, C W.J. and Newbold (1984). Forecasting Econometric Time Series, Third Edition, Academic Press.
Granger, C.W.J. and Hatanka, M. (1964). Spectral Analysis of Economic Time Series, Princeton University Press.
Hannan. E.J. (1960). Time Series Analysis, Metheun, London.
Kendall, MG. (1974). Time Series, CnMles Griffin, London.
Kendall, MG> and Sroan, A. (1966). The Advanced Theory of Statistics, Vol. 3, Charles Griffin, London.

Koopmans, L.H. (1974). The Spectral Analysis of Time Series, Academic Press.
Montgomery, D.C. and Johnson, L.A (1977) Forecasting and Time Series Analysis, McGraw Hill.
Nelson, C.R (1973). Applied Time Series for managerial forecasting. Holden-day.
Priestly, MB. (1981). Spectral Analysis and Time Series. Griffin, London.

SCT: 4.1 (c): ACTUARIAL STATISTICS (*OPTIONAL*)

Unit 1: Basic deterministic model: Cash flows, discount function, Interest and discount rates, balances and reserves, internal rate of return, The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premiums, interest and survivorship discount function, guaranteed payments, deferred annuities

15 Hrs

Unit 2: Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern of reserves, recursion, detailed analysis of an insurance, bases for reserves, non forfeiture values, policies involving a return of the reserve, premium difference and paid-up formula.

10 Hrs

Unit 3: Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves. The general insurance - annuity identity, Select mortality: Select an ultimate tables, Changes in formulas.

10Hrs

Unit 4: Multiple life contracts: Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances Multiple decrement theory: Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities: Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

15 Hrs

Books for Reference:

Neill, A. (1977) Life Contingencies, Heinemann, London.
Newton L.Bowers, Jr, Hans U.Gerber, James C.Hickman, Donald A. Jones and Cecil J. Nesbitt (1997) Actuarial Mathematics, The Society of Actuaries.
King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
Donald D.W.A. (1970) Compound Interest and Annuities, Heinemann, London.
Jordan, C.W. Jr. (1967) Life Contingencies, Second edition, Chicago Society of Actuaries.
Hooker, P.F. and Longley Cook, L.W. (1953) Life and Other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
Spurgeen, E.T. Life Contingencies, Third edition, Cambridge University Press.

SCT: 4.1(d) : STATISTICAL GENETICS (*OPTIONAL*)

Unit 1: Basic biological concepts in genetics (relevant to this course)

05 Hrs

Unit 2: Mendel's law, Hardy Weinberg equilibrium. Mating tables, estimation of allele frequency

(dominant / co-dominant cases). Approach to equilibrium for X-linked gone, Natural selection, mutation, genetic drift, equilibrium when both natural selection and mutation are operative.

20 Hrs

Unit 3: Non-random mating, inbreeding, phenotypic assortative mating.

10 Hrs

Unit 4: Analysis of family data (a) Relative pair data, I, T; 0 matrices, identity by descent, (b) family data - estimation of segretation ratio under ascertainment bias, (c) Pedigree data- Elston - Stewart algorithm for calculation of likelihoods. Linkage, Estimation of recombination fraction, inheritance of quantitative traits. Models and estimation of parameters.

10 Hrs

Unit 5: Sequence similarity, homology and alignment. Algorithms for (a) pairwise sequence alignment, (b) multiple sequence alignment, construction of phylogenetic trees, UPGMA, Neighbour joining, maximum parsimony and maximum likelihoodalgorithms.

05 Hrs

Books for Reference:

C. C. Li (1976). First course on population genetics. Boxwood Press, California.
W. J. Ewens (1979). Mathematical population genetics. Springer Verlag.
T. Nagylaki (992). Introduction to theoretical population genetics. Springer Verlag.
R. Durbin, S. R. Eddy, A. Krogh, G. Mitchison (998). Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids.

OEP 4.1: DEMOGRAPHY (OPEN ELECTIVE)

Unit 1: Sources of Demography data coverage and content of errors.
Unit 2: Measures of fertility
Unit 3: Measures of mortality and Life table.
Unit 4: Migration, Impact of migration of society.

Books for Reference:

Spiegelman, H : Introduction to demography, Harvard University press.
S.C Gupta and V.k. kapoor : Apllied Statistics, S. Chand publication
United Nations Manuals: II, III, IV, VII.