



**OFFICE OF THE DEAN
SCHOOL OF MATHEMATICAL AND PHYSICAL SCIENCES
DHANAMANJURI UNIVERSITY, MANIPUR**

No.1/3/2024-SYL/SMPS(DMU)

Imphal, the 22nd June, 2026

To

The Registrar
DMU, Manipur

Subject: Submission of Syllabi for M.Sc.1 yr and M.Sc.2 yrs programmes in Chemistry and Statistics
(2026-27)

Sir

I am to submit herewith Syllabi for M.Sc.1 yr and M.Sc.2 yrs programmes in Chemistry and Statistics (2026-27) after approval in its BSS meeting held on 22nd July, 2026 through recommendations of corresponding DBSs of the concerned departments. The syllabi for the two subjects are enclosed herewith for your doing the needful.

With regards,

Encl.: As stated above.

Yours faithfully


(Prof. L. Nandababu Singh)

Dean

School of Mathematical and Physical Sciences
DMU, Manipur

Proceedings of the BSS Meeting under School of Mathematical and Physical Sciences, DMU held on 22/06/2026

Proceedings of BSS meeting held on 22/06/2026 at 1p.m. in the Office of the Dean with Prof. L.Nandababu Singh in the Chair, are detailed below.

Agenda of the meeting:

- 1.Approval of syllabi for M.Sc. 1yr and M.Sc.2 yrs programmes in Chemistry and Statistics
- 2.Approval of Guidesheets.

The following members were present in the meeting:

- 1.Prof.R.K. London Singh(Chemistry Dept.,DMU)-Member
- 2.Prof.N.Sharat Singh(Statistics Dept.,DMU)-Member
- 3.Prof.M.Kuber Singh(Mathematics Dept.,DMU)-Member
- 4.M.Shomananda Singh(Assoc.Prof.,Physics Dept.,DMU)-Member
- 5.Thingom Biswajit(Asst.Prof.,Electronics Dept.,DMU)
- 6.Dr.S.Sobita Devi(Asst.Prof.,Statistics Dept.,DMU)
- 7.Dr.M.Aken Singh(Asst.Prof.,Chemistry Dept.,DMU)

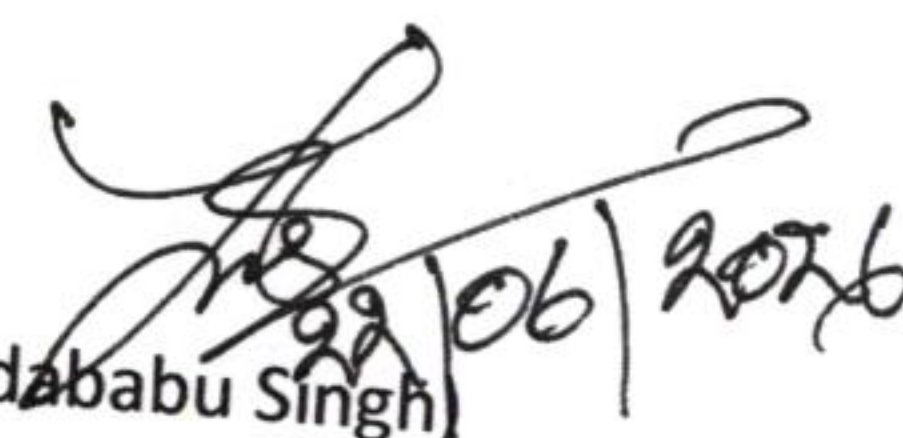
In the meeting, the following resolutions were taken:

Resolution1: The syllabi for M.Sc.1 yr and M.Sc.2yrs programmes in Chemistry and statistics recommended from corresponding DBSs, were further approved. *Electronics*

Resolution2: Recommendation of Dr.S.Samarendra Singh(Assoc. Prof.,Dept. of Mathematics,DMU) as supervisor for Durgamohon Polem(Asst. Prof.,Dept. of Computer Science,DMU) by BSD of Mathematics Department,DMU, has been further approved in the BSS meeting.

Resolution3: Three faculty members-(a)Dr. Th. Birkramjit Singh(Asst.Prof.,Department of Mathematics,DMU)(b) Dr.Kh.Babina Devi(Asst.Prof.,Department of Mathematics,DMU), and (c) Dr.Ch. Sonia (Asst.Prof.,Department of Mathematics,DMU), who were recommended for Guidesheets by BSD of Mathematics Department,DMU, have been further approved in the BSS meeting.

The meeting ended with thanks from Chairperson.


(Prof.L.Nandababu Singh)
Chairperson(Dean),
School of Mathematical and Physical Sciences,DMU

Dean
School of Mathematical and Physical Sciences
Ghanamanjuri University, Manipur



DEPARTMENT OF STATISTICS
DHANAMANJURI UNIVERSITY, MANIPUR

To

The Chairman,

Board of Studies of the School (BSS)
School of Mathematical and Physical Sciences, DMU

Subject: Submission of Syllabus 1 (one) year and 2 (two) years PG Programme in Statistics

Sir,

As approved by the BSD, Department of Statistics, Dhanamanjuri University, Imphal, hereby submit the above-mentioned Syllabus for your kind approval.

With due regards,

Encl: Details of cited above

Imphal, The 19th June, 2026

Yours sincerely,

O. Tomba Singh

(Dr. O. Tomba Singh)
Head, Dept. of Statistics

Dhanamanjuri University, Imphal

Head
Department of Statistics
Dhanamanjuri University

DHANAMANJURI UNIVERSITY
MANIPUR



SYLLABUS FOR 1 (ONE) YEAR M.SC. STATISTICS
BASED ON UGC CURRICULUM AND CREDIT
FRAMEWORK

JUNE, 2026

1. INTRODUCTION

The National Education Policy (NEP), 2020 envisions a transformative framework for higher education in India, emphasizing flexibility, multidisciplinary learning, skill enhancement, and outcome-based curriculum design. In alignment with this vision, the University Grants Commission (UGC) has developed a new Curriculum and Credit Framework for Postgraduate Programmes in June 2024. The duration of the postgraduate programme shall be either 1 year or 2 years. The revised framework focuses on strengthening analytical thinking, computational skills, research aptitude, and practical applications of statistics relevant to academia, industry, government, and society.

In line with NEP 2020, the Department of Statistics has adopted the Curriculum and Credit Framework for both 1-year and 2-year postgraduate programmes. The curriculum integrates theoretical foundations, statistical computing, data analysis, modern statistical methodologies, and interdisciplinary applications to prepare students for professional careers, research, and lifelong learning in the field of Statistics.

2. LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

Nature and Extent of the M.Sc. Programme in Statistics

The Learning Outcome-Based Curriculum Framework (LOCF) for the M.Sc. Programme in Statistics is designed to reflect the depth, breadth, and interdisciplinary nature of contemporary statistical education. The programme encompasses Discipline Specific Core (DSC) and Discipline Specific Elective (DSE) courses covering areas such as Real Analysis, Linear Algebra, Distribution Theory, Probability Theory, Stochastic Processes, Linear Models and Regression Analysis, Multivariate Analysis, Design and Analysis of Experiments, Survival Analysis, Advanced Statistical Inference, Reliability Theory, Non-Parametric Inference, Demography, Econometrics, Time Series Analysis, Operations Research, Bayesian Inference, Official Statistics, Statistical Decision Theory, and Data Science Methods.

The curriculum emphasizes statistical computing, data analysis, research methodology, and project-based learning. It equips students with the knowledge and skills necessary to address challenges in science, technology, business, public policy, health, and social sciences through evidence-based decision-making. Through structured learning outcomes, the programme promotes quantitative reasoning, computational proficiency, research competence, ethical practices, and interdisciplinary collaboration, preparing graduates for careers in academia, research institutions, government agencies, industries, and data-driven enterprises.

Programme Objectives

- a. To provide students with a strong foundation in statistical theory, methodology, and applications across diverse domains.
- b. To cover a broad spectrum of statistical disciplines ranging from mathematical foundations to advanced data analytical techniques.

- c. To develop expertise in core areas such as Probability Theory, Statistical Inference, Linear Models, Multivariate Analysis, Experimental Design, and Stochastic Processes.
- d. To offer flexibility through elective courses including Reliability Theory, Econometrics, Demography, Time Series Analysis, Bayesian Inference, Official Statistics, Statistical Decision Theory, and Data Science.
- e. To promote both theoretical understanding and practical competence through statistical computing, data analysis laboratories, projects, and research work.
- f. To integrate modern computational tools, statistical software, and data science methodologies with traditional statistical approaches.
- g. To cultivate critical thinking, problem-solving ability, quantitative reasoning, and research aptitude, enabling students to contribute effectively in academic, industrial, and policy-making environments.

Programme Attributes

- a. Advanced disciplinary, interdisciplinary, and multidisciplinary knowledge.
- b. Mastery of core and elective courses in Statistics.
- c. Research competence and analytical ability.
- d. Statistical computing and data analytical skills.
- e. Proficiency in statistical software, programming, modelling, simulation, and interpretation of data.
- f. Critical thinking, quantitative reasoning, and problem-solving skills.
- g. Effective communication and professional aptitude.
- h. Skills in scientific writing, technical reporting, presentation, and dissemination of statistical findings to academic, professional, and public audiences.
- i. Ethical awareness and responsible use of data.
- j. Familiarity with statistical software packages, computational tools, data science platforms, and digital technologies relevant to statistical research and practice.
- k. Preparedness for continuous professional development, competitive examinations, higher studies, and research careers.

3. PROGRAMME LEARNING OUTCOMES (PLO)

Upon successful completion of the M.Sc. Programme in Statistics, students will be able to:

- a. Demonstrate comprehensive knowledge of mathematical and statistical concepts, theories, and methodologies at advanced levels.

- b. Apply statistical principles and methodologies to design studies, collect, manage, analyze, and interpret data in diverse fields.
- c. Utilize advanced statistical techniques, computational tools, and software for solving real-world problems and conducting research.
- d. Critically evaluate statistical literature, research findings, and methodological developments to support evidence-based decision-making.
- e. Conduct independent and collaborative research with ethical responsibility, contributing to scientific advancement and societal development.
- f. Communicate statistical findings effectively through technical reports, scientific writing, presentations, and outreach activities tailored to academic, professional, and public audiences.
- g. Integrate interdisciplinary knowledge from mathematics, computer science, economics, health sciences, environmental studies, and other allied fields to address complex problems.
- h. Demonstrate leadership, teamwork, adaptability, and professional competence in academic, industrial, governmental, and research settings.
- i. Engage in lifelong learning and professional development, preparing for careers in academia, research institutions, government organizations, industries, financial sectors, and data-driven enterprises.
- j. Apply statistical thinking and data-driven approaches to support policy formulation, planning, sustainable

Course Structure of 1-Year PG Programme (Statistics)

Semester-I

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	Number of credits
STA-611	DSC	Design and Analysis of Experiments	20	80	100	4
STA-612	DSC	Statistical Computing II (Practical)	-	100	100	4
STA-613	DSE	Reliability Theory	20	80	100	4
STA-614	DSE	Non-Parametric Inference	20	80	100	4
STA-615	DSE	Demography	20	80	100	4
STA-616	DSE	Econometrics	20	80	100	4
STA-617	DSE	Time Series Analysis	20	80	100	4
STA-618	DSE	Operation Research	20	80	100	4
STA-619	DSE	Bayesian Inference	20	80	100	4
STA-620	DSE	Statistical process and quality control	20	80	100	4
Total					500	20
Any THREE papers out of the Paper Nos. STA-613 to STA-620						

Semester-II

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	No. of credits
STA-621	DSC	Survival Analysis	20	80	100	4
STA-622	DSC	Advanced statistical inference	20	80	100	4
STA-623	DSE	Advanced Design & Analysis of Experiment	20	80	100	4
STA-624	DSE	Official Statistics	20	80	100	4
STA-625	DSE	Advanced Statistical Computing & Data Mining	20	80	100	4
STA-626	DSE	Statistical Decision Theory	20	80	100	4
STA-627	DSE	Actuarial statistics	20	80	100	4
STA-628	DSC	Research Methodology	10	40	50	2
STA-629	DSE	Research (Thesis/Dissertation/ Project work/Field work/Patent)	-	150	150	6
	VAC/ AEC	Environment & climate change/ Disaster management/ Foreign language	-	50	50	2
Total					550	22
Any ONE papers out of the Paper Nos. STA-623 to STA-627						

DETAILED SYLLABI

Semester –I

STA-611: Design and Analysis of Experiments

Unit I: Introduction to designed experiments; General block design and its information matrix (C), criteria for connectedness, balance and orthogonality; Intrablock analysis (estimability, best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypotheses); BIBD- recovery of interblock information; Youden design - intrablock analysis. Analysis of covariance in a general Gauss-Markov model, applications to standard designs.

Unit II: Fixed, mixed and random effects models; Variance components estimation – study of various methods; Tests for variance components; Missing plot technique – general theory and applications.

Unit III: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2 and 3 factorial experiments in randomized blocks; Complete and partial confounding. Fractional replication for symmetric factorials. Split plot and split block experiments.

Unit IV: Application areas: Response surface experiments; first order designs and orthogonal designs; clinical trials, longitudinal data, treatment- control designs; Model validation and use of transformation; Tukey's test for additivity.

Reference Books:

1. Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiments, Springer.
3. Das, M.N. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
4. Giri, N. (1986): Analysis of Variance, South Asian Publishers.
5. John, P.W.M. (1971): Statistical Design and Analysis of Experiments, Macmillan.
6. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.
7. Montgomery, C.D. (1976): Design and Analysis of Experiments, Wiley, New York.
8. Myers, R.H. (1971): Response Surface Methodology, Allyn & Bacon.
9. Pearce, S.C. (1984): Design of Experiments, Wiley, New York.
10. Rao, C.R. and Kleffe, J. (1988): Estimation of Variance Components and applications, North Holland.
11. Searle, S. R., Casella, G. and McCulloch, C. E. (1992): Variance Components, Wiley.

STA-612: Statistical Computing II (Practical)

UNIT I: Introduction to R: Installing R, R console, Script file, Workspace, Getting help, R packages, Installing and loading packages. R data structures: vectors, matrices, array, data frames, factors, lists. Creating datasets in R, Importing and exporting dataset, annotating

datasets. Graphs: Creating and saving graphs, customizing symbols, lines, colors and axes, combining multiple graphs into one, bar plots, boxplot and dot plots, pie chart, stem and leaf display, histogram and kernel density plots. Data management: Manipulating dates and missing values, understanding data type conversion, creating and recoding variables, sorting, merging and sub-setting data sets. Mathematical and statistical functions, character functions, looping and conditional statements, user defined functions.

UNIT II: Basic statistics: Descriptive statistics, frequency and contingency tables, outlier detection, testing of normality, basics of statistical inference in order to understand hypothesis testing, p-value and confidence intervals. Parametric tests: Tests for population mean and variance for two or more populations, tests for independence and measures of association, sample size determination for common statistical methods using pwr package. Nonparametric tests.

UNIT III: Correlation: Correlations between quantitative variables and their associated significance tests. Regression Analysis: Fitting simple and multiple regression model forward, backward and stepwise regression, polynomial regression, regression diagnostics to assess the statistical assumptions, methods for modifying the data to meet these assumptions more closely, selecting a final regression model from many competing models. ANOVA: Fitting and interpreting ANOVA type models, evaluating model assumptions, basic experimental designs: CRD, RBD, LSD and factorial experimental designs.

UNIT IV: Time series Analysis: Creating and manipulating a time series, Components of a time series, auto-correlation and partial correlation function, estimating and eliminating the deterministic components of a time series. Developing Predictive Models: Forecasting using exponential models, predictive accuracy measures for time-series forecast, testing for stationarity, Forecasting using ARMA and ARIMA models. EM algorithm: Applications to missing and incomplete data problems, mixture models

Reference Books:

1. Crawley, M.J. (2013). The R Book, 2nd ed., John Wiley.
2. Davies, T. M. (2016). The Book of R: A First Course in Programming and Statistics, No Starch Press, San Francisco.
3. Field, A., Miles, J. and Field, Z. (2012). Discovering Statistics using R, Sage, Los Angels.
4. Kabacoff, R.I. (2015). R in Action: Data Analysis and Graphics in R, 2nd ed., Manning.

STA-613: Reliability Theory

Unit I: Reliability concepts & measures, components and systems, coherent system, reliability of the coherent system. Availability, types of availability- point wise, interval, asymptotic. Failure rate and mean time to failure and their inter-relationships. Statistical failure models: exponential. gamma, weibull, pareto, normal, lognormal and related distributions.

Unit II: System components and configurations: series-parallel, parallel-series, and K-out of -N- system. Series- strength reliability and its estimation. Reliability Bounds- classical and Bayesian approach.

Unit III: Maintenance Policies, System with imperfect switch. Concept of redundancy, types of redundancy, priority redundant, repairable system, comparison of component, unit and standby redundancies.

Unit IV: Model Plotting techniques: Reliability function with Markov model. Two unit cold standby & parallel unit system with constant failure rate, Arbitrary Repair rates & Regenerative point Techniques. Stress strength reliability and its estimation. IFR, IFRA, NBU, DMRL and NBUE and their duals, loss of memory property of the exponential distribution.

Reference Books:

1. Bain, L.J. and Engelhardt, M. (1991). Statistical Analysis of Reliability and Life- Testing Models, Marcel Dekker Inc., U.S.A.
2. Martz, H.F. and Wailer, R.A. (1982). Bayesian Reliability Analysis, John Wiley and Sons, Inc., New York.
3. Sinha, S.K. (1986). Reliability and Life-Testing, Wiley Eastern Ltd., New Delhi.

STA-614: Non-Parametric Inference

Unit-I: Density estimates, survey of existing methods. Rosenblatt's naïve density estimator, its bias and variance. Consistency of Kernel density estimators and its MSE.

Unit-II: one-sample problems based on sign test, Wilcoxon signed Rank test, run test and Kolmogorov – Smirnov test. Two sample problems based on sign test, Wilcoxon signed rank test for paired comparisons, Wilcoxon Mann-Whitney test, (Expectations and variances of above test statistics, Statements about their exact and asymptotic distributions).

Unit-III: Two sample problems based on Kolmogorov – Smirnov Test, Wald-Wolfowitz Runs test and Normal scores test. Ansari-Bradley test for two sample dispersions. (Expectations and variances of above test statistics, Statements about their exact and asymptotic distributions).

Unit-IV: Chi-Square test of goodness of fit and independence in contingency tables. Tests for independence based on Spearman's rank correlation and Kendall's Tau. Kruskal-Wallis test for one-way layout (K-samples). Friedman test for two-way layout (randomised block).

Unit-V: Asymptotic Relative Efficiency (ARE) and Pitman's theorem. ARE of one sample, paired sample and two sample locations tests. The concept of Rao's second order efficiency and Hodges-Lehman's deficiency with examples.

Reference Books:

1. Gibbons, J.D. (1978). *Nonparametric Statistical Inference*, McGraw-Hill Book Company, New York.
2. Hollander, M. and Wolfe, D.A. (1999). *Nonparametric Statistical Methods* (2nd Edition), John Wiley & Sons, Inc., New York.
3. Silverman, B.W. (1986). *Density Estimation for Statistics and Data Analysis*, Chapman and Hall, London.
4. Conover, W.J. (1999). *Practical Nonparametric Statistics* (3rd Edition), John Wiley & Sons, Inc., New York.
5. Siegel, S. and Castellan, N.J. (1988). *Nonparametric Statistics for the Behavioral Sciences* (2nd Edition), McGraw-Hill Book Company, New York.
6. Ferguson, T.S. (1967). *Mathematical Statistics: A Decision Theoretic Approach*, Academic Press, New York.

STA-615: Demography

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

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

Unit III: Measures of Mortality; construction of abridged life tables. Distributions of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate. Models for population growth and their fitting to population data. Stochastic models for population growth.

Unit IV: Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility.

Unit V: Methods for population projection. Use of Leslie matrix.

Reference Books:

1. Bartholomew, D. J. (1982). *Stochastic Models for Social Processes*, John Wiley.
2. Benjamin, B. (1969). *Demographic Analysis*, George, Allen and Unwin.
3. Chiang, C. L. (1968). *Introduction to Stochastic Processes in Biostatistics*, John Wiley.
4. Cox, P. R. (1970). *Demography*, Cambridge University Press.
5. Keyfitz, N. (1977). *Applied Mathematical Demography*, Springer Verlag.

6. Spiegelman, M. (1969). *Introduction to Demographic Analysis*; Harvard University Press.
7. Wolfenden, H. H. (1954). *Population Statistics and Their Compilation*; American Actuarial Society.

STA-616: Econometrics

UNIT I: Introduction- Objective behind building econometric models, nature of econometrics, model building, role of econometrics. General linear model (GLM). Estimation under linear restrictions.

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

UNIT III: Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT IV: Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models.

UNIT V: GLM with stochastic regressors, Instrumental variables (I.V): estimation, consistency property, asymptotic variance of I.V estimators. Bayesian analysis of linear model with non-informative priors and conjugate priors.

UNIT VI: Distributed lag models, polynomial lag models, Almon's lag model, determination of degree of polynomial and lag length. Adaptive expectation model, partial adjustment model, compound geometric lag model, and methods of estimation.

UNIT VII: Simultaneous-equation methods: Estimation - Recursive systems, two stage least squares (2SLS) estimators, and full information maximum likelihood (FIML).

Reference Books:

1. Gujarati, D. and Guneshker, S. (2007). *Basic Econometrics*, 4th Ed., McGraw Hill Companies.
2. Johnston, J. (1972). *Econometric Methods*, 2nd Ed., McGraw Hill International.
3. Koutsoyiannis, A. (2004). *Theory of Econometrics*, 2 Ed., Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009). *Introduction to Econometrics*, 4 Ed., John Wiley & Sons.
5. Greene, W.H. (2003). *Econometric Analysis*, Prentice Hall
6. Ramanathan, R. (2002). *Introductory Econometrics with Applications*, Harcourt College Publishers

STA-617: Time Series Analysis

UNIT I: Time-series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

UNIT II: Exploratory Time Series Analysis, Tests for trend and Seasonality. Exponential and Moving Average Smoothing. Holt and Winters smoothing. Forecasting based on smoothing, Adaptive smoothing.

UNIT-III: 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. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Forecasting. Residual analysis and diagnostic checking.

UNIT IV: Spectral analysis of weakly stationary process. Periodogram and correlogram analyses. Computations based on Fourier transform. Spectral decomposition of weakly AR process and representation as a one-sided MA process - necessary and sufficient conditions. Implication in prediction problems.

Reference Books:

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. Montgomery, 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.

STA-618: Operation Research

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

Unit II: Review of LP problems; duality theorem; transportation and assignment problems; non-linear programming-Kuhn Tucker conditions, Wolfe's and Beale's algorithms for solving quadratic programming problems. Bellman's principle of optimality, general formulation, computational methods and application of dynamic programming.

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

Unit IV: Queueing models-specifications and effectiveness measures. Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue-length and waiting time. M/G/1 queue and Pollaczek Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues. Machine interference problem.

Unit V: Sequencing and scheduling problems. 2 machine n-job and 3-machine n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings. Branch and bound method for solving travelling salesman problem.

Reference Books:

1. Churchman C.W., Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research; John Wiley.
2. Gross, D. and Harris, C.M. (1974) Fundamentals of Queueing Theory; John Wiley.
3. Hadley G. (1964) Non-linear and Dynamic programming; Addison Wesley.
4. Hadley G. and Whitin T.M. (1963) Analysis of Inventory Systems; Prentice Hall.
5. Hillier F.S. and Lieberman G.J. (1962) Introduction to Operations Research; Holden Day.
6. Kanti Swarup, Gupta, P.K. and Singh, M.M.. (1985) Operations Research; Sultan Chand & Sons.
7. Kleinrock L. (1975) Queueing Systems, vol. 1, Theory; John Wiley.
8. Mckinsey J.C.C. (1952) Introduction to the Theory of Games; McGraw Hill.
9. Murthy K.G. (1976) Linear and Combinatorial Programming; John Wiley.
10. Saaty T.L. (1961) Elements of Queueing Theory with Applications; McGraw Hill.
11. Starr M.K. and Miller D.W. (1962) Inventory Control-Theory and Practice; Prentice Hall
12. Taha H.A. (1982) Operational Research: An Introduction; Macmillan.
13. Wagner H.M. (1973) Principles of O.R. with Applications to Managerial Decisions; Prentice Hall.

STA-619: Bayesian Inference

UNIT-I: Subjective interpretation of probability in terms of fair odds. Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter. Bayes theorem and computation of the posterior distribution.

UNIT-II: Natural Conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non informative, improper and invariant priors. Jeffrey's invariant prior.

UNIT-III: Bayesian point estimation: as a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 - 1 loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.

UNIT IV: Bayesian interval estimation: Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

UNIT V: Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. Discussion of Lindley's paradox for testing a point hypothesis for normal mean against the two-sided alternative hypothesis.

Reference Books:

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. Bernardo, 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.

STA-620: Statistical process and quality control

UNIT-I: Basic concept of process monitoring and control, process capability and process optimization.

UNIT-II: 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.

UNIT-III: Acceptance sampling plans for attribute inspection; single, double and sequential sampling plans and their properties; Plans for inspection by variables for one-sided and two sided

specifications; Mil Std and IS plans; Continuous sampling plans of Dodge type and Wald-Wolfowitz type and their properties. Bayesian sampling plans.

UNIT-IV: Capability indices C_p , C_{pk} and C_{pm} ; estimation, confidence intervals and tests of hypotheses relating to capability indices for Normally distributed characteristics.

UNIT-V: Use of Design of Experiments in SPC; factorial experiments, fractional factorial designs, construction of such designs and analysis of data.

UNIT-VI: Multivariate quality control; use of control ellipsoid and of utility functions.

Reference Books:

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.

Semester –II

STA-621: Survival Analysis

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

UNIT-II: Two sample problem-Gehan test, Log rank test. Mantel-Haenszel test, Tarone - Ware tests.

UNIT-III: Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates. Rank test for the regression coefficients. Frailty models: Likelihood formulation for Gamma frailty under Exponential and Weibull baselines.

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

Reference Books:

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.

STA-622: Advanced statistical inference

UNIT- I: Consistency and asymptotic relative efficiency of estimators, Consistent asymptotic normal (CAN) estimator, CAN estimator for one-parameter Cramer family, Cramer-Huzurbazar theorem, Method of maximum likelihood estimation, Method of scoring, Fisher lower bound to asymptotic variance.

UNIT- II: Similar tests, Neyman structure, UMPU tests for composite hypotheses, Likelihood ratio test (LRT), Asymptotic distribution of LRT statistic, Consistency of large sample test.

UNIT- III: Sequential tests-SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

UNIT- IV: Non-parametric methods-estimation and confidence interval, U-statistics and their asymptotic properties, nonparametric tests-single sample location, location-cum-symmetry, randomness and goodness of fit problems.

Reference Books:

1. Kale, B. K. (1999) A first Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi V. (1988). An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New Delhi (Student Edition).
3. Lehmann E. L. (1986) - (Latest) Theory of Point Estimation (Student Edition).
4. Lehmann, E. L. (1986). Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973) : Linear Statistical Inference.
6. Dudewicz, E. J. and Mishra, S. N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition).

7. Ferguson T. S. (1967). Mathematical Statistics. Academic Press.
8. Zacks, S. (1971). Theory of Statistical Inference, John Wiley and Sons, New York.
8. Casella, G. and Berger, R.L. (2013). Statistical Inference, Cengage Learning.
9. Gibbons, J.D. and Chakraborti, S. (2021). Nonparametric Statistical Inference, Chapman and Hall/CRC Press.

STA-623: Advanced Design & Analysis of Experiment

UNIT -I: Finite group and finite field, finite geometry - projective and Euclidean, construction of complete set of mols, lattice designs and their analyses, construction of BIBDs using mols, finite geometry and difference method of lose, inter and intra-block analyses of a BIBD.

UNIT -II: Two -associate PBIB designs - association scheme and intra-block analysis, group divisible designs, dual and linked block designs, resolvable and affine-resolvable designs, general row-column designs - connectedness and intra-block analysis.

UNIT -III: Fractional factorial designs, orthogonal and balanced arrays and their connections with confounded and fractional factorials.

UNIT -IV: Response surface designs - orthogonality, rotatability and blocking, construction and analysis, method of steepest ascent. (6L)

UNIT -V: Experiments with mixtures - models, analysis and designs.

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UNIT -VI: Optimum designs - various optimality criteria and their interpretations, regression designs - exact and approximate designs, optimal linear and quadratic regression designs over $[-1, 1]$, Equivalence Theorem [statement and simple applications only], optimality of BIBD, optimal chemical balance weighing designs, optimality of 2 factorial designs.

UNIT -VII: Repeated measurements designs [first order residual effects] – analysis.

Reference Books:

1. Atkinson, A. C. and Donev, A. N. (1992). Optimal Experimental Designs. Oxford University Press.
2. Bose, R. C. and Shimamoto, T. (1952, 1973). Classification and analysis of PBIBD designs with two associate classes. Jour. Amer. Stat. Assoc. Vol. 47, pp 151-184.
3. Chakrabarty, M. C. (1962). Mathematics of Design of Experiments. Asia Publ. House.
4. Cornell, M. (1963). Mixture Experiments. Wiley.
5. John, P. W. M. (1971). Statistical Design and Analysis of Experiments. MacMillan.
6. Khuri, A. and Cornell. M. (1991). Response Surface Methodology. Marcel Dekker.
7. Pukelsheim, F. (1993). Optimal Design of Experiments. Wiley.

8. Raghavarao, D. (1971). Construction and Combinatorial Problems in Design of Experiments. Wiley.
9. Rao, C.R. and Kleffe, J. (1988). Estimation of variance Components and Applications. North-Holland, Amsterdam.
10. Searle, S.R., Casella, G. and McCulloch, C.E. (1992). Variance Components. John Wiley, New York.
11. Shah, K. R. and Sinha, B. K. (1989). Theory of Optimal Designs. Springer-Verlag.

STA-624: Official Statistics

UNIT-I: 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.

UNIT-II: Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India.

UNIT-III: System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

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

Reference Books:

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.

STA-625: Advanced Statistical Computing and Data Mining

UNIT- I: Introduction to databases, tasks in building a data mining database, data warehouses, online analytical data processing, Data mining and machine learning, supervised and unsupervised learning.

UNIT- II: Similarity and distance measures, Outliers, Minimum spanning tree, squared error clustering, K-means clustering, Hierarchical clustering, Block clustering and two-way clustering: Hartigan's block clustering algorithm, Biclustering, Plaid models for biclustering.

UNIT- III: Extensions of regression models, McCullon-Pitts Neuron (Threshold Logic Unit), Rosenblatt's Single layer perceptron, single unit perceptron gradient descent learning algorithm, Multilayer perceptron, feed forward and back propagation learning algorithm, Self organizing maps (SOM) or Kohonen neural network, on-line and batch versions of SOM algorithm.

UNIT- IV: Classification trees, node impurity function and entropy function, choosing the best split pruning algorithm for classification trees. Regression trees, terminal node value and splitting strategy, pruning the tree and best pruned subtree. Bagging tree based classifiers and regression tree predictors.

Essential Readings:

1. Bishop, C.M. (1995). Neural Networks for pattern Recognition, Oxford University Press.
2. Hastie, T., Tibshirani, R. and Friedman, J. (2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer.
3. Duda, R.O., Hart, P.E. and Strok, D.G. (2000). Pattern Classification, John Wiley & Sons.
4. Han, J. and Kamber, M. (2000). Data Mining: Concepts and Techniques, Morgan
5. Hand, D., Mannila, H. and Smyth, P. (2001). Principles of Data Mining, MIT Press.
6. Haykin, S. (1998). Neural Networks: A Comprehensive Foundation, Prentice Hall. Kaufmann.
7. McLachlan, G.J. and Krishnan, T. (1997). The EM Algorithms and Extensions, John Wiley & Sons.

STA-626: Statistical Decision Theory

UNIT-I: Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules.

UNIT-II: Concepts of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

UNIT-III: Supporting and separating hyperplane theorems, minimax theorem of for finite parameter space, minimax estimators of Normal and Poisson mean, admissibility of minimax rules.

UNIT-IV: 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, estimation of a distribution function.

UNIT-V: Multivariate normal distribution, exponential family of distributions, sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

UNIT-VI: Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems, sequential tests of a simple hypothesis against a simple alternative, SPRT and stopping rule principle.

Reference Books:

1. Berger, J. O. (1985). Statistical Decision Theory and Bayesian Analysis. 2nd Ed. Springer.
2. Ferguson, T. S. (1967). Mathematical Statistics - A Decision Theoretic Approach, Academic Press.

STA-627: Actuarial statistics

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

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

UNIT-III: Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

UNIT-IV: Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT-V: Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

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

UNIT-VII: 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.

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

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

UNIT-X: A brief outline of payment premiums and net premiums

Reference Books:

1. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1966), Actuarial Mathematics, Society of Actuaries, 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

STA-628: Research Methodology

UNIT-I: Evolution of Statistics as a discipline, Important milestones in statistical research, Contributions of statisticians and statistical institutions in allied sciences, Importance and necessity of ethical considerations in statistical research.

UNIT-II: Accessing literature: Manual, Scientific reports and Statistical Database, Electronic: e-journals, e-books, and Online Database, Referencing Style: Modern Language Association (MLA), American Psychological Association (APA), Chicago Manual of Style (Chicago), Harvard Referencing Style (Harvard), Vancouver Referencing Style (Vancouver). Impact Factor as per Journal Citation Reports (JCR), Scimago Journal Rank (SJR), and cite score. Multi-Criteria Decision-Making (MCDM) methods like Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA) etc. Selection of Journals vis-à-vis specific research area/ topic.

UNIT-III: Concept of Inductive and Deductive inference in Statistics, Application and formulation of statistical inferences in various research domains, Mode of conducting field research and operationalisation of variables. Textual analysis of sub-topics in analytic research.

UNIT-IV: Inverse probability, Iterative techniques as approximation to complex differential and integral forms.

Reference Books:

1. Cox, D. R. (2006). Principles of Statistical Inference, Cambridge University Press.
2. Hald, A. (1999). A History of Mathematical Statistics from 1750 to 1930, John Wiley & Sons.
3. Krippendorff, K. (2018). Content analysis: An introduction to its methodology, Sage publications.
4. Kumar, R. (2018). Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.
5. 1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.

**DHANAMANJURI UNIVERSITY
MANIPUR**



**SYLLABUS FOR 2 (TWO) YEARS M.SC. STATISTICS
BASED ON UGC CURRICULUM AND CREDIT
FRAMEWORK**

JUNE, 2026

1. INTRODUCTION

The National Education Policy (NEP), 2020 envisions a transformative framework for higher education in India, emphasizing flexibility, multidisciplinary learning, skill enhancement, and outcome-based curriculum design. In alignment with this vision, the University Grants Commission (UGC) has developed a new Curriculum and Credit Framework for Postgraduate Programmes in June 2024. The duration of the postgraduate programme shall be either 1 year or 2 years. The revised framework focuses on strengthening analytical thinking, computational skills, research aptitude, and practical applications of statistics relevant to academia, industry, government, and society.

In line with NEP 2020, the Department of Statistics has adopted the Curriculum and Credit Framework for both 1-year and 2-year postgraduate programmes. The curriculum integrates theoretical foundations, statistical computing, data analysis, modern statistical methodologies, and interdisciplinary applications to prepare students for professional careers, research, and lifelong learning in the field of Statistics.

2. LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

Nature and Extent of the M.Sc. Programme in Statistics

The Learning Outcome-Based Curriculum Framework (LOCF) for the M.Sc. Programme in Statistics is designed to reflect the depth, breadth, and interdisciplinary nature of contemporary statistical education. The programme encompasses Discipline Specific Core (DSC) and Discipline Specific Elective (DSE) courses covering areas such as Real Analysis, Linear Algebra, Distribution Theory, Probability Theory, Stochastic Processes, Linear Models and Regression Analysis, Multivariate Analysis, Design and Analysis of Experiments, Survival Analysis, Advanced Statistical Inference, Reliability Theory, Non-Parametric Inference, Demography, Econometrics, Time Series Analysis, Operations Research, Bayesian Inference, Official Statistics, Statistical Decision Theory, and Data Science Methods.

The curriculum emphasizes statistical computing, data analysis, research methodology, and project-based learning. It equips students with the knowledge and skills necessary to address challenges in science, technology, business, public policy, health, and social sciences through evidence-based decision-making. Through structured learning outcomes, the programme promotes quantitative reasoning, computational proficiency, research competence, ethical practices, and interdisciplinary collaboration, preparing graduates for careers in academia, research institutions, government agencies, industries, and data-driven enterprises.

Programme Objectives

- a. To provide students with a strong foundation in statistical theory, methodology, and applications across diverse domains.
- b. To cover a broad spectrum of statistical disciplines ranging from mathematical foundations to advanced data analytical techniques.

- c. To develop expertise in core areas such as Probability Theory, Statistical Inference, Linear Models, Multivariate Analysis, Experimental Design, and Stochastic Processes.
- d. To offer flexibility through elective courses including Reliability Theory, Econometrics, Demography, Time Series Analysis, Bayesian Inference, Official Statistics, Statistical Decision Theory, and Data Science.
- e. To promote both theoretical understanding and practical competence through statistical computing, data analysis laboratories, projects, and research work.
- f. To integrate modern computational tools, statistical software, and data science methodologies with traditional statistical approaches.
- g. To cultivate critical thinking, problem-solving ability, quantitative reasoning, and research aptitude, enabling students to contribute effectively in academic, industrial, and policy-making environments.

Programme Attributes

- a. Advanced disciplinary, interdisciplinary, and multidisciplinary knowledge.
- b. Mastery of core and elective courses in Statistics.
- c. Research competence and analytical ability.
- d. Statistical computing and data analytical skills.
- e. Proficiency in statistical software, programming, modelling, simulation, and interpretation of data.
- f. Critical thinking, quantitative reasoning, and problem-solving skills.
- g. Effective communication and professional aptitude.
- h. Skills in scientific writing, technical reporting, presentation, and dissemination of statistical findings to academic, professional, and public audiences.
- i. Ethical awareness and responsible use of data.
- j. Familiarity with statistical software packages, computational tools, data science platforms, and digital technologies relevant to statistical research and practice.
- k. Preparedness for continuous professional development, competitive examinations, higher studies, and research careers.

3. PROGRAMME LEARNING OUTCOMES (PLO)

Upon successful completion of the M.Sc. Programme in Statistics, students will be able to:

- a. Demonstrate comprehensive knowledge of mathematical and statistical concepts, theories, and methodologies at advanced levels.

- b. Apply statistical principles and methodologies to design studies, collect, manage, analyse, and interpret data in diverse fields.
- c. Utilize advanced statistical techniques, computational tools, and software for solving real-world problems and conducting research.
- d. Critically evaluate statistical literature, research findings, and methodological developments to support evidence-based decision-making.
- e. Conduct independent and collaborative research with ethical responsibility, contributing to scientific advancement and societal development.
- f. Communicate statistical findings effectively through technical reports, scientific writing, presentations, and outreach activities tailored to academic, professional, and public audiences.
- g. Integrate interdisciplinary knowledge from mathematics, computer science, economics, health sciences, environmental studies, and other allied fields to address complex problems.
- h. Demonstrate leadership, teamwork, adaptability, and professional competence in academic, industrial, governmental, and research settings.
- i. Engage in lifelong learning and professional development, preparing for careers in academia, research institutions, government organizations, industries, financial sectors, and data-driven enterprises.
- j. Apply statistical thinking and data-driven approaches to support policy formulation, planning, sustainable

COURSE STRUCTURE OF 2- YEAR PG PROGRAMME (STATISTICS)

Semester - I

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	No. of credits
STA-501	DSC	Real Analysis	20	80	100	4
STA-502	DSC	Linear Algebra	20	80	100	4
STA-503	DSC	Distribution Theory	20	80	100	4
STA-504	DSC	Sample Surveys & Statistics for National Development	20	80	100	4
STA-505	DSC	Statistical Computing-I (Practical)	-	100	100	4
STA-506	DSC	Data Analysis based on STA-502, & STA-504 (Practical)	-	100	100	4
Total					600	24

Semester - II

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	No. of credits
STA-507	DSC	Probability Theory	20	80	100	4
STA-508	DSC	Stochastic Processes	20	80	100	4
STA-509	DSC	Linear Models & Regression Analysis	20	80	100	4
STA-510	DSC	Multivariate Analysis	20	80	100	4
	VAC/AEC	Environment and climate change/ Disaster management/ Foreign language	-	50	50	2
Total					450	18

Semester - III

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	No. of credits
STA-611	DSC	Design and Analysis of Experiments	20	80	100	4
STA-612	DSC	Statistical Computing II (Practical)	-	100	100	4
STA-613	DSE	Reliability Theory	20	80	100	4
STA-614	DSE	Non-Parametric Inference	20	80	100	4
STA-615	DSE	Demography	20	80	100	4
STA-616	DSE	Econometrics	20	80	100	4
STA-617	DSE	Demography	20	80	100	4
STA-618	DSE	Time Series Analysis	20	80	100	4
STA-619	DSE	Operation Research	20	80	100	4
STA-620	DSE	Bayesian Inference	20	80	100	4
Total					500	20
Any THREE papers out of the Paper Nos. STA-613 to STA-620						

Semester - IV

Paper Code	Paper Type	Paper Title	Internal Assessment Marks	End Semester Marks	Total Marks	No. of credits
STA-621	DSC	Survival Analysis	20	80	100	4
STA-622	DSC	Advanced statistical inference	20	80	100	4
STA-623	DSE	Advanced Design & Analysis of Experiment	20	80	100	4
STA-624	DSE	Official Statistics	20	80	100	4
STA-625	DSE	Data Science Methods and Reproducible Research	20	80	100	4
STA-626	DSE	Statistical Decision Theory	20	80	100	4
STA-627	DSE	Actuarial statistics				
STA-628	DSC	Research Methodology	10	40	50	2
STA-629	DSE	Research (Thesis/Dissertation/Project work/Field work/Patent)	-	150	150	6
Total					500	20
Any ONE papers out of the Paper Nos. STA-623 to STA-626						

DETAILED SYLLABI

SYLLABUS FOR 2 YEARS M.SC. STATISTICS

Semester - I

STA-501: Real Analysis

UNIT-I: Countability, supremum and infimum of sets of real numbers, denseness property of rational numbers, limit points and interior points of a set, open sets, closed sets, their properties, Compactness.

UNIT-II: Sequence of real number, convergent of sequences, bounded sequences, monotonic sequence Cauchy's general principle of convergence. Series of real numbers, convergence of series, tests for convergence of series, absolute convergence, Cauchy product of two series and its convergence. Power series and radius of convergence.

UNIT-III: Functions, limit, continuity, uniform continuity, absolute continuity, functions of bounded variation, calculus of one variable: differentiability, Roll's theorem, mean value theorem and Taylor series expansion. Maxima-minima of functions of one real variable. Functions of several variables, limit, continuity, partial derivative, the gradient vector, directional derivatives, differentials of functions of several variables, Maxima- minima of functions of several variables.

UNIT-IV: Double and multiple integrals (triple integral only), evaluation of multiple integrals by repeated integration (triple integral only), change of variables in multiple integration. Improper integrals, differentiation under the sign of integral.

Reference Books:

1. Abbott, S. (2001), Understanding Analysis, Springer, New York
2. Apostol T.M. (1975). Mathematical Analysis: A modern approach to advanced calculus. Addison-Wesley
3. Bartle R. G. and Sherbert D. R., (2007), Introduction to Real Analysis, Wiley
4. Bartle, R. G. (1976). Elements of Real Analysis, John Wiley
5. Goldberg R. R. (1976). Methods of Real Analysis, John Wiley
6. Kumar, A. and Kumaresan, S. (2014). A Basic Course in Real Analysis, CRC Press
7. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw - Hill

STA-502: Linear Algebra

UNIT-I: Vector spaces, inner product of vector spaces, linear dependence and linear independence of vectors, basis and dimension, properties and uses of a basis. Linear transformation and their matrix representations, injective, surjective and inverse linear

transformations, rank of a matrix, linear equations, solution space and null space, generalized inverse, echelon forms, canonical forms, Gram-Schmidt orthogonalization, projection theorem.

UNIT-II: Determinants and their simple properties, partitioned matrices, inverses, vector operator, special types of matrices, orthogonal and idempotent matrices, symmetric and positive definite matrices. Eigen values and eigen vectors, Spectral decomposition of a symmetrical matrix (Full rank and non-full rank cases), Example of spectral decomposition, Spectral decomposition of asymmetric matrix, Cayley Hamilton theorem, Algebraic and geometric multiplicity of characteristic roots, Diagonalization of matrices, Factorization of a matrix, Eigen values and eigen vectors for solution of Differential equations. Generalized inverses: Moore-Penrose inverse, G-inverse.

UNIT-III: Quadratic forms with symmetric matrices, definiteness of a real quadratic form, reduction of quadratic forms, simultaneous reduction of two quadratic forms, maxima and minima of ratios of two quadratic forms, quadratic form inequalities

Reference Books:

1. Biswas, S. (1997): A Text Book of Matrix Algebra, 2nd Edition, New Age International Publishers.
2. Golub, G.H. and Van Loan, C.F. (1989): Matrix Computations, 2nd edition, John Hopkins University Press, Baltimore-London.
3. Graybill, F.A. (1983): Matrices with applications in Statistics, 2nd Ed. Wadsworth.
4. Hadley, G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
5. Rao, C.R. (1973): Linear Statistical Inferences and its Applications, 2nd edition, John Wiley and Sons.
6. Robinson, D.J.S. (1991): A Course in Linear Algebra with Applications, World Scientific, Singapore.
7. Searle, S.R. (1982): Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.
8. Strang, G. (1980): Linear Algebra and its Application, 2nd edition, Academic Press, London, New York.

STA-503: Distribution Theory

Unit-I: Brief review of basic distribution theory. Compound, truncated and mixture distributions, power series distributions, functions of random variables and their distributions using Jacobian of transformation and other tools.

Unit-II: Conditional expectation, correlation, multiple and partial correlation. Linear and multiple regressions.

Unit-III: Markov, Holder, Jensen and Liapunov inequalities.

Unit-IV: Approximating distributions. Delta method and its applications. Approximating distributions of sample moments. Transformation of statistics.

Unit-V: Characterization of distribution (Geometric, negative exponential, Normal, gamma). Non-central chi-square, t- and F- distributions and their properties. Concept of censoring

Unit-VI: Order statistics - their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distributions (Statement only) with applications.

Unit-VII: Robust procedures, Robustness of sample mean, Sample standard deviation, Chi-square test and Student's t-test. Sample size determination for testing and estimation procedures (complete and censored data) for normal, exponential, Weibull and gamma distributions.

Reference Books:

1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley, Int'l Students' Edition.
2. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern.
4. Pitman, J. (1993): Probability, Narosa Publishing House.
5. Johnson, S. and Kotz, (1972): Distributions in Statistics, Vol. I, II and III, Houghton and Mifflin. Cramer H. (1946), Mathematical Methods of Statistics, Princeton.
6. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. (1992). A First Course in Order Statistics, John Wiley & Sons.
7. Mukhopadhyay, P. (2015). Mathematical Statistics. New Central Book Agency.

STA-504: Sample Surveys & Statistics for National Development

A. Sample Survey

UNIT-I: Basic ideas and distinctive features of sampling, Probability sampling designs, sampling schemes, inclusion probabilities and estimation. Review of important results in simple and stratified random sampling, Fixed (Design –based) and Superpopulation (model based) approaches.

UNIT-II: Sampling with varying probabilities (unequal probability sampling) with or without replacement: pps, π ps and non- π ps sampling procedures and estimation based on them, Nonnegative variance estimation

UNIT-III: Two-way stratification, post-stratification, controlled sampling, Estimation based on auxiliary data (involving one or more auxiliary variables) under design-based and model-based approaches, Double (two-phase) sampling with special reference to the selection with unequal probabilities in at least one of the phases.

UNIT-IV: Systematic sampling and its application to structured populations, Cluster sampling (with varying sizes of clusters), Two-stage sampling (with varying sizes of first-stage units), Warner's and Simmons' randomized response techniques for one qualitative sensitive characteristic.

Reference Books

1. Chaudhuri, A. and Mukerjee, R. (1988) Randomized Response: Theory and Techniques, New York: Marcel Dekker Inc.
2. Cochran, W. G.: Sampling Techniques [3rd Edition, 1977). Wiley
3. Des Raj and Chandak (1998): Sampling Theory.
4. Narosa Murthy, M. N. (1977). Sampling Theory & Methods. Statistical Publishing Society, Calcutta.
5. Sukhatme et al (1984). Sampling Theory of Surveys with Applications. Iowa State University Press & IARS.
6. Singh, D. and Chaudhary, F. S. (1986). Theory and Analysis of Sample Survey Designs. New Age International Publishers.

B. Statistics for National Development

UNIT-5: Economic development: Growth in per capita income and 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. Measuring inequality in incomes, Gini coefficient, Theil's measure. Poverty measurement - different issues, measures of incidence and intensity, combined measures e.g., indices due to Kakwani, Sen etc.

Reference Books

1. CSO (1980): National Accounts Statistics - Sources and Health.
2. Keyfitz, N. (1977): Applied Mathematical Demography, Springer Verlag. UNESCO: Principles for Vital Statistics Systems. Series M -12.
3. Sen, A. (1997): Poverty and Inequality.

STA-506: Data Analysis based on STA-502, STA-503& STA-504 (Practical)

1. Distribution Fitting and checking the goodness of fit of Normal distribution
2. Distribution Fitting and checking the goodness of fit of negative exponential distribution
3. Distribution Fitting and checking the goodness of fit of Geometric distribution
4. Determine multiple and partial correlation coefficients for a given multivariate dataset.
5. Fit a simple linear regression model and estimate regression parameters.
6. Fit a multiple regression model and interpret the regression coefficients.
8. Computation of adjoint and inverse of a matrix
9. Computation of Determinants of matrix
10. Inverses of a matrix by partitioning
11. Rank of a matrix
12. Solutions of matrix equations
13. Characteristic roots and vectors of a matrix
14. Reducing a Quadratic Form to its canonical form and finding its rank and index
15. Proving that a quadratic form is positive or negative definite

- 16 Finding the product of two matrices by considering partitioned matrices
17. Finding inverse of a matrix by using Cayley-Hamilton theorem
18. To select SRS with and without replacement.
19. For SRSWOR and SRSWR, estimate mean, standard error, the sample size.
20. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
21. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.
22. PPS (Probability Proportional to Size) and π ps (Horvitz-Thompson framework)

Semester - II

STA-507: Probability Theory

UNIT- I: Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in R_k , sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue-Steljes measures.

UNIT-II: Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

UNIT-III: Markov's, Chebychev's and Kolmogorov's inequalities, Modes of stochastic convergence, Jensen, Liapounov, holder's and Minkowsky's inequalities, Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky's theorem, Borel - Cantelli lemma and Borel 0-1 law.

UNIT-IV Concept of Independence, Laws of large numbers, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, strong law of large numbers and Kolmogorov's theorem, Central limit theorem, Lindeberg and Levy and Liapunov forms of CLT.

Reference Books

1. Ash, Robert. (1972). Real Analysis and Probability. Academic Press.
2. Billingsley, P. (1986). Probability and Measure. Wiley.
3. Dudley, R. M. (1989). Real Analysis and Probability, Wadsworth and Brooks/Cole.
4. Kingman, J F C and Taylor, S. J. (1966). Introduction to Measure and Probability. Cambridge University Press.
5. Bhat, B.R. (1999). Modern Probability Theory, 3rd Edition, New Age International Publishers.
6. Feller, W. (1968). An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edition, John Wiley & Sons.

STA-508: Stochastic Processes

Unit-I: Introduction to stochastic processes: Definition and examples of stochastic process, Classification of SPs according to state space and time domain. Types of stochastic processes: independent process, Bernoulli process, processes with independent increments, processes with stationary increments, Markov processes, counting processes, second-order processes, Gaussian processes, martingales, Brownian motion. Stationary process: weakly stationary and strongly stationary processes. Elementary problems and applications.

Unit-II: Markov chains: definition and examples of Markov chain (MC), transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities, classification of states, basic limit theorem of Markov chain. Finite state Markov chains, Chapman-Kolmogorov equations, calculation of n-step transition probability and its limit. Classification of states, aperiodic & irreducible MC, recurrent & transient MC, concept of total probability with recursion, absorption probability, mean hitting time, mean return time, stationary distribution. Random walk and gambler's ruin problem.

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

Unit-IV: 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; Moving average and auto regressive 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.

Reference Books

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 Mifflin & 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.

STA-509: Linear Models and Regression Analysis

UNIT-I: Gauss-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.

UNIT-II: 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-Keuls.

UNIT-III: 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 and Remedies

UNIT-IV: Multicollinearity, ridge regression, subset selection of explanatory variables, Mallows-Cp Statistics and its applications.

Reference Books

1. Cook, R. D. and Weisberg, S. (1982). Residual and Influence in Regression.
2. Chapman and Hall. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis. 3rd Ed. Wiley.
3. Gunst, R. F. and Mason, R. L. (1980). Regression Analysis and Its Applications - A Data Oriented Approach.
4. Marcel and Dekker. Rao, C. R. (1973). Linear Statistical Inference and Its Applications.
5. Wiley Eastern. Weisberg, S. (1985). Applied Linear Regression. Wiley.

STA-510: Multivariate Analysis

UNIT-I: Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Matrix of normal distribution, Multivariate central limit theorem

UNIT-II: Wishart matrix, its distribution and properties, Distribution of sample generalized variance, Hotelling's T^2 statistic, its distribution and properties, applications in tests on mean vector for one and two multivariate normal populations, Mahalanobis' D^2 statistic.

UNIT-III: Likelihood ratio test criteria for testing equality of mean and covariance matrices, Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao's U-statistic, its distribution and applications.

UNIT-IV: Classification and Discrimination procedures for discrimination between two multivariate normal populations, Sample discriminant function, Classification rule based on expected cost of misclassification (ECM), Canonical Correlation Analysis, Principal Components Analysis, Elements of factor analysis and cluster analysis, Multivariate Analysis of Variance (MANOVA) of one-way classified data, Wilk's Lambda criterion.

Reference Books

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, John Wiley & Sons.
2. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley & Sons.
3. Rencher, A.C. and Christensen, W.F. (2012). Methods of Multivariate Analysis, John Wiley & Sons.
4. Giri, N.C. (1977). Multivariate Statistical Inference, Academic Press.
5. Hair, J.F., Babin, B.J., Anderson, R.E. and Black, W.C. (2022). Multivariate Data Analysis, Cengage Learning.
6. Hardle, W.K. and Simar, L. (2015). Applied Multivariate Statistical Analysis, Springer.
7. Johnson, R.A. and Wichern, D.W. (2015). Applied Multivariate Statistical Analysis, Pearson.
8. Kshirsagar, A.M. (1996). Multivariate Analysis, Marcel Dekker.
8. Lawley, D.N. and Maxwell, A.E. (1971). Factor Analysis as a Statistical Method, Butterworths.
9. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, John Wiley & Sons.

Semester - III

STA-611: Design and Analysis of Experiments

Unit-I: Introduction to designed experiments; General block design and its information matrix (C), criteria for connectedness, balance and orthogonality; Intrablock analysis (estimability, best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypotheses); BIBD- recovery of interblock information; Youden design - intrablock analysis. Analysis of covariance in a general Gauss-Markov model, applications to standard designs.

Unit-II: Fixed, mixed and random effects models; Variance components estimation – study of various methods; Tests for variance components; Missing plot technique – general theory and applications.

Unit-III: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2 and 3 factorial experiments in randomized blocks; Complete and partial confounding. Fractional replication for symmetric factorials. Split plot and split block experiments.

Unit-IV: Application areas: Response surface experiments; first order designs and orthogonal designs; clinical trials, longitudinal data, treatment- control designs; Model validation and use of transformation; Tukey's test for additivity.

Reference Books:

1. Alope Dey (1986): Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiments, Springer.
3. Das, M.N. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
4. Giri, N. (1986): Analysis of Variance, South Asian Publishers.
5. John, P.W.M. (1971): Statistical Design and Analysis of Experiments, Macmillan.
6. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.
7. Montgomery, C.D. (1976): Design and Analysis of Experiments, Wiley, New York.
8. Myers, R.H. (1971): Response Surface Methodology, Allyn & Bacon.
9. Pearce, S.C. (1984): Design of Experiments, Wiley, New York.
10. Rao, C.R. and Kleffe, J. (1988): Estimation of Variance Components and applications, North Holland.
11. Searle, S. R., Casella, G. and McCulloch, C. E. (1992): Variance Components, Wiley.

STA-612: Statistical Computing II (Practical)

UNIT-I: Introduction to R: Installing R, R console, Script file, Workspace, Getting help, R packages, Installing and loading packages. R data structures: vectors, matrices, array, data frames, factors, lists. Creating datasets in R, Importing and exporting dataset, annotating datasets. Graphs: Creating and saving graphs, customizing symbols, lines, colors and axes,

combining multiple graphs into one, bar plots, boxplot and dot plots, pie chart, stem and leaf display, histogram and kernel density plots. Data management: Manipulating dates and missing values, understanding data type conversion, creating and recoding variables, sorting, merging and sub-setting data sets. Mathematical and statistical functions, character functions, looping and conditional statements, user defined functions.

UNIT-II: Basic statistics: Descriptive statistics, frequency and contingency tables, outlier detection, testing of normality, basics of statistical inference in order to understand hypothesis testing, p-value and confidence intervals. Parametric tests: Tests for population mean and variance for two or more populations, tests for independence and measures of association, sample size determination for common statistical methods using pwr package. Nonparametric tests.

UNIT-III: Correlation: Correlations between quantitative variables and their associated significance tests. Regression Analysis: Fitting simple and multiple regression model forward, backward and stepwise regression, polynomial regression, regression diagnostics to assess the statistical assumptions, methods for modifying the data to meet these assumptions more closely, selecting a final regression model from many competing models. ANOVA: Fitting and interpreting ANOVA type models, evaluating model assumptions, basic experimental designs: CRD, RBD, LSD and factorial experimental designs.

UNIT-IV: Time series Analysis: Creating and manipulating a time series, Components of a time series, auto-correlation and partial correlation function, estimating and eliminating the deterministic components of a time series. Developing Predictive Models: Forecasting using exponential models, predictive accuracy measures for time-series forecast, testing for stationarity, Forecasting using ARMA and ARIMA models. EM algorithm: Applications to missing and incomplete data problems, mixture models

Reference Books

1. Crawley, M.J. (2013). The R Book, 2nd ed., John Wiley.
2. Davies, T. M. (2016). The Book of R: A First Course in Programming and Statistics, No Starch Press, San Francisco.
3. Field, A., Miles, J. and Field, Z. (2012). Discovering Statistics using R, Sage, Los Angeles.
4. Kabacoff, R.I. (2015). R in Action: Data Analysis and Graphics in R, 2nd ed., Manning.

STA-613: Reliability Theory

Unit-I: Reliability concepts & measures, components and systems, coherent system, reliability of the coherent system. Availability, types of availability- point wise, interval, asymptotic. Failure rate and mean time to failure and their inter-relationships. Statistical failure models: exponential. gamma, weibull, pareto, normal, lognormal and related distributions.

Unit-II: System components and configurations: series-parallel, parallel-series, and K-out of -N- system. Series- strength reliability and its estimation. Reliability Bounds- classical and Bayesian approach.

Unit-III: Maintenance Policies, System with imperfect switch. Concept of redundancy, types of redundancy, priority redundant, repairable system, comparison of component, unit and standby redundancies.

Unit-IV: Model Plotting techniques: Reliability function with Markov model. Two unit cold standby & parallel unit system with constant failure rate, Arbitrary Repair rates & Regenerative point Techniques. Stress strength reliability and its estimation. IFR, IFRA, NBU, DMRL and NBUE and their duals, loss of memory property of the exponential distribution.

Reference Books

1. Bain, L.J. and Engelhardt, M. (1991). Statistical Analysis of Reliability and Life- Testing Models, Marcel Dekker Inc., U.S.A.
2. Martz, H.F. and Wailer, R.A. (1982). Bayesian Reliability Analysis, John Wiley and Sons, Inc., New York.
3. Sinha, S.K. (1986). Reliability and Life-Testing, Wiley Eastern Ltd., New Delhi.

STA-614: Non-Parametric Inference

Unit-I: Density estimates, survey of existing methods. Rosenblatt's naïve density estimator, its bias and variance. Consistency of Kernel density estimators and its MSE.

Unit-II: one-sample problems based on sign test, Wilcoxon signed Rank test, run test and Kolmogorov – Smirnov test. Two sample problems based on sign test, Wilcoxon signed rank test for paired comparisons, Wilcoxon Mann-Whitney test, (Expectations and variances of above test statistics, Statements about their exact and asymptotic distributions).

Unit-III: Two sample problems based on Kolmogorov – Smirnov Test, Wald–Wolfowitz Runs test and Normal scores test. Ansari–Bradley test for two sample dispersions. (Expectations and variances of above test statistics, Statements about their exact and asymptotic distributions).

Unit-IV: Chi–Square test of goodness of fit and independence in contingency tables. Tests for independence based on Spearman's rank correlation and Kendall's Tau. Kruskal–Wallis test for one-way layout (K-samples). Friedman test for two-way layout (randomised block).

Unit-V: Asymptotic Relative Efficiency (ARE) and Pitman's theorem. ARE of one sample, paired sample and two sample locations tests. The concept of Rao's second order efficiency and Hodges–Lehman's deficiency with examples.

Reference Books

1. Gibbons, J.D. (1978). *Nonparametric Statistical Inference*, McGraw-Hill Book Company, New York.
2. Hollander, M. and Wolfe, D.A. (1999). *Nonparametric Statistical Methods* (2nd Edition), John Wiley & Sons, Inc., New York.
3. Silverman, B.W. (1986). *Density Estimation for Statistics and Data Analysis*, Chapman and Hall, London.
4. Conover, W.J. (1999). *Practical Nonparametric Statistics* (3rd Edition), John Wiley & Sons, Inc., New York.
5. Siegel, S. and Castellan, N.J. (1988). *Nonparametric Statistics for the Behavioral Sciences* (2nd Edition), McGraw-Hill Book Company, New York.
6. Ferguson, T.S. (1967). *Mathematical Statistics: A Decision Theoretic Approach*, Academic Press, New York.

STA-615: Demography

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

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

Unit-III: Measures of Mortality; construction of abridged life tables. Distributions of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate. Models for population growth and their fitting to population data. Stochastic models for population growth.

Unit-IV: Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility.

Unit-V: Methods for population projection. Use of Leslie matrix.

Reference Books

1. Bartholomew, D. J. (1982). *Stochastic Models for Social Processes*, John Wiley.
2. Benjamin, B. (1969). *Demographic Analysis*, George, Allen and Unwin.
3. Chiang, C. L. (1968). *Introduction to Stochastic Processes in Biostatistics*; John Wiley.
4. Cox, P. R. (1970). *Demography*, Cambridge University Press.
5. Keyfitz, N. (1977). *Applied Mathematical Demography*; Springer Verlag.

6. Spiegelman, M. (1969). *Introduction to Demographic Analysis*; Harvard University Press.
7. Wolfenden, H. H. (1954). *Population Statistics and Their Compilation*; American Actuarial Society.

STA-616: Econometrics

UNIT-I: Introduction - Objective behind building econometric models, nature of econometrics, model building, role of econometrics. General linear model (GLM). Estimation under linear restrictions.

UNIT-II: Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity.

UNIT-III: Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT-IV: Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models.

UNIT-V: GLM with stochastic regressors, Instrumental variables (I.V): estimation, consistency property, asymptotic variance of I.V estimators. Bayesian analysis of linear model with non-informative priors and conjugate priors.

UNIT-VI: Distributed lag models, polynomial lag models, Almon's lag model, determination of degree of polynomial and lag length. Adaptive expectation model, partial adjustment model, compound geometric lag model, and methods of estimation.

UNIT-VII: Simultaneous-equation methods: Estimation - Recursive systems, two stage least squares (2SLS) estimators, and full information maximum likelihood (FIML).

Reference Books

1. Gujarati, D. and Guneshker, S. (2007). *Basic Econometrics*, 4th Ed., McGraw Hill Companies.
2. Johnston, J. (1972). *Econometric Methods*, 2nd Ed., McGraw Hill International.
3. Koutsoyiannis, A. (2004). *Theory of Econometrics*, 2 Ed., Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009). *Introduction to Econometrics*, 4 Ed., John Wiley & Sons.
5. Greene, W.H. (2003). *Econometric Analysis*, Prentice Hall
6. Ramanathan, R. (2002). *Introductory Econometrics with Applications*, Harcourt College Publishers

STA-617: Time Series Analysis

UNIT-I: Time-series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

UNIT-II: Exploratory Time Series Analysis, Tests for trend and Seasonality. Exponential and Moving Average Smoothing. Holt and Winters smoothing. Forecasting based on smoothing, Adaptive smoothing.

UNIT-III: 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. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Forecasting. Residual analysis and diagnostic checking.

UNIT-IV: Spectral analysis of weakly stationary process. Periodogram and correlogram analyses. Computations based on Fourier transform. Spectral decomposition of weakly AR process and representation as a one-sided MA process - necessary and sufficient conditions. Implication in prediction problems.

Reference Books

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.

STA-618: Operation Research

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

Unit-II: Review of LP problems; duality theorem; transportation and assignment problems; non-linear programming-Kuhn Tucker conditions, Wolfe's and Beale's algorithms for solving quadratic programming problems. Bellman's principle of optimality, general formulation, computational methods and application of dynamic programming.

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

Unit-IV: Queueing models-specifications and effectiveness measures. Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue-length and waiting time. M/G/1 queue and Pollaczek Khinchine result. Steady-state solutions of M/E_k/1 and E_k/M/1 queues. Machine interference problem.

Unit-V: Sequencing and scheduling problems. 2 machine n-job and 3-machine n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings. Branch and bound method for solving travelling salesman problem.

Reference Books

1. Churchman C.W., Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research; John Wiley.
2. Gross, D. and Harris, C.M. (1974) Fundamentals of Queueing Theory; John Wiley.
3. Hadley G. (1964) Non-linear and Dynamic programming; Addison Wesley.
4. Hadley G. and Whitin T.M. (1963) Analysis of Inventory Systems; Prentice Hall.
5. Hillier F.S. and Lieberman G.J. (1962) Introduction to Operations Research; Holden Day.
6. Kanti Swarup, Gupta, P.K. and Singh, M.M.. (1985) Operations Research; Sultan Chand & Sons.
7. Kleinrock L. (1975) Queueing Systems, vol. 1, Theory; John Wiley.
8. McKinsey J.C.C. (1952) Introduction to the Theory of Games; McGraw Hill.
9. Murthy K.G. (1976) Linear and Combinatorial Programming; John Wiley.
10. Saaty T.L. (1961) Elements of Queueing Theory with Applications; McGraw Hill.
11. Starr M.K. and Miller D.W. (1962) Inventory Control-Theory and Practice; Prentice Hall.
12. Taha H.A. (1982) Operational Research: An Introduction; Macmillan.
13. Wagner H.M. (1973) Principles of O.R. with Applications to Managerial Decisions; Prentice Hall.

STA-619: Bayesian Inference

UNIT-I: Subjective interpretation of probability in terms of fair odds. Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter. Bayes theorem and computation of the posterior distribution.

UNIT-II: Natural Conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non informative, improper and invariant priors. Jeffrey's invariant prior.

UNIT-III: Bayesian point estimation: as a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 - 1 loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.

UNIT-IV: Bayesian interval estimation: Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

UNIT-V: Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. Discussion of Lindley's paradox for testing a point hypothesis for normal mean against the two-sided alternative hypothesis.

Reference Books

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. Bernardo, 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.

STA-620: Statistical process and quality control

UNIT-I: Basic concept of process monitoring and control, process capability and process optimization.

UNIT-II: 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.

UNIT-III: Acceptance sampling plans for attribute inspection; single, double and sequential sampling plans and their properties; Plans for inspection by variables for one-sided and two-sided specifications; Mil Std and IS plans; Continuous sampling plans of Dodge type and Wald-Wolfowitz type and their properties. Bayesian sampling plans.

UNIT-IV: Capability indices C_p , C_{pk} and C_{pm} ; estimation, confidence intervals and tests of hypotheses relating to capability indices for Normally distributed characteristics.

UNIT-V: Use of Design of Experiments in SPC; factorial experiments, fractional factorial designs, construction of such designs and analysis of data.

UNIT-VI: Multivariate quality control; use of control ellipsoid and of utility functions.

Reference Books

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.

Semester - IV

STA-621: Survival Analysis

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

UNIT-II: Two sample problem-Gehan test, Log rank test. Mantel-Haenszel test, Tarone - Ware tests.

UNIT-III: Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates. Rank test for the regression coefficients. Frailty models: Likelihood formulation for Gamma frailty under Exponential and Weibull baselines.

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

Reference Books

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.

STA-622: Advanced statistical inference

UNIT- I: Consistency and asymptotic relative efficiency of estimators, Consistent asymptotic normal (CAN) estimator, CAN estimator for one-parameter Cramer family, Cramer-Huzurbazar theorem, Method of maximum likelihood estimation, Method of scoring, Fisher lower bound to asymptotic variance.

UNIT-II: Similar tests, Neyman structure, UMPU tests for composite hypotheses, Likelihood ratio test (LRT), Asymptotic distribution of LRT statistic, Consistency of large sample test.

UNIT- III: Sequential tests-SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

UNIT- IV: Non-parametric methods-estimation and confidence interval, U-statistics and their asymptotic properties, nonparametric tests-single sample location, location-cum-symmetry, randomness and goodness of fit problems.

Reference Books

1. Kale, B. K. (1999) A first Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi V. (1988). An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New Delhi (Student Edition).
3. Lehmann E. L. (1986) - (Latest) Theory of Point Estimation (Student Edition).
4. Lehmann, E. L. (1986). Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973) : Linear Statistical Inference.
6. Dudewicz, E. J. and Mishra, S. N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition).
7. Ferguson T. S. (1967). Mathematical Statistics. Academic Press. 8. Zacks, S. (1971). Theory of Statistical Inference, John Wiley and Sons, New York.
8. Casella, G. and Berger, R.L. (2013). Statistical Inference, Cengage Learning.
9. Gibbons, J.D. and Chakraborti, S. (2021). Nonparametric Statistical Inference, Chapman and Hall/CRC Press.

STA-623: Advanced Design & Analysis of Experiment

UNIT-I: Finite group and finite field, finite geometry - projective and Euclidean, construction of complete set of mols, lattice designs and their analyses, construction of BIBDs using mols, finite geometry and difference method of lose, inter and intra-block analyses of a BIBD.

UNIT-II: Two -associate PBIB designs - association scheme and intra-block analysis, group divisible designs, dual and linked block designs, resolvable and affine-resolvable designs, general row-column designs - connectedness and intra-block analysis.

UNIT-III: Fractional factorial designs, orthogonal and balanced arrays and their connections with confounded and fractional factorials.

UNIT-IV: Response surface designs - orthogonality, rotatability and blocking, construction and analysis, method of steepest ascent. (6L)

UNIT-V: Experiments with mixtures - models, analysis and designs.

UNIT-VI: Optimum designs - various optimality criteria and their interpretations, regression designs - exact and approximate designs, optimal linear and quadratic regression designs over

[- ,1], Equivalence Theorem [statement and simple applications only], optimality of BIBD, optimal chemical balance weighing designs, optimality of 2 factorial designs.

UNIT-VII: Repeated measurements designs [first order residual effects] – analysis.

Reference Books

1. Atkinson, A. C. and Donev, A. N. (1992). Optimal Experimental Designs. Oxford University Press.
2. Bose, R. C. and Shimamoto, T. (1952, 1973). Classification and analysis of PBIBD designs with two associate classes. Jour. Amer. Stat. Assoc. Vol. 47, pp 151-184.
3. Chakrabarty, M. C. (1962). Mathematics of Design of Experiments. Asia Publ. House.
4. Cornell, M. (1963). Mixture Experiments. Wiley.
5. John, P. W. M. (1971). Statistical Design and Analysis of Experiments. MacMillan.
6. Khuri, A. and Cornell. M. (1991). Response Surface Methodology. Marcel Dekker.
7. Pukelsheim, F. (1993). Optimal Design of Experiments. Wiley.
8. Raghavarao, D. (1971). Construction and Combinatorial Problems in Design of Experiments. Wiley.
9. Rao, C.R. and Kleffe, J. (1988). Estimation of variance Components and Applications. North-Holland, Amsterdam.
10. Searle, S.R., Casella, G. and McCulloch, C.E. (1992). Variance Components. John Wiley, New York.
11. Shah, K. R. and Sinha, B. K. (1989). Theory of Optimal Designs. Springer-Verlag.

STA-624: Official Statistics

UNIT-I: 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.

UNIT-II: Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India.

UNIT-III: System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

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

Reference Books

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.

STA-625: Advanced Statistical Computing and Data Mining

UNIT-I: Introduction to databases, tasks in building a data mining database, data warehouses, online analytical data processing, Data mining and machine learning, supervised and unsupervised learning.

UNIT- II: Similarity and distance measures, Outliers, Minimum spanning tree, squared error clustering, K-means clustering, Hierarchical clustering, Block clustering and two-way clustering: Hartigan's block clustering algorithm, Biclustering, Plaid models for biclustering.

UNIT- III: Extensions of regression models, McCullon-Pitts Neuron (Threshold Logic Unit), Rosenblatt's Single layer perceptron, single unit perceptron gradient descent learning algorithm, Multilayer perceptron, feed forward and back propagation learning algorithm, Self organizing maps (SOM) or Kohonen neural network, on-line and batch versions of SOM algorithm.

UNIT- IV: Classification trees, node impurity function and entropy function, choosing the best split pruning algorithm for classification trees. Regression trees, terminal node value and splitting strategy, pruning the tree and best pruned subtree. Bagging tree-based classifiers and regression tree predictors.

Essential Readings

1. Bishop, C.M. (1995). Neural Networks for pattern Recognition, Oxford University Press.
2. Hastie, T., Tibshirani, R. and Friedman, J. (2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer.
3. Duda, R.O., Hart, P.E. and Strok, D.G. (2000). Pattern Classification, John Wiley & Sons.
4. Han, J. and Kamber, M. (2000). Data Mining: Concepts and Techniques, Morgan
5. Hand, D., Mannila, H. and Smyth, P. (2001). Principles of Data Mining, MIT Press.
6. Haykin, S. (1998). Neural Networks: A Comprehensive Foundation, Prentice Hall. Kaufmann.
7. McLachlan, G.J. and Krishnan, T. (1997). The EM Algorithms and Extensions, John Wiley & Sons.

STA-626: Statistical Decision Theory

UNIT-I: Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules.

UNIT-II: Concepts of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

UNIT-III: Supporting and separating hyperplane theorems, minimax theorem of for finite parameter space, minimax estimators of Normal and Poisson mean, admissibility of minimax rules.

UNIT-IV: 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, estimation of a distribution function.

UNIT-V: Multivariate normal distribution, exponential family of distributions, sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

UNIT-VI: Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems, sequential tests of a simple hypothesis against a simple alternative, SPRT and stopping rule principle.

Reference Books

1. Berger, J. O. (1985). Statistical Decision Theory and Bayesian Analysis. 2nd Ed. Springer.
2. Ferguson, T. S. (1967). Mathematical Statistics - A Decision Theoretic Approach, Academic Press.

STA-627: Actuarial statistics

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

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

UNIT-III: Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

UNIT-IV: Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT-V: Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

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

UNIT-VII: 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.

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

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

UNIT-X: A brief outline of payment premiums and net premiums

Reference Books

1. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1966), Actuarial Mathematics, Society of Actuaries, 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

STA-628: Research Methodology

UNIT-I: Evolution of Statistics as a discipline, Important milestones in statistical research, Contributions of statisticians and statistical institutions in allied sciences, Importance and necessity of ethical considerations in statistical research.

UNIT-II: Accessing literature: Manual, Scientific reports and Statistical Database, Electronic: e-journals, e-books, and Online Database, Referencing Style: Modern Language Association (MLA), American Psychological Association (APA), Chicago Manual of Style (Chicago), Harvard Referencing Style (Harvard), Vancouver Referencing Style (Vancouver). Impact Factor as per Journal Citation Reports (JCR), Scimago Journal Rank (SJR), and cite score. Multi-Criteria Decision-Making (MCDM) methods like Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA) etc. Selection of Journals vis-à-vis specific research area/ topic.

UNIT-III: Concept of Inductive and Deductive inference in Statistics, Application and formulation of statistical inferences in various research domains, Mode of conducting field

research and operationalisation of variables. Textual analysis of sub-topics in analytic research.

UNIT-IV: Inverse probability, Iterative techniques as approximation to complex differential and integral forms.

Reference Books

1. Cox, D. R. (2006). Principles of Statistical Inference, Cambridge University Press.
2. Hald, A. (1999). A History of Mathematical Statistics from 1750 to 1930, John Wiley & Sons.
3. Krippendorff, K. (2018). Content analysis: An introduction to its methodology, Sage publications.
4. Kumar, R. (2018). Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.
5. 1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.