BANARAS HINDU UNIVERSITY

DEPARTMENT OF STATISTICS
Faculty of Science

PROPOSED SYLLABI of

M.A./M. Sc. PROGRAMME
IN
STATISTICS

w.e.f. 2015-16

FOUR SEMESTER POST - GRADUATE COURSE
IN
STATISTICS

1. The Post Graduate Course in STATISTICS shall be Two – Year Degree Course comprising of FOUR SEMESTERS (Two Semesters in each year). The total credits including all the four semesters will be 80 including Minor Elective Papers.

2. There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper (Core Courses, Major and Minor Elective papers) except Paper No. STM - 416: Project Work – II in Semester – IV.

3. Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions.

4. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.

5. Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce.

6. All the practical papers shall be of FOUR HOURS duration.

7. In the paper "Research Methodology and Project Work – I" (Paper No. STM - 303) in Semester – III, there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation.

8. In semester – IV, the Project Work – II (Paper No. STM - 416) will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce.

9. If a student offers four major elective papers from the same module, he/she will be certified to have specialized in that module.

10. The two MINOR ELECTIVE THEORY papers (one in each of the semesters –II and III) will be offered by the students of other departments of the faculty, who are not pursuing Post – Graduation in Statistics.

Eligibility Criterion for the admission in M.Sc. Statisics:

B.A/B.Sc. (Hons) & B.A./B.Sc. under at least 10+2+3 pattern securing a minimum of 50% marks in aggregate in subjects (considering all three years of the of B.A./B.Sc Course). The candidate whose admission is sought must be Honours subject at B.A./B.Sc. (Hons) level/ subject studied in all three parts at Graduate level. For admission in M.Sc in Statistics, a candidate must also have studied Mathematics as one of the subject at the Graduate level.

The titles, contents of theory papers as well as practical papers and distribution of credits to papers shall be as follows :

PROPOSED COURSE FOR M. A. / M. Sc. STATISTICS
Department of Statistics, Banaras Hindu University, Varanasi

DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS

SEMESTER - I

Course Code	Title	Credit
STM – 101	Survey Sampling	3
STM – 102	Linear Models and Regression Analysis	3
STM – 103	Probability	3
STM – 104	Statistical Inference - I	3
STM – 105	Statistical Computing	3
STM – 106	Practical Paper based on the contents of Papers STM – 101, STM -102, STM-104 and STM - 105	4
	Total	**19**

SEMESTER - II

Course Code	Title	Credit
STM – 201	Distribution Theory	3
STM – 202	Multivariate Analysis	3
STM – 203	Design and Analysis of Experiments	3
STM – 204	Statistical Inference – II	3
STM – 205	Stochastic Processes	3
STM – 206	Practical Paper based on the contents of Papers STM – 202, STM – 203 & STM - 204	4
STM - 207M	Statistical Methods (Minor Elective for students of other programmes)*	2
	Total	**21**

SEMESTER - III

Course Code	Title	Credit
STM– 301	Statistical Decision Theory	3
STM – 302	Demography	3
STM – 303	Research Methodology and Project Work – I	3
Any TWO papers out of the Paper Nos. STM – 304 to STM – 307		
STM – 304	Advanced Operations Research - I	3
STM – 305	Reliability Theory	3
STM – 306	Computer Intensive Statistical Methods - I	3
STM – 307	Time Series Analysis	3
STM – 308	Practical Paper based on the contents of Papers STM – 301, STM – 302 and selected Major Elective Papers	3
STM309M	Sampling Theory, Design of Experiments (Minor Elective for students of other programmes) *	2
	Total	**20**

*Students of Statistics shall offer Minor Electives from other programmes.

SEMESTER - IV

Course Code	Title	Credit
Any FIVE papers out of the Paper Nos. STM – 401 to STM – 414		
STM – 401	Bayesian Inference	3
STM – 402	Non – Parametric and Semi – Parametric Methods	3
STM – 403	Applied Regression Analysis	3
STM – 404	Survival Analysis	3
STM – 405	Advanced Operations Research – II	3
STM – 406	Statistical Processes and Quality Control	3
STM – 407	Quantitative Epidemiology	3
STM – 408	Clinical Trials	3
STM – 409	Computer Intensive Statistical Methods – II	3
STM – 410	Computer Programming	3
STM – 411	Statistical Pattern Recognition	3
STM – 412	Econometrics	3
STM – 413	Actuarial Statistics	3
STM – 414	Official Statistics	3
STM – 415	Practical Paper based on the contents of selected Elective papers	3
STM – 416	Project Work – II	2
	Total	**20**
	GRAND TOTAL	**80**

There shall be sessionals/tutorials/class tests/seminars in class/group discussions in each theory and practical paper except Paper No. STM – 416: Project Work – II in Semester – IV.
Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals/ tutorials / class tests / seminars in class / group discussions. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.

The course contents of different papers are as follows:

Semester I

STM – 101 : SURVEY SAMPLING Credits : 3

Concept of Fixed population and super-population approaches. Concepts and distinct features of probability sampling and non – probability sampling schemes, sampling designs and sampling error.

Review of some important results in SRSWOR and SRSWR related to the estimation of population mean/total and proportions.

Estimation of population mean/total in stratified populations, Allocation problem in stratified random sampling (i) for fixed cost and (ii) for specified precision and corresponding expressions for variance of stratified sample mean. Post stratification, Double sampling with post stratification, Deep stratification, Controlled sampling.

Unequal probability sampling: PPSWR/PPSWOR methods of sample selection (including cumulative total method and Lahiri's scheme). Comparison of SRSWR and PPSWR schemes. Ordered estimators of Des Raj and Murthy (for n=2). Construction of unordered estimators from ordered estimators. Horvitz Thompson's estimator of a finite population total/mean. Expressions for variance of Horvitz Thompson's estimator and their unbiased estimators. Issue of negativity of estimated variance and its resolution. πPS sampling scheme and some of its important results. Midzuno-Sen sampling scheme.

Double sampling scheme: Ratio, regression and product estimators with double sampling and their comparison with estimators with known population mean of auxiliary variable. Some unbiased ratio type estimators for population mean.

Concept of cluster sampling, two stage sampling with unequal cluster sizes and interpenetrating sub-sampling.

Kinds of non-sampling errors with special reference to non-response problems. Hansen and Hurwitz estimator for population mean. Concept of randomized response and some well-known randomized response techniques for sensitive characteristics.

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References :

1. Cassel, C.M., Sarndal, C.E. and Wretman (1977): Foundation of Inference in Survey Sampling, Wiley Inter Science, New York.
2. Choudhari A. and Vos, J.W.E. (1988): Unified Theory of Strategies of Survey Sampling, North Holland, Amsterdam.
3. Hedayat, A.S. and Sinha, B.K. (1991): Design and Inference in Finite Population Sampling, Wiley.
4. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publication Society, Calcutta.
5. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling, New Age International (P).

6. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
7. Chaudhuri, A. and R. Mukherjee (1988): Randomised response: theory and techniques, New York, Marcel Deckker Inc.
8. Cochran, W.G.: Sampling Techniques (3^{rd} edition. 1977), Wiley.
9. Singh D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.

STM – 102 : LINEAR MODELS AND REGRESSION ANALYSIS Credits : 3

Grauss-Markov linear models, estimable functions, error and estimation space, normal equations and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators.

One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only), Multiple comparison tests due to Tukey, Scheffe and Student-Newmann-Karl.

Simple linear regression, multiple, regression, fit of polynomials and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies.

Multi co-linearity, ridge regression, sub-set selection of explanatory variables, Mallows C_P Statistics.

References :

1. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1967): An Outline of Statistical Theory, Vol. 2, The World Press Pvt. Ltd., Calcutta.
2. Rao, C.R. (1973); Linear Statistical Inference and its Application, Wiley Eastern.
3. Graybill, I.A. (1961): An Introduction to Linear Statistical Models, Vol. 1, McGraw Hill Book Co. Inc.
4. Draper, N.R. and Smith H. (1998); Applied Regression Analysis, 3^{rd} Ed. Wiley.
5. Weisberg, S. (1985): Applied Linear Regression, Wiley.
6. Cook, R.D. and Weisherg, S. (1982): Residuals and Inference in Regression, Chapman and Hall.

STM – 103: PROBABILITY Credits : 3

Classes of sets, fields, sigma fields, minimal sigma field, Borel sigma field, sequence of sets, lim sup and lim inf of a sequence of sets, measure, probability measure, properties of measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue - Steiltzes measures.

Measurable functions, random variables, sequence of random variables,. Integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou's lemma, dominated convergence theorem. Characteristic function, uniqueness theorem, Levy's continuity theorem (statement only), Convergence in distribution, Convergence in probability, almost sure convergence.

Borel-Cantelli lemma, independence, weak law and strong law of large numbers for independently and identically distributed sequences.

CLT for a sequence of independent random variables under Lindeberg's condition, CLT for independently and identically distributed random variables.

References :

1. Robert, A. (1972): Real Analysis and Probability, Academic press.

2. Billingsley, P. (1989): Probability and Measure, Wiley.

3. Dudley, R.M. (1989): Real Analysis and Probability, Wadsworth and Books.

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

STM – 104: STATISTICAL INFERENCE – I Credits : 3

Extension of Cramer-Rao inequality for multi-parameter case, Bhattacharya bounds, information in data about the parameters as variation in likelihood function.

Ideas of sufficient and minimal complete-sufficient statistics, sufficiency when the range of variate depends on parameter, minimum variance unbiased estimators, Rao-Blackwell and Lehman-Scheffe theorems, examples based on some standard distributions.

Asymptotic properties of maximum likelihood estimators, solution of likelihood equations, method of scoring, Newton-Raphson method.

General decision problems, loss function, risk function, estimation and testing viewed as general decision problems, minimax decision, Bayes decision, least favourable prior, Bayes estimation under squared error loss, some simple illustrations based on binomial, Poisson, and normal distributions, procedure for obtaining minimax estimators from Bayes estimators.

References :

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

2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.

3. Lehmann, E.L. (1986): Theory of Point Estimation, Student Edition.

4. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.

5. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.

6. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.

7. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.

STM – 105: STATISTICAL COMPUTING Credits : 3

Programming in a high level such as C (preferred) or FORTRAN. The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software. Topics should include simple syntax, loops, pointers and arrays, functions, input/output, and linking to databases.

Numerical analysis and statistical applications. The purpose of this unit is to apply programming skills in methods and alogrithms useful in probability, statistics, and data analysis. Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations.

References :

1. B.W. Kernighan and D.M. Ritchie (1988): The C Programming Language, Second edition, Prentice Hall.

2. W.H. Press, S.A. Teukolsky, W.T. Vellering, and B.P. Flannery (1993): Numerical Recipes in C, Second edition, Cambridge University Press.

3. B. Ryan and B.L. Joiner (2001). MINITAB Handbook, Fourth edition, Duxbury.

4. R.A. Thisted (1988): Elements of Statistical Computing, Chapman and Hall.

STM– 106 : Practical paper based on the contents of Papers Survey Sampling (STM-101), Linear Models and Regression Analysis (STM -102), Statistical

Inference–I (STM - 104) and Statistical Computing (STM – 105) Credits : 3

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

Semester II

STM – 201 : DISTRIBUTION THEORY Credits : 3

Brief review of basic distribution theory, joint, marginal conditional p.m.f.'s and p.d.f's, standard discrete and continuous distributions, bivariate normal, bivariate exponential, multivariate normal and multinomial distributions, functions of random variables and their distributions using Jacobian of transformation and other tools.

Compound, truncated and mixture distributions, multiple and partial correlations, linear and multiple regressions. Markov, Holder, Jensen, Liapunov inequalities.

Sampling distributions, non-central chi-square, t and F distributions and their properties. distributions of quadratic forms under normality and related distribution theory.

Order statistics, their distributions and properties, joint and marginal distributions of order statistics, extreme values and their asymptotic distributions (statement only) with applications. approximating distributions Delta method and its applications, approximating distributions of sample moments, transformations of statistics.

References :

1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students edition.
2. Rohatagi, V.K. (1984): An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973); Linear Statistical Inference and its Applications, Wiley Eastern.
4. Pitman, J. (1993): Probability, Narosa Publishing House.
5. Jonson, S. and Kotz, S. (1972): Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.

STM - 202 : MULTIVARIATE ANALYSIS Credits : 3

Multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector.

Wishart matrix – its distribution and properties, distribution of sample generalized variance, null and non-null distribution of multiple correlation coefficient.

Hotelling's T^2 and its sampling distribution, application in test on mean vector for one and more multivariate normal population and also on equality of components of a mean vector in multivariate normal population.

Classification problem: Standards of good classification, procedure of classification based on multivariate normal distributions.

Principal components, dimension reduction, canonical variates and canonical correlation— definition, use, estimation and computation.

References :

1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis, 2nd Ed., Willey.
2. Giri, N.C. (1977): Multivariate Statistical Inference, Academic Press.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, Marcel Dekker.
4. Morrison, D.F. (1976): Multivariate Statistical Methods, 2nd Ed. McGraw Hill.
5. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, J. Wiley.
6. Rao, C.R. (1973): Linear Statistical Inference and its Applications, 2nd Ed. Wiley.
7. Seber, G.A.F. (1984): Multivariate Observations, Wiley.

8. Sharma, S. (1996); Applied Multivariate Techniques, Wiley.
9. Srivastava, M.S. and Khatri, C.G. (1979): An introduction to multivariate statistics, North Holland.
10. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, Prentice Hall, 3rd Edition.

STM – 203 : DESIGN AND ANALYSIS OF EXPERIMENTS Credits : 3

Review of linear estimation and basic designs, missing plot technique:- General theory and applications, Analysis of Co-variance for CRD and RBD.

Incomplete block design: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments.

Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.

References :

1. Alok Dey (1986): Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiment, Springer.
3. Das, M. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
4. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.
5. Montgomery, C.D. (1976): Design and Analysis of Experiment, Wiley, New York.
6. Mysers, R.H. (1971): Response Surface Methodology, Allyn and Bacon.
7. Giri (1986): Analysis of Variance, South Asian Publishers.

STM – 204 : STATISTICAL INFERENCE – II Credits : 3

Consistent Asymptotic normal estimators and their properties, CAN estimators obtained by ML method in one parameter exponential case, Invariant estimators, location and scale invariant estimators, Pitman's method for obtaining location and scale invariant estimators.

Interval estimation by confidence sets, Neyman theory, general method for constructing confidence intervals, shortest confidence intervals, uniformly most accurate intervals, example based on normal distribution.

Neyman-Pearson lemma, generalized Neyman-Pearson lemma, monotone likelihood ratio families, UMP tests for one and two sided alternatives, admissibility and unbiasedness of tests, type A and type A_1 tests, similar tests, tests having Neyman structure, likelihood ratio test (LRT) asymptotic distribution of LRT statistic.

Wald's sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions.

References :

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.

3. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
6. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
7. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students' edition.

STM – 205 : STOCHASTIC PROCESSES Credits : 3

Introduction to stochastic processes (SPs): Classification of SPs according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler's ruin problem; Applications from social, biological and physical sciences.

Discrete state space continuous time MC: Kolmogorov – Feller differential equations; Poisson process, birth and death process; Wiener process as a limit of random walk; first-passage time and other problems.

Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem; study of residual life time process. Stationary process; weakly stationary and strongly stationary processes; Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov processes.

References :

1. Adke, S.R. and Manjunath, S.M. (1984): An Introduction to Finite Markov Processes, Willey Eastern.
2. Bharat, B.R. (2000): Stochastic Models: Analysis and Applications, new Age International, India.
3. Cinlar, E. (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W. (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E. (1963): The Theory of Branching Processes, Springer-Verlag.
6. Hoel, P.G., Port, S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes, Houghton Miffin & Co.
7. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
8. Karlin, S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Vol. 1, Academic Press.
9. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E. (1962): Stochastic Processes, Holden-Day.

STM – 206 : Practical paper based on the contents of Papers Multivariate Analysis (STM -202) Design of Analysis & Experiments (STM – 203) and Statistical Inference – II (STM – 204) & Stochastic Processes (STM – 205) Credits : 4

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

STM207M : STATISTICAL METHODS Credits : 2

Descriptive Statistics: Collection and Presentation of data, Measures of central tendency, dispersion, skewness and kurtosis for the study of nature of data.

Idea of correlation and regression, correlation coefficient, Method of least squares.

Important statistical distributions: Binomial, Poisson and normal distributions.

Elementary idea of test of significance.

References :

1. Bhat, B. R., Srivenkataramana, T. and Rao Madhava, K. S. (1996) : "Statistics : A Beginner's Text" Vol. I & II, New Age International (P) Ltd.
2. Snedecors, G.W. and Cochran, W.G. (1967) : "Statistical Methods", Iowa State university Press.
3. Goon, A.M., Gupta, .K. and Dasgupta, B. (1991) : "Fundamentals of Statistics" Vol. I, World Press, Calcutta.
4. Parzen, E. (1960) : "Modern Probability Theory and Its Applications", Wiley Eastern.
5. Mukhopadhyay, P. (1996) : "Mathematical Statistics", New Central Book Agency.
6. Hogg, R.V. and Craig, A.T. (1972) : "Introduction to Mathematical Statistics", Amerind Publishing Co.
7. Spiegel, M.R. (1967) : "Theory and Problem of Statistics", Schaum's Publishing Series.
8. Freund, J.E. (2001) : "Mathematical Statistics", Prentice Hall of India.

Semester III

STM – 301: STATISTICAL DECISION THEORY Credits : 3

Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles.

Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

Supporting and separating hyperplane theorems, minimax theorem of for finite parameter s pace, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Invariant decision rules – location parameter problems, invariance and minimaxity , admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations.

Sufficient statistics essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

References:

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, 2nd Edition. SpringerVerlag.
2. Ferguson, T.S. (1967): Mathematical Statistics – A Decision Theoretic Approach, Academic Pres.
3. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Bernando, J.M. and Smith, A.F.M. Bayesian Theory, John Wiley and Sons.
6. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 302 : DEMOGRAPHY Credits : 3

Coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices. population transition theory.

Measures of fertility; stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters; estimation of parity progression from open birth interval data.

Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table.

Stable and quasi-stable populations, intrinsic growth rate. Models of population growth and their filling to population data.

Internal migration and its measurement, migration models, concept of international migration.

Methods for population projection, component method of population projection, Nuptiality and its measurements.

References:

1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.
2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L. (1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.

5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.

6. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.

7. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society.

STM – 303 : RESEARCH METHODOLOGY AND PROJECT WORK – I Credits : 3

(In this paper there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation).

Concept and definitions, variables and hypotheses, theory and facts, formulation of research problems, development of research methodology and research methods-collection of data, statistical techniques used, evaluation and accuracy of results, developments of knowledge-approaches, rationalistic mode, scientific mode. Identification of problem, formulation of hypotheses, imagination in the formulation of scientific law, recognition of a problem area and identifying the relative questions.

Steps in research process-

A. Conceptual phase-formulation of the research problem, literature review, developing the hypothesis.

B. Empirical phase- preparing the research design, determination of sample size, collection of data.

C. Analytical phase- analysis of data, hypothesis testing, generalization and interpretations, writing up, conclusions.

Types of variables- independent, dependent and control variables.

Measurements - concept and level of measurement, scaling technique, validity and reliability of a measurement.

Types of data and methods of collection of data, pre-testing, pilot survey, longitudinal survey, prospective and retrospective surveys, sampling and non-sampling errors, sampling unit and sampling frame, population and sample, scrutinizing of data, estimation of coverage and errors in data collection, revisits.

References:

1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.

2. Dominowski, R.L. (1980): Research Methods, Prentice Hall Inc., New Jersey.

3. Mishra, R.P. (1980): Research Methodology, Handbook Concept Publishing Company, New Delhi.

4. IIPS (1996): Research Methodology, IIPS, Mumbai.

STM – 304 : ADVANCED OPERATIONS RESEARCH – I Credits : 3

Review of linear programming problems (LPP); revised simplex method; duality theorem; bounded variable problems.

Degeneracy in TP; unbalanced TP.

Two-person games; pure and mixed strategies; existence of solution and uniqueness of value in zero-sum games; finding solution in 2×2, 2×m and m×n games; reduction of game problem to a linear programming problem.

Dynamic Programming: Bellman's principle of optimality; general formulation of dynamic programming; computational methods and applications of dynamic programming in solving LPP.

Queuing Models: M/G/1 queue and Pollazcek – Khinchine result; steady-state solutions of $M/E_K/1$ and $E_K/M/1$ queues.

Non-Linear Programming: Kuhn-Tucker conditions; Wolfe's and Beale's algorithms for solving quadratic programming problems.

Analytical structure of deterministic inventory problems; EOQ formula of Harris; its sensitivity analysis and extensions allowing quantity discounts and shortages.

Inventory models with random demand; discrete and continuous stochastic inventory models with instantaneous demand.

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References:

1. Saaty, T.L. (1961): Elements of Queuing Theory with Applications; McGraw Hill.
2. Gross, D. and Harris, C.M. (1974): Fundamentals of Queuing Theory, John Wiley.
3. Hadley, G. (1964): Non-Linear and Dynamic Programming; Addison Wesley.
4. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
5. Kanti Swaroop, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
6. Philips, D.T., Ravindran, A. and Solberg, J.: Operations Research, Principles and Practice.
7. Mckinsey, J.C.C. (1952): Introduction to the Theory of Games; McGraw Hill.
8. Hadley, G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.

STM – 305 : RELIABILITY THEORY Credits : 3

Reliability concepts and measures; components and systems; coherent systems; Reliability of coherent system; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Life distributions; reliability function; hazard rate; common life distributions – exponential, Weibull, gamma, normal, etc.; Estimation of parameters and tests in these models.

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.

Basic ideas of accelerated life testing.

Notions of aging; IFR; IFRA; NBU; DMRL and NBUE classes and their duals; lo of memory property of the exponential distribution; closures of these classes under formation of coherent systems; convolution and mixtures.

Univariate shock models and life distribution arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.

Maintenance and replacement policies; availability of reparable systems; modelling of a repairable system by a non-homogeneous Poisson process.

Reliability growth models; Probability plotting techniques.

References:

1. Cox, D. R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
2. Gross A. j. and Clark, V.A. (1975): Survival Distribution: Reliability applications in the Biomedical Sciences, John Wiley and Sons.
3. Elandt – Johnson, R.E. Johnson N. L.: Survival Models and Data Analysis, John Wiley and Sons.
4. Miller, R. G. (1981): Survival Analysis (John Wiley).

5. Kalbfleisch J. D. and Prentice R. (1980): The Statistical Analysis of failure Time data, John Wiley.

STM – 306 : COMPUTER - INTENSIVE STATISTICAL METHODS – I Credits : 3

Exploratory data analysis: transforming data, graphical methods of clustering, outliers.

Linear regression**:** Influential observations and diagnostics robust methods, collinearity, variable selection.

Generalized linear models: exponential families and ML estimation, analysis of deviance and variable selection, logistic regression.

Nonlinear regression: estimation, hypothesis testing, goodness of fit.

EM algorithm: applications to missing and incomplete data problems, mixture models.

Smoothing with kernels, density estimation, simple non-parametric regression.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References :

1. R. Gnandesikan (1997): Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley.
2. D.A. Belsley, E. Kuh, and R.E. Welsch (1980): Regression Diagnostics, Wiley.
3. P. McCullagh and J.A. Nelder (1999): Generalized Linear Models, Third edition, Chapman and Hall.
4. G.E.F. Seber and C.J. Wild (1989): Nonlinear Regression, Wiley.
5. G.J. McLachlan and T. Krishnan (1997): The EM Algorithms and Extensions, Wiley.
6. J.S. Simonoff (1996): Smoothing Methods in Statistics, Springer.

STM – 307 : TIME SERIES ANALYSIS Credits : 3

Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties.

Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

Detailed study of the stationary processes: (1) moving average (MA), (2) auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods.

Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, estimation of ARIMA model parameters.

Spectral analysis of weakly stationary process, peridogram and correlogram analyses, computations based on Fourier transform.

References:

1. Box, G.E.P. and Jenkins, G.M. (1976): Time series analysis—Forecasting and Control, Holden-day, San Francisco.
2. Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
3. Montgemory, D.C. and Johnson, L.A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
4. Kendall, Sir Maurice and Ord, J.K. (1990): Time Series (Third Edition), Edward Arnold.
5. Brockwell, P.J. and Davis, R.A.: Time Series: Theory and Methods (Second Edition), Springer-Verlag.
6. Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.

7. Granger, C.W.J. and Newbold (1984): Forecasting Econometric Time Series, Third Edition, Academic Press.
8. Priestley, M.B. (1981): Spectral Analysis & Time Series, Griffin, London.
9. Kendall, M.G. and Stuart A. (1966): The Advanced Theory of Statistics, Volume 3, Charles Griffin, London.
10. Bloomfield, P. (1976): Fourier Analysis of Time Series—An Introduction, Wiley.
11. Granger, C.W.J. and Hatanka, M. (1964): Spectral Analysis of Economic Time Series, Princeton Univ. Press, N.J.
12. Koopmans, L.H. (1974). The spectral Analysis of Time Series, Academic Press.
13. Nelson, C.R. (1973): Applied Time Series for Managerial Forecasting, Holden-Day.
14. Findley, D.F. (Ed.) (1981): Applied Time Series Analysis II, Academic Press.

STM - 308 : Practical paper based on the contents of Papers Demography (STM – 302) and selected Major Elective Papers Credits : 4

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

STM309M : SAMPLING THEORY, DESIGN OF EXPERIMENTS AND DATA ANALYSIS

Credits : 2

(The course will involve only the concepts and uses of theories rather than rigorous derivations of the results.)

Basic concepts of sampling from a finite population; sampling versus complete enumeration; simple random sampling; sample size determination; stratified random sampling; systematic sampling; cluster sampling and multi – stage sampling (all sampling schemes without proof of expressions).

Analysis of variance techniques: One way and two way classified data.

Design of experiments: Randomization, replication, local control; completely randomized design; randomized block design and Latin square design.

References :

1. Cochran, W.G. (1977) : Sampling Techniques, 3rd Edition, Wiley.
2. DesRaj (2000) : Sample Survey Theory, Narosa Publishing House
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
4. Das, M.N. and Giri, N (1986) : Design and Analysis of Experiments, Springer Verlag.
5. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991) : Fundamentals of Statistics, Vol. II, World Press, Calcutta
6. Gibbons, J.D. (1985) : Non – Parametric Statistical Inference, 2nd Edition, Marcel Dekkar, Inc.
7. Rohatgi, V.K. (1988) : An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
8. Siegel, S. : Non – Parametric Statistics for the Behavioural Sciences,
9. Mood, A.M., Greybill, F.A. and Boes, D.C. (1974) : Introduction to the Theory of Statistics, McGraw Hill

Semester IV

STM - 401 : BAYESIAN INFERENCE Credits : 3

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, hierarchical priors and partial exchangeability. Parametric Empirical Bayes.

Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference.

Bayesian decision theory: Bayes solutions for practical decision problems. Point estimation, credible sets, testing of hypotheses. Comparison with classical procedures.

Ideas on Bayesian robustness. Asymptotic expansion for the posterior density. Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof).

References:

1. Berger, J.O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.
4. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
5. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.
6. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
7. Box, G.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.

STM - 402 : NON - PARAMETRIC AND SEMI - PARAMETRIC METHODS

Credits : 3

Empirical distribution function, Gilvenko Cantelli Theorem, Kolmogorov Goodness of fit test.

One sample U-statistics, kernel and symmetric kernel, two sample U-statistics, asymptotic distribution of U-statistics. UMVUE property of U-statistics, asymptotic distribution of linear function of order statistics.

Rank tests, locally most powerful rank tests, linear rank statistics and their distributional properties under null hypothesis, Pitman's asymptotic relative efficiency.

One sample location problem, sign test and signed rank test, two sample Kolmogorov Smirnov tests, two simple location and scale problems. Wilcoxon-Mann-Whitney test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis K sample test.

Cox's proportional hazards model, rank test (partial likelihood) for regression coefficients, Concepts of jackknifing method of Queenouille for reducing bias, Bootstrap methods.

References:

1. Davison, A.C. and Hinkley, D.V. (1997): Bootstrap Methods and Their Application, Cambridge University Press.
2. Gibbons, J.D. (1985): Non-Parametric Statistical Inference, 2nd ed. Marcel Dekker, Inc.
3. Randles, R.H. and Woffe, D.A. (1979): Introduction to the Theory of Non-Parametric Statistics, John Wiley & Sons, Inc.
4. Fraser. D.A.S. (1957): Nonparametric Methods in Statistics, John Wiley & Sons, Inc.

5. Hajek, J. and Sodal. Z. (1967): Theory of Rank Tests, Academic Pess.
6. Puri, M.L. and Sen, P.K. (1971): Nonparametric Methods of Multivariate Analysis, John Wiley & Sons, Inc.
7. Cox, D.R. and Oakes, D. (1983): Survival Analysis, Chapman and Hall.

STM – 403 : APPLIED REGRESSION ANALYSIS Credits : 3

Residuals and their analysis, influential observations, power transformations for dependent and independent variables.

Robust and L-1 regression, estimation of prediction error by cross-validation and boot-strap.

Non-linear regression models, different methods of estimation (Least squares, Maximum Likelihood), Asymptotic properties of estimators

Generalized linear models, analysis of binary and grouped data by using logistic models, log-linear models.

Bayes analysis of linear and generalized linear models.

References:

1. Bates, D.M. and Watts, D.G. (1988): Nonlinear Regression, Analysis and its Application, Wiley, New York.
2. Cook, R.D. and Weisberg, S. (1982): Residuals and Inference in Regression, Chapman and Hall, London.
3. Draper, N.R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., Willey, New York.
4. Efron, B. and Tibsirani, J.R. (1993): An Introduction to the Bootstrap, Chapman and Hall, New York.
5. Kashirsagar, A.M. (1995): Growth Curves, Marcel and Dekker, New York.
6. McCullagh, P. and Nelder, J.A. (1989): Generalized Linear Models, 2nd Ed., Chapman and Hall, London.
7. Searle, S.R. (1987): Linear Models for Unbalanced Data, Wiley, New York.
8. Seber, G.A. and Wild, G.J. (1989): Nonlinear Regression, Wiley, New York.
9. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 404: SURVIVAL ANALYSIS Credits : 3

Concept of time, order and random censoring, likelihood in the distributions – exponential, gamma, Weibull, lognormal, Pareto, Linear failure rate, inference for these distribution.

Life tables, failure rate, mean residual life and their elementary classes and their properties.

Estimation of survival function – actuarial estimator, Kaplan – Meier estimator, estimation under the assumption of IFR/DFR, tests of exponentiality against non-parametric classes, total time on test.

Two sample problem – Gehan test, log rank test.

Semi-parametric regression for failure rate – Cox's proportional hazards model with one and several covariates. rank test for the regression coefficient.

Competing risk model, parametric and non-parametric inference for this model.

Multiple decrement life table.

References:

1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

STM – 405 : ADVANCED OPERATIONS RESEARCH – II Credits : 3

Integer programming: Branch and bound algorithm and cutting plane algorithm. Multi-criterion and goal programming.

Concept of stochastic programming.

Sequencing and scheduling problems: 2 machine n-job and 3–machines n-job problems with identical machine sequence for all jobs, 2-job n-machine problem with different routings, travelling-salesman problem.

Sensitivity analysis: Changes in cost vector, requirement vector and coefficient matrix A. Parametric programming: variation in objective function coefficients and availability of resources.

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

References:

1. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
2. Hillier, F.S. and Leiberman, G.J. (1962): Introduction to Operations Research; Holden Day.
3. Kanti Swaroop, Gupta, P.K. and Singh, M. M. (1985): Operations Research; Sultan Chand and Sons.
4. Churchman, C.W.; Ackoff, R.L. and Arnoff, E.L. (1957): Introduction to Operations Research; John Wiley.
5. Mckuisey, J.C.C. (1952): Introduction to the Theory of Games, McGraw Hill.
6. Kleinrock, L. (1975): Queuing Systems, Vol. I; John Wiley.
7. Hadley G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.
8. Starr, M. K. and Miller, D.W. (1962): Inventory Control – Theory and Practice; Prentice Hall.
9. Shamblin, J.E. and Stevens, G.T. (1974): Operations Research: A Fundamental Approach; McGraw Hill.

STM – 406: STATISTICAL PROCESSES AND QUALITY CONTROL Credits : 3

Basic concepts of process monitoring ad control; process capability and process optimization.

General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic design of X-bar chart.

Acceptance sampling plans for attributes inspection; single and double sampling plans and their properties; plans for inspection by variables for one-sided and two sided specification.

Mil Std. and IS plans; continuous sampling plans of Dodge type and Wald-Wolfiwitz type and then properties.

Sequential sampling plan and its properties; Bayesian sampling plans.

Capability indices Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Use of design of experiments in SPC; factorial experiments, fractional factorial designs; construction of such designs and analysis of data.

Multivariate quality control; use of control ellipsoid and of utility functions.

References

1. Montgomery, D.C. (1985): Introduction to Statistical Quality Control; Wiley.
2. Montgomery, D.C. (1985): Design and Analysis of Experiments; Wiley.
3. Ott, E.R. (1975): Process Quality Control; McGraw Hill
4. Phadke, M.S. (1989): Quality Engineering Through Robust Design; Prentice Hall.
5. Wetherill, G.B. (1977): Sampling Inspection and Quality Control; Halsted Press.
6. Wetherill, G.B. and Brown, D.W.: Statistical Process Control: Theory and Practice.

STM – 407 : QUANTITATIVE EPIDEMIOLOGY Credits : 3

Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.

Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference.

Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.

Special Topics: epidemiology of infections and chronic disease, Cancer and cancer prevention, environmental epidemiology.

References:

1. K. J. Rothman and S. Geenland (ed.) (1988). Modern Epidemiology, Lippincott-Raven.
2. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. D. McNeil (1996). Epidemiological Research Methods. Wiley and Sons.
4. J. F. Jekel, J. G. Elmore, D.L. Katz (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.

STM – 408 : CLINICAL TRIALS Credits : 3

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I – IV trials, multicenter trials.

Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of phase III trials with sequential stopping,

Reporting and analysis: analysis of categorical outcomes from Phase I – III trials, analysis of survival data from clinical trials.

Introduction to Meta-analysis of clinical trials.

References:

1. S. Piantadosi (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
2. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. L. M. Friedman, C. Furburg, D. L. Demets (1998): Fundamentals of Clinical Trials Springer Verlag.
4. J. L. Fleiss (1989): The Design and Analysis of Clinical Experiments. Wiley and Son.
5. E. Marubeni and M. G. Valsecchi (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

STM – 409 : COMPUTER - INTENSIVE STATISTICAL METHODS – II Credits : 3

Stochastic simulation: generating random variables, simulating standard univariate and multivariate distributions.

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

Markov Chain Monte Carlo Methods: Gibbs sampling for standard distributions.

Simulation based testing: simulating test statistics and power functions, permutation tests.

Bootstrap methods: re sampling paradigms, bias and standard errors, confidence intervals.

Jackknife and cross validation.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:

1. G.S. Fishman (1996): Monte Carlo: Concepts, Algorithms, and Applications, Springer.
2. R.Y. Rubinstein (1981): Simulation and the Monte Carlo Method, Wiley.
3. M.A. Tanner (1996): Tools for Statistical Interference, Third edition, Springer.
4. B. Efron and R.J. Tibshirani (1993): An introduction to the Bootstrap, Chapman and Hall.
5. J. Shao and D. Tu (1995): Jackknife and the Bootstrap, Springer Verlag.

STM – 410 : COMPUTER PROGRAMMING Credits : 3

This course is intended to introduce object-oriented computer programming. It assumes prior exposure to programming in languages in such as C and/or Fortran. The language of choice here is C^{++}.

Introduction to object-oriented programming concepts and design.

Programming in C^{++}: data types and operations, functions and parameters, classes, constructors, input output, control statements such as if-else, switch, for, while and do-while, pointers and references, dynamic allocation, processing of linked lists, arrays and character strings, libraries.

Introduction to program analysis: simple testing and debugging.

Note on practicals/tutorials: As this is programming course, hand-on practical sessions are important and should be held in conjunction with lectures.

References:

1. R. Decker, and S. Hirshfield (1998): The Object Concept: An Introduction to Computer Programming using C^{++}, PWS Publishing.
2. S.B. Lippmann and J. Lajole (1998): C_{++} Primer. Third edition, Addison-Wesley.
3. P. Naughton (1996): The Java Handbook. Tata McGraw-Hill.

4. W.J. Savitch (2001): Problem Solving with C_{++}: The Object of Programming Edition, Addison-Wesley Longman.

5. K. Fukunga (1990): Introduction to Statistical Pattern Recognition, Second Edition, Academic Pres s.

6. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.

7. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 411 : STATISTICAL PATTERN RECOGNITION Credits : 3

Linear classifiers: Linear discriminant function (LDF) for minimum squared error. LDF for binary outputs, perception learning algorithm.

Nearest neighbour decision rules: description, convergence, finite sample considerations, use of branch and bound methods.

Probability of errors: Two classes, normal distributions, equal covariance matrix assumptions, Chernolf bounds and Bhattacharya distance, estimation of probability of error.

Feature selection and extraction: Interclass distance measures, discriminant analysis, probabilistic distance measures, principal components.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:

1. R.O. Duda and P.E. Hart (1973): Pattern Recognition and Scene Analysis, Wiley.

2. K. Fukunga (1990): Introduction to Statistical Pattern Recognition. Second Edition, Academic Press.

3. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.

3. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 412 : ECONOMETRICS Credits : 3

Nature of econometrics, the general linear model (GLM) and its extensions, ordinary least squares (OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction, heteroscedastic disturbances, pure and mixed estimation.

Auto correlation, its consequences and tests. Theil BLUS procedure, estimation and prediction, multicollinearity problem, its implications and tools for handling the problem, ridge regression.

Linear regression and stochastic regression, instrumental variable estimation. errors in variables, autoregressive linear regression, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model.

Simultaneous linear equations model and its generalization, identification problem, restrictions on structural parameters, rank and order conditions.

Estimation in simultaneous equations model, recursive systems, 2 SLS estimators.

References :

1. Apte, P.G. (1990): Text books of Econometrics, Tata McGraw Hill.

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

3. Gujarathi, D. (1979): Basic Econometrics, McGraw Hill.

4. Intrulligator, M.D. (1980): Econometric models—Techniques and applications, Prentice Hall of India.

5. Johnston, J. (1984): Econometric methods. Third edition, McGraw Hill.

6. Klein, L.R. (1962): An introduction to Econometrics, Prentice Hall of India.
7. Koutsoyiannis, A. (1979): Theory of Econometrics, Macmillan Press.
8. Malinvaud, E. (1966): Statistical methods of Econometrics, North Holland.
9. Srivastava, V.K. and Giles D.A.E. (1987): Seemingly unrelated regression equations models, Maicel Dekker.
10. Theil, H. (1982): Introduction to the theory and practice of Econometrics, John Wiley.
11. Walters, A. (1970): An introduction to Econometrics, Macmillan & Co.
12. Wetherill, G.B. (1986): Regression analysis with applications, Chapman Hall.

STM – 413 : ACTUARIAL STATISTICS Credits : 3

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

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 decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

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 and varying benefit insurance, recursions, commutation functions.

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities.

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

A brief outline of payment premiums and net premiums

References:

1. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1966), 'Actuarial Mathematics,' Society of Actuarials, Ithaca, Illinois, U.S.A., Second Edition (1997).
2. Spurgeon, E.T. (1972): Life Contingencies, Cambridge University Press.
3. Neill, A. (1977): Life Contingencies, Heinemann.

STM – 414 : OFFICIAL STATISTICS Credits : 3

Introduction to Indian and International statistical systems. role, function and activities of central and state statistical organizations, organization of large scale sample surveys, role of national sample survey organization general and special data dissemination systems.

Population growth in developed and developing countries, evaluation and performance of family welfare programmes, projections of labour force and manpower, scope and content of population census of India.

System of collection of agricultural statistics, crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

References:

1. Basic Statistics Relating to the Indian Economy (CSO), 1990.
2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO), 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V.G.: Estimation of Crop Yields (FAO).
6. Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

STM – 415 : Practical paper based on the contents of selected Elective Papers

Credits : 3

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

STM– 416 : Project Work - II Credits : 2

(The Project Work – II will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce).