Syllabus for M. Sc. Statistics
Department of Statistics
North-Eastern Hill University

Course No.	Course Name		Marks
Semester I			
STAT – 411	Ancillary Mathematics	:	100
STAT – 412	Measure Theory and Probability	:	100
STAT – 413	Distribution Theory	:	100
STAT – 414	Matrix Algebra and Numerical Analysis (Pract)	:	50
STAT – 415	Distribution Theory (Pract)	:	50
STAT – 416	Computer Programming (Pract)	:	50
Semester II			
STAT – 421	Inference – I	:	100
STAT – 422	Sample Surveys	:	100
STAT – 423	Linear Models and Regression Analysis	:	100
STAT – 424	Inference – I (Pract)	:	50
STAT – 425	Sample Surveys (Pract)	:	50
STAT – 426	Linear Models and Regression Analysis (Pract)	:	50
Semester III			
STAT – 531	Inference – II	:	100
STAT – 532	Design of Experiments	:	100
STAT – 533	Time Series Analysis	:	100
STAT – 534	Inference – II (Pract)	:	50
STAT – 535	Design of Experiments (Pract)	:	50
STAT – 536	Time Series Analysis (Pract)	:	50
Semester IV			
STAT – 541	Multivariate Analysis	:	100
STAT – 542	Econometrics and Economic Statistics	:	100
STAT – 543	Environmental Statistics	:	20
Optional Paper (Any one from (a) & (b))			
STAT – 544 (a)	Operations Research	:	80
STAT – 544 (b)	Reliability	:	80
STAT – 545	Multivariate Analysis (Pract)	:	50
STAT – 546	Econometrics and Economic Statistics (Pract)	:	50
Practical for relevant optional paper			
STAT – 547 (a)	Operations Research (Pract)	:	50
STAT – 547 (b)	Reliability (Pract)	:	50
	Total Marks	:	**1800**

1. A minimum of 10 practicals to be done in each practical course
2. All practicals except practicals in STAT-416 are to be done using MS-EXCEL
3. For each course, 25 % marks are to be allotted for internal assessment

Semester I

STAT – 411 **Ancillary Mathematics**

UNIT – I : Recap of elements of set theory; Introduction to real numbers. Introduction to n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano – Weirstrass theorem, Heine – Borel theorem. Sequences and series; their convergence.

(9L)

UNIT – II : Real valued function; continuous functions, uniform continuity. Differentiation; maxima – minima of functions, functions of several variables, constrained maxima – minima of functions, mean value theorem, Taylor's theorem, differentiation under the sign of integral – Leibnitz rule.

(9L)

UNIT – III : Fields, vector spaces, subspaces, linear dependence, basis and dimension of a vector space, completion theorem, linear equations. Vector spaces with an inner product, Gram-Schmidt ortghogonalization process, orthonormal basis and orthogonal projection of a vector.

(9L)

UNIT – IV : Linear transformations, algebra of matrices, row an column spaces of a matrix, elementary matrices, determinants, rank and inverse of a matrix, partitioned matrices, Kronecker product. Real quadratic forms, positive definite matrix. Characteristic roots and vectors, Cayley – Hamilton theorem, minimal polynomial, similar matrices.

(9L)

UNIT – V : Difference table. Methods of interpolation; Lagrange's interpolation formula, Newton's divided difference formula. Numerical differentiation based on Newton's and Lagrange's formula. Numerical integration; Trapezoidal, Simpson's one-third and three-eighth formula for numerical integration.

(9L)

Text Books

Hadley, G. (1987). Linear Algebra, Narosa Publishing House , New Delhi.

Narayan, S. (1993). Mathematical Analysis, S. Chand and Co., New Delhi.

Rudin, W. (1976). Principles of Mathematical Analysis, 3rd edition, McGraw-Hill, New York.

Scarborough, J.B. (1971). Numerical and Mathematical Analysis, Oxford and IBH, New Delhi.

Searle, S.R. (1982). Matrix Algebra useful for Statistics, John Wiley & Sons, New York.

Additional references

Apostol, T.M. (1985). Mathematical Analysis, Narosa Publishing House, New Delhi.

Demidovich, B.P. and Moran, I.A. (1981). Computational Mathematics, Mir Publications, Moscow.

Hoffman, K. and Kunze, R. (1971). Linear Algebra, 2nd edition. Prentice Hall, New Jersey.

Rao, A.R. and Bhimasankaram, P. (1992). Linear Algebra, Tata McGraw-Hill, New Delhi

Rao, C.R. (1995). Linear Statistical Inference and its Applications, Wiley Eastern, New Delhi.

STAT – 412 **Measure Theory and Probability**

UNIT – I : Fields, sigma fields, generated fields and generated sigma fields. Borel sets in R^N. Measures and their elementary properties Continuity of finite measures. Extension of measures (discussion only). Induced measures. Measurable functions as limits of sequences of simple functions. Definite and indefinite integrals of measurable functions. Monotone and dominated convergence theorem (statement and discussion).

(9L)

UNIT – II : Probability measure and conditional probability measures. Brief review of independence of events and conditional probability. Random variables and their distribution functions (DF), probability mass functions (pmf) and probability density functions (pdf). Borel function of random variables, their distributions and their expectations. Independence of random variables.

(9L)

UNIT – III : Characteristic functions and their elementary properties. Inversion and uniqueness theorem (statements and discussion only). Weak convergence of DF's. Polya's theorem and continuity theorem (statement only). Almost sure convergence, convergence in probability and convergence in distribution and their relationship.

(9L)

UNIT – IV : Weak law of large numbers, Chebychev's law of large numbers. Khinchin's theorem and its applications. Contilli's lemma, Borel zero-one law and Kolmogorov's zero-one law. Kolmogorov's strong law of large numbers (both iid and non-iid cases). Demoivre-Laplace central limit theorem. Lindeberg-Levy's central limit theorem. Statement and discussion of Lindeberg- Feller's theorem.

(9L)

UNIT – V : Introduction to stochastic processes (SP), classification of SP's, Markov chain, Chapman-Kolmogorov's equations, poisson process, birth and death process. Classification of states, transition probability. Applications from social, biological and social sciences.

(9L)

Text Books

Billingsley, P. (1986). Probability and Measure, John Wiley & Sons, New York.

Feller, W. (1985). Introduction to Probability Theory and its Applications, Wiley Eastern, New Delhi

Rao, C.R. (1995). Linear Statistical Inference and its Applications, Wiley Eastern, New Delhi.

Singh, B.M. (2002). Measure, Probability & Stochastic Processes, South Asian publishers, New Delhi.

Additional references

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

Natarajan, A.M. and Tamilarasi, A. (2003). Probability, Random Process and Queing Theory, New Age International Publishers, New Delhi.

STAT – 413 **Distribution Theory**

UNIT – I : Random variables and its probability mass function (pmf) and probability density function (pdf). Joint pmf and pdf of several variables, marginal and conditional pmf and pdf. Expectation, marginal and conditional expectation, independence of random variables. Generating function of random variables and its properties.

(10L)

UNIT– II : Univariate Discrete distributions; properties and application of uniform discrete, binomial, poisson, hypergeometric, geometric negative binomial distribution and multinomial distribution.

(9L)

UNIT – III : Univariate continuous Distributions; statement, derivation of properties and applications of normal, beta, gamma, cauchy, exponential, weibull and lognormal. Pearsonian system of curves.

(9L)

UNIT – IV : Sampling distribution from binomial, poisson, exponential and normal populations. Bivariate distributions; bivariate normal. Distribution of functions of random variables.

(8L)

UNIT – V : Large sample tests. Derivation and properties of chi-square, t and F distributions and their inter relationship. Test of significance based on chi-square, t and F distributions.

(9L)

Text Books

Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley, New York.

Mood, A.M., Grabyl, F.A. and Boes, D.C. (2001). Introduction to Theory of Statistics, Tata McGraw Hill, New Delhi.

Rao, C.R. (1995). Linear Statistical Inference and its Applications, Wiley Eastern, New Delhi.

Rohatgi, V.K. (1984). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.

Additional Reference

Hogg, R.V. and Craig, A.L. (1978). Introduction to Mathematical Statistics, McMillan, New York.

Johnson, S and Kotz (1995). Distributions in Statistics, Vol – 1, II and III, Houghton and Miffin.

Pitman, J. (1993). Probability, Narosa Publishing House, New Delhi.

STAT – 414 Matrix Algebra and Numerical Analysis (practical)

List of Practicals

1. Determinants – by row and column operations, by partitioning
2. Inverses of a matrix – by row and column operations, by partitioning
3. Rank of a matrix
4. Solutions of matrix equations
5. Characteristic roots and vectors of a matrix
6. Interpolation using Lagrange's formula
7. Interpolation using Newton's divided difference formula
8. Numerical differentiation using Newton's formula
9. Numerical differentiation using Lagrange's formula
10. Numerical integration using trapezoidal formula
11. Numerical integration using Simpson's one-third formula
12. Numerical integration using Simpson's three-eighth formula

Text Books

Scarborough, J.B. (1971). Numerical and Mathematical Analysis, Oxford and IBH, New Delhi.

Searle, S.R. (1982). Matrix Algebra useful for Statistics, John Wiley & Sons, New York.

Shankararao, G. (2002). Numerical Analysis, New Age International Publishers, New Delhi.

Shastri, S.S. (2002). Introduction to Numerical Analysis, Prentice Hall of India, New Delhi.

STAT – 415 Distribution Theory (practical)

List of Practicals

1. Fitting of binomial distribution
2. Fitting of poisson distribution
3. Fitting of negative binomial distribution
4. Fitting of multinomial distribution
5. Fitting of normal distribution
6. Fitting of lognormal distribution
7. Fitting of Pearsonian Type – I curve
8. Fitting of Pearsonian Type – III curve
9. Fitting of Pearsonian Type –VI curve
10. Testing of hypothesis using chi-square distribution
11. Testing of hypothesis using Student's t distribution
12. Testing of hypothesis using F distribution
13. Large sample tests

Text Books

Bhattacharyya, G.K. and Johnson, R.A. (1977). Statistical Concepts and Methods, John Wiley, New York.

Goon, A.M., Gupta, M.K. and Dasgupta, B. (2000). Fundamentals of Statistics, Vol. I, World Press, Kolkata.

Hogg, R.V. and Tanis, E.A. (2003). Probability and Statistical Inference, Pearson Education, Delhi.

STAT – 416 **Computer Programming (practical)**

List of Practicals (using Fortran 77)

1. Factorial of a positive Integer
2. Ordering of a given set of observations
3. Finding maximum and minimum of a given set of observation
4. Mean, Variance and quantiles for ungrouped and grouped data
5. Correlation coefficients for ungrouped data, intra-class correlation coefficient
6. Fitting of exponential curve and straight line to the given data
7. Fitting of binomial and Poisson distribution.
8. Calculating the correlation coefficient for grouped data
9. Numerical Integration
10. Root extraction
11. Random number generation
12. Matrix Computation

Text Books

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Mathur, Rajiv (2000). Learning EXCEL-97 for Windows Step by Step, Galgotia, New Delhi.

Page, Clive, G. (1998). Professional Programmers Guide to FORTRAN – 77. Pitman Publishing House, London

Pal, Madhumangal (2002). FORTRAN – 77 with Numerical and Statistical Analysis, Asian books, New Delhi.

Rajaraman, V.(2001). Computer Programming in Fortran – 77 Prentice Hall of India, New Delhi.

Xavier, C. (1994). FORTRAN – 77 and Numerical Methods and Statistical, Analysis, Asian Books, New Delhi.

Note: Before starting practicals, Fortran 77 will be introduced.

Semester II

STAT – 421 **Inference – I**

UNIT – I : Parametric models, point estimation, tests of hypotheses and interval estimation viewed as decision problems with given loss functions, joint distribution of a sample and induced sampling distribution of a statistic. Likelihood Function, examples form standard discrete and continuous models (viz. bernoulli, poisson, negative binomial, normal, exponential, gamma, pareto). Plotting likelihood functions for these models up to two parameters.

(9L)

UNIT – II : Information in data about the parameters as variation in likelihood function, concept of no information, sufficiency, Neyman factorizability criterion, likelihood equivalence, minimal sufficient statistic, exponential families and Pitman families, Invariance property of sufficiency under one-one transformation of sample space and parameter space. Fisher information for one and several parameters models.

(9L)

UNIT – III : Methods of estimation; maximum likelihood method, methods of moments choice of estimators based on unbiasedness, minimum variance, mean squared error, minimum variance unbiased estimators, Rao-Blackwell theorem, completeness,

(9L)

UNIT – IV : Lehmann-Scheffe theorem, necessary and sufficient conditions for MVUE, Cramer – Rao lower bound approach. Tests of Hypotheses; concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test, Wald's SPRT with prescribed errors of two types, Neyman-Pearson Lemma, MP test for simple null against simple alternative hypothesis.

(9L)

UNIT – V : UMP tests for simple null hypothesis against one-sided alternatives and for sided null against one-sided alternatives in one parameter exponential family. Interval estimation; confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses.

(9L)

Text Books

Hogg, R.V. and Craig, A.T. (2002). Introduction to Mathematical statistics, Pearson Education, Delhi.

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

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

Additional References

Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley, New York.

Lehman, E.L. (1986). Testing of Hypothesis, John Wiley, Singapore.

Lehman, E.L. (1986). Theory of Point Estimation, John Wiley, Singapore

Rao, C.R. (1995), Linear Statistical Inference, Wiley Eastern, New Delhi.

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

STAT – 422 **Sample Surveys**

UNIT – I : Review of basic finite population sampling techniques; simple random sampling with replacement and without replacement (srswr and srswor), estimator based on distinct units, systematic sampling and related results on estimation of population mean, total, confidence interval and sample size.

(9L)

UNIT – II : Unequal probability sampling; pps wr and wor methods (including Lahiri's scheme) and related estimators of a finite population mean. Hansen – Hurwitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2. Horvitz – Thompson Estimator (HTE).

(9L)

UNIT – III : Stratified sampling. Allocation problem and construction of strata. Ratio and regression estimators based on srswor method of sampling.

(9L)

UNIT - IV : Cluster sampling with clusters of equal and unequal sizes. Two-stage sampling with equal and unequal number of second stage units. Double sampling.

(9L)

UNIT – V : Non-sampling errors and biased responses, errors in surveys, modeling observational errors, estimation of variance components, application to longitudinal studies (repetitive surveys). Randomized response technique: Warner's related question model, unrelated question model.

(9L)

Text Books

Cochran, W.G. (1997). Sampling Techniques, Wiley Eastern, New Delhi.

Mukhopadhyay, P.(1998). Theory and Methods of Survey Sampling, Prentice Hall of India, New Delhi.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press and IARS.

Additional References

Chaudhury, A. and Mukherjee, R. (1988). Randomized Response: Theory and Techniques, Marcel Decker, New York.

Murthy, M.N. (1977). Sampling Theory and Methods, Statistical Publishing Society, Kolkata.

Raj, D. and Chandhok, P. (1998). Sampling Theory. Narosa Publishing House , New Delhi.

STAT – 423 **Linear Models and Regression Analysis**

UNIT – I : Simple regression with one independent variable (X), assumptions, estimation of parameters, standard error of estimator, testing of hypothesis about β, standard error of prediction. Testing of hypotheses about parallelism, equality of intercepts, congruence, extrapolation, optimal choice of X. (9L)

UNIT – II : Diagnostic checks and correction; graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X, weighted least squares (WLS), inverse regression. Multiple regression; standard Gauss Markov setup, least square (LS) estimation, error and estimation spaces.

(9L)

UNIT – III : Variance-Covariance of LS estimators. Estimation of error variance, case with correlated observations. LS estimation with restriction on parameters. Simultaneous estimation of linear parametric functions. Test of hypotheses for one and more than one linear parametric functions. Confidence intervals and regions. Analysis of variance (ANOVA).

(9L)

UNIT – IV : Nonlinear regression; choice of initial values, monomolecular, gompertz and logistic nonlinear growth models. Methods of nonlinear estimation; Newton – Raphson, steepest descent, Levenberg-Marquardt's methods.

(9L)

UNIT – V : Logistic regression; logit transform, maximum likelihood (ML) estimation. Tests of hypotheses; Wald's test, likelihood ratio (LR) test, score test, test for overall regression. Multiple logistic regression; forward and backward method. Interpretation of parameters, relation with categorical data analysis.

(9L)

Text Books

Chatterjee, S. and Price, B. (1991). Regression Analysis by Example, John Wiley, New York.

Draper, N.R. and Smith, H (1998). Applied Regression Analysis, John Wiley, New York.

Seber, C.E.F. and Wild, C.J. (1989). Nonlinear Regression, John Wiley, New York.

Additional Reverences

Hosmer, D.W.and Lemeshow, S. (1989). Applied Logistic Regression, John Wiley, New York.

McCullagh, P and Nelder, J.A. (1989). Generalized Linear Models, Chapman and Hall, New York.

Ratkowsky, D. A (1983). Nonlinear Regression Modelling, Marcel Dekker, New York.

STAT – 424 **Inference - I (practical)**

List of Practicals

1. Estimation of parameters by maximum likelihood method for binomial distribution
2. Estimation of parameters by maximum likelihood method for poisson distribution
3. Estimation of parameters by maximum likelihood method for exponential distribution
4. Estimation of parameters by maximum likelihood method for normal distribution
5. Estimation of parameters by maximum likelihood method for lognormal distribution
6. Estimation by the method of scoring for cauchy distribution
7. Estimation by the method of scoring for chi-square distribution
8. Estimation by the method of minimum chi-square
9. Estimation by the method of moments
10. SPRT test for binomial distribution
11. SPRT test for poisson distribution
12. SPRT test for normal distribution
13. Testing of hypotheses, power curves and confidence interval

Text Books

Bhattacharyya, G.K. and Johnson, R.A. (1977). Statistical Concepts and Methods, John Wiley, New York.

Goon, A.M., Gupta, M.K. and Dasgupta, B. (2000). Fundamentals of Statistics, World Press, Kolkata.

Hogg, R.V. and Tanis, E.A. (2003). Probability and Statistical Inference, Pearson Education, Delhi.

STAT – 425 **Sample Surveys (practical)**

List of Practicals

1. Simple random sampling (wr and wor)- estimation of mean and total
2. Simple random sampling (wr and wor)- estimation of proportion
3. PPS sampling- estimation of mean and total
4. Stratified Sampling- estimation of mean and total
5. Stratified Sampling- estimation of proportion
6. Stratified Sampling- proportional and optimum allocation
7. Estimation in linear systematic sampling
8. Estimation in circular systematic sampling
9. Ratio estimator in srswor
10. Regression estimator in srswor
11. Estimation in two-stage sampling
12. Estimation in double Sampling
13. Estimation in cluster Sampling

Text Books

Krishnaiah, P.R. and Rao, C.R. (1988). Hand Book of Statistics, Vol. 6, Elsevier, Netherlands

Singh, D. and Choudhary, F.S. (1986). Theory and Analysis of Sample Survey Designs, New Age International Publishers, New Delhi.

Som, R.K. (1996). Practical Sampling Techniques, Marcel Dekker, New York.

STAT – 426 Linear Models and Regression Analysis (Practical)

List of Practicals

1. Fitting of simple regression with one independent variable
2. Testing of hypothesis about β, parallelism, intercepts
3. Tests for normality
4. Fitting of polynomial regression
5. Transformation on Y or X
6. Weighted least squares
7. Fitting of Multiple regression
8. Variance – Covariance of LS estimators
9. Tests of hypothesis of one or more linear parametric functions
10. Nonlinear regression- monomolecular, gompertz and logistic models
11. Fitting of logistic regression
12. Wald's test, LR test, Score test
13. Multiple logistic regression – forward and backward method

Text Books

Chatterjee, S. and Price, B. (1991). Regression Analysis by Example, John Wiley, New York.

Draper, N.R. and Smith, H (1998). Applied Regression Analysis, John Wiley, New York.

Seber, C.E.F. and Wild, C.J. (1989). Nonlinear Regression, John Wiley, New York.

Semester III

STAT – 531 **Inference– II**

UNIT – I : Order statistics and their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distribution (statement only) with applications.

(9L)

UNIT – II : One sample U-statistics, Kernel and symmetric kernel. Two sample U-statistics, Asymptotic distribution of U-statistics, UMVUE property of U-statistics,

(9L)

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

(9L)

UNIT – IV : Basic concepts of decision theory; minimax approach and Baye's approach, structure of Baye's rule, complete class of rules, construction of minimax rule. Pont estimation as a decision problem, hypothesis testing of as a decision problem, interval estimation as a decision problem. Problem of classification.

(9L)

UNIT – V : Concepts and evaluation of subjective probability of an event; subjective prior distribution of a parameter. Baye's theorem and computation of posterior distribution. Natural conjugate family of prior for a model. Loss function, Baye's risk. Bayesian estimation of parameters of binomial, poisson, normal and exponential distributions.

(9L)

Text Books

Ferguson, T.S. (1996). Mathematical Statistics- A Decision theory approach, Academic press, London.

Gibbons, J.D. (1985). Non-parametric Statistical Inference, Marcel Dekker, New York.

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

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

Additional References

Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. John Wiley and Sons, New York.

Ferguson, T.S. (1996). A Course on Large Sample Theory. Chapman and Hall, London.

Puri, M.L. and Sen, P.K. (1971). Non-parametric Methods in Multivariate Analysis, John Wiley and Sons, New York.

STAT – 532 **Design of Experiments**

UNIT – I : Introduction to design of experiments; general block design and its information matrix, criteria for connectedness, balance and orthogonality. Intrablock analysis, estimability, best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypotheses**.**

(9L)

UNIT – II : Balance incomplete block design (BIBD); recovery of interblock information. Youden design-intrablock analysis. Analysis of covariance in a general Gauss-Markov model, applications to standard designs.

(9L)

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

(9L)

UNIT – VI : 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.

(9L)

UNIT – V : 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.

(9L)

Text Books

Cochran, W.G. and Cox, G.M. (1959). Experimental Designs, Asia Publishing House, Singapore.

Das, M.N. and Giri, N. (1979). Design and Analysis of Experiments, Wiley Eastern, New Delhi.

Giri, N. (1986). Analysis of Variance, South Asian Publishers.

Joshi, D.D. (1987). Linear Estimation and Design of Experiments, Wiley Eastern, New Delhi.

Montgomery, C.D. (2001). Design and Analysis of Experiments, John Wiley, New York.

Additional References

Dey , Aloke (1986). Theory of Block Designs, Wiley Eastern, New Delhi.

Pearce, S.C. (1984). Design of Experiments, John Wiley, New York.

Searle, S.R. Casella, G. and McGulloch, C.E. (1992). Variance Components, John Wiley, New York.

STAT – 533 **Time Series Analysis**

UNIT – I : Time-Series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. Exploratory time series analysis, tests for trend and seasonality. Exponential and moving average smoothing, Holt and winters smoothing. Forecasting based on smoothing, adaptive smoothing.

(9L)

UNIT – II : Detailed study of the stationary processes; (1) moving average (MA) , (2) auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkin's models.

(9L)

UNITS – III : 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.

(9L)

UNIT – IV : Spectral analysis of weakly stationary process. Periodogram and correlogram analysis. Computations based on Fourier transform.

(9L)

UNIT –V : Spectral decomposition of weakly AR process and representation as a one-sided MA process – necessary and sufficient conditions. Implication in prediction problems.

(9L)

Text Books

Anderson, T.W. (1971). The Statistical Analysis of Time Series, John Wiley, New York.

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

Kendall, Sir Maurice and Ord, J.K. (1990), Time Series, Edward Arnold, London.

Additional References

Fuller, W.A. (1976). Introduction to Statistical Time Series, John Wiley, New York.

Granger, C.W.J. and Newbold (1984). Forecasting Econometric Time Series, Academic Press, New York.

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

STAT – 534 Inference – II (practical)

List of Practicals

1. One and two sample U-test
2. Sign test
3. Signed rank test
4. One and two sample Kolmogorov-Smirnov tests
5. Wilcoxon-Mann-Whitney test
6. Normal Score Test
7. Kruskal-Wallis K Sample Test
8. Minimax rule
9. Hypothesis testing
10. Interval estimation
11. Bayesian estimation of binomial parameters
12. Bayesian estimation of normal parameters

Text Books

Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. John Wiley and Sons, New York.

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

STAT – 535 Design of Experiments (practical)

List of Practicals

1. One-way classified data
2. Two way classification with single and equal observations
3. Two way classification with unequal observations
4. Latin Square Design
5. Balanced Incomplete Block Design.
6. Analysis of covariance in one way classified data
7. Analysis of covariance in two way classified data
8. 2^n factorial experiments- n=3
9. 2^n factorial experiments- n= 4
10. Total confounding in 2^n, n= 3, 4
11. Partial confounding in 2^n, n= 3, 4
12. 3^2 factorial experiments

Text Books

Cochran, W.G. and Cox, G.M. (1959). Experimental Designs, Asia Publishing House, Singapore.

Joshi, D.D. (1987). Linear Estimation and Design of Experiments, Wiley Eastern, New Delhi.

Montgomery, C.D. (2001). Design and Analysis of Experiments, John Wiley, New York.

STAT-536 Time series Analysis (Practical)

List of Practicals

1. Exploratory analysis of time series data- trend
2. Exploratory analysis of time series data- seasonality
3. Smoothing of time series data
4. Numerical exercises on MA models – forecasting
5. Numerical exercises on AR models - forecasting
6. Numerical exercises on ARMA models – forecasting
7. Numerical exercises on ARIMA models - forecasting
8. Numerical exercises on Box-Jenkins models
9. Residual analysis and diagnostic checking
10. Computations based on Fourier transform
11. Periodogram analysis and interpretation
12. Corelogram analysis and interpretation

Text Books

Anderson, T.W. (1971). The Statistical Analysis of Time Series, John Wiley, New York.

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

Granger, C.W.J. and Newbold (1984). Forecasting Econometric Time Series, Academic Press, New York.

Semester IV

STAT – 541 **Multivariate Analysis**

UNIT – I : Notions of multivariate distribution, multivariate normal distribution; distribution of linear combination of normally distributed variates, marginal distribution, conditional distribution, independence of variates, multiple correlation coefficient, moment generating function, characteristic function, moments, quadratic form.

(9L)

UNIT – II : Random sample from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Wishart matrix, its distribution and properties. Distribution of sample generalized variance. Distribution of sample correlation coefficient.

(9L)

UNIT – III : Hotelling's T^2 statistic and its null distribution. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Principal components. Canonical variables and canonical correlation; definition, use, estimation and computation.

(9L)

UNIT – IV : General multivariate linear regression model; estimation of parameters, general multivariate linear hypothesis, tests of linear hypotheses. Likelihood ratio test criterion. Multivariate analysis of variance (MANOVA) of one classified data.

(9L)

UNIT – V : Classification and discrimination; procedures for discrimination between two multivariate normal populations, Fisher's discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation, classification involving more than two multivariate normal populations. Cluster Analysis.

(9L)

Text Book

Anderson, T.W. (1983). An Introduction to Multivariate Statistical Analysis, Wiley Eastern, New Delhi.

Rao, C.R. (1995), Linear Statistical Inference, Wiley Eastern, New Delhi.

Sharma, S. (1996). Applied Multivariate Techniques. John Wiley, New York.

Singh, B.M. (2002). Multivariate Statistical Analysis, South Asian Publishers, New Delhi.

Additional References

Giri, N.C. (1977). Multivariate Statistical Inference. Academic Press, New York.

Johnson, R. and Wychern, D.W. (2002). Applied Multivariate Statistical Analysis, Pearson Education, Delhi.

Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker, New York.

Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley, New York.

Seber, G.A.F. (1984). Multivariate Observations, John Wiley, New York.

STAT-542 **Econometrics and Economic Statistics**

UNIT – I : Nature of econometrics. The general linear model (GLM) and its extension. Ordinary least squares (OLS) estimation and prediction. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances. Pure and mixed estimation. Grouping of observations and of equations.

(9L)

UNIT – II : Auto correlation, its consequences and tests. Theil BLUS procedure. Estimation and prediction. Multicollinearity problems, its implications and tools for handling the problem. Ridge regression.

(9L)

UNIT – III : Linear regression with stochastic regressors. Instrumental variable estimation. Errors in variables. Autoregressive linear regression. Distributed lag models. Use of principal components, canonical correlations and discriminant analyses in econometrics.

(9L)

UNIT – IV : 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.

(9L)

UNIT – V : 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.

(9L)

Text Books

Apte PG (1990). Test book of Econometrics, Tata McGraw Hill, New Delhi.

Johnston, J. (1984). Econometric methods, McGraw Hill, New York.

Ray, Devraj (1998). Development Economics, Oxford University Press, Oxford.

Sen, A. (1997). Poverty and Inequality, Oxford University Press, Oxford.

Additional References

Nagar, A.L. (1983). Basic Statistics, Oxford University Press, Oxford.

Foster, James E. and Sen, A. (1973). On Economic Inequality, Oxford Univ. Press, Oxford.

CSO (1980). National Accounts Statistics – Sources and Health, New Delhi.

Intrulligator, M.D. (1980). Econometric models-Techniques and Applications, Prentice Hall of India, New Delhi.

STAT-543 **Environmental Statistics**

UNIT – I : Ecological Diversity: Species abundance curve, Indices of diversity (Simpson's index, Shannon – Wiener index). Diversity as average rarity. Harvesting renewable biological resources – Maximum sustainable yield, tragedy of the commons, Air and water pollution.

(9L)

Text Books

Bodkin, Daniel D. (1995). Environmental Science- Earth As a Living Planet, John Wiley & Sons, New York.

Clack, C.W. (1976). Mathematical Bioeconomics: Optimal Management of Renewable Resources, John Wiley and Sons, New York.

Gore, Anil and Paranjpe, S.A. (2000). A Course on Mathematical and Statistical Ecology, Kluwer.

Pielou, E.C. (1997). An Introduction to Mathematical Ecology, John Wiley and Sons, New York.

Smith, J. M. (1982). Evolution and the Theory of Games, Cambridge University Press, Cambridge.

STAT-544 (a) **Operations 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.

(9L)

UNIT – II : Review of linear programming (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.

(9L)

UNIT – III : Analytical structure of inventory problems; Economic order quantity (EOQ) formula of Harris, its sensitivity analysis and extension allowing quantity discounts and shortages. Multi-item inventory subject to constraints. P and Q- systems with constant and random lead items.

(9L)

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 Pollazcek Khinchine result. Steady state solutions of M/Ek/1. Simulation.

(9L)

Text Books

Kanti, S., Gupta, P.K. and Singh, M.M. (1995). Operations Research, Sultan Chand & Sons, New Delhi.

Taha, H.A. (1982). Operational Research: An Introduction, Macmillan, New York.

Wagner, H.M. (1994). Principles of Operations Research, Prentice Hall of India, New Delhi.

Additional References

Hillier, F.S. and Leiberman, G.J. (1962). Introduction to Operations Research, Holden-day, San Francisco.

STAT-544 (b) **Reliability**

UNIT – I : Reliability concepts and measures; components and systems, coherent systems; reliability coherent systems, cuts and paths, modular decomposition, bounds and system reliability; structural and reliability importance components.

(9L)

UNIT – II : Life distributions; reliability function, hazard rate, common life distributions; exponential, weibull, gamma etc. Estimation of parameters and tests in these models.

(9L)

UNIT – III : Notions of ageing; increasing failure rate (IFR), increasing failure rate average (IFRA), not better than used (NBU), decreasing mean residual life (DMRL) and not better than used in expectation (NBUE). Classes and their duals; loss of memory property of the exponential distribution; closures of these classes under formation of coherent systems, convolutions and mixtures.

(9L)

UNIT – IV : Univariate shock models and the distributions arising out of them; bivariate shock models, common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its esimation.

(9L)

Text Books

Bain L.J. (1991) Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker, New York.

Barlow R.E. and Proschan, F. (1985). Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.

Additional References

Lawless, J.F. (1982). Statistical Models and Methods of Life Time Data, John Wiley, New York.

Nelson, W. (1982). Applied Life Data Analysis, John Wiley, New York.

STAT – 545 Multivariate Analysis (practical)

List of Practicals

1. Estimation of mean vector and dispersion matrix
2. Test of hypothesis of mean vector
3. Multiple correlation
4. Partial correlation
5. Multiple regression
6. Partial regression
7. Hotelling T^2
8. Moholanobis D^2
9. Principal component analysis
10. Factor analysis
11. Discriminant analysis
12. Cluster analysis
13. Multivariate analysis of variance (MANOVA)

Text Books

Johnson, R. and Wychern, D.W. (2002). Applied Multivariate Statistical Analysis, Pearson Education, Delhi.

Seber, G.A.F. (1984). Multivariate Observations, John Wiley, New York.

STAT-546 Econometrics and Economic Statistics (practical)

List of Practicals

1. OLS estimation and prediction in GLM.
2. Use of dummy variables (dummy variable trap) and seasonal adjustment.
3. GLS estimation and prediction.
4. Tests for heteroscedasticity: pure and mixed estimation.
5. Tests for autocorrelation. BLUS procedure.
6. Ridge regression.
7. Instrumental variable estimation.
8. Estimation with lagged dependent variables.
9. Identification problems - checking rank and order conditions.
10. Estimation in recursive systems.
11. Two SLS estimation.
12. Simulation studies to compare OLS, 2 SLS, LISE and FIML methods.

Text Books

CSO (1980). National Accounts Statistics – Sources and Health, New Delhi.

Green, W. (2000). Econometric Analysis, Pearson Education, Delhi

Ray, Devraj (1998). Development Economics, Oxford University Press, Oxford.

STAT-547 (a) Operations Research (practical)

List of Practicals

1. Linear programming
2. Maximisation / minimization problem
3. With / without constraint
4. Graphical method
5. Simplex method
6. Transportation problem
7. Northwest corner method
8. Simplex method
9. Assignment problem
10. Hungarian method
11. EOQ model
12. M/M/1 model
13. M/M/c model

Text Books

Kanti, S., Gupta, P.K. and Singh, M.M. (1995). Operations Research, Sultan Chand & Sons, New Delhi.

Taha, H.A. (1982). Operational Research: An Introduction, Macmillan, New York.

STAT-547 (b) Reliability (practical)

List of Practicals

1. Reliability estimation for different systems
2. Hazard rate estimation
3. Estimation based on life distributions
4. Exponential distribution
5. Weibull distribution
6. Gamma distribution
7. Testing based on life distributions
8. Determination of hazard rate for censored data
9. Reliability for censored data
10. Reliability growth models
11. probability plotting techniques
12. Hollander-Proschan test
13. Deshpande tests

Text Books

Bain L.J. (1991) Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker, New York.

Nelson, W. (1982). Applied Life Data Analysis, John Wiley, New York.