PONDICHERRY UNIVERSITY

DEPARTMENT OF STATISTICS

SYLLABUS FOR M.Sc STATISTICS
(CBCS Pattern)
Effective from the Academic Year 2014-2015

PONDICHERRY UNIVERSITY
PUDUCHERRY 605 014

M.Sc. STATISTICS (CBCS - Semester Pattern)

REGULATIONS

Aim of the Course

The Degree of Master of Science in Statistics aims to train the students in the development and applications of Statistical techniques for analyzing data arising in the scientific investigation of problems in the various disciplines. It is also proposed to provide first hand practical experience in handling modern statistical softwares in the analysis of such data.

Eligibility for admission

Candidates for admission to the first year of the M.Sc. (Statistics) degree programme shall be required to have passed the B.Sc. degree examination of any Indian University recognized by the University Grants Commission with Statistics as the main subject or Mathematics as the main subject with Mathematical Statistics as one of the minor subject and a minimum of 55% marks in the main and allied subjects.

Duration of the Course

The course shall be of two years duration spread over four semesters. The maximum duration to complete the course shall not be more than 8 semesters.

Eligibility for admission to Examination

A candidate shall be permitted to appear for the M.Sc. examination in a subject of study only if he/she secures not less than 70% attendance in the subject concerned.

Medium

The medium of instruction shall be English.

Passing Minimum

As per the Choice Based Credit System regulations of the Pondicherry University.

M.Sc. (STATISTICS) – COURSE STRUCTURE
(With effect from 2014-15 onwards)

Objectives

The present course is intended to provide a platform for talented students to undergo higher studies in the subject as well as to train them to suit the needs of the society. Apart from teaching core Statistics subjects, the students are also trained to handle real life problems through practical classes. As part of the course, the students are taught some programming languages and also trained in various statistical softwares such as SPSS, SYSTAT, R language.

Eligibility

B.Sc. degree in Statistics or Mathematics with Mathematical Statistics as a minor subject with a minimum 55% of marks.

Duration of the Course

The course duration shall normally be of two years duration spread over four semesters.

Medium

The medium of instruction shall be English.

Choice Based Credit System (CBCS)

The M.Sc. Statistics program is offered through a unique CBCS. The salient feature of the CBCS is that the program is offered through credit based courses. Subjects are divided into Hard Core and Soft Core. Hard Core subjects are compulsory. The students have the choice to select from among the list of soft core subjects. Soft core subjects are similar to elective subjects.

A student is expected to complete a minimum of 72 credits within four semesters. Students are assessed and awarded letter grades based on their performances in the respective courses.

Weightage of marks

The weightage of marks for Continuous Internal Assessment (CIA) and end semester examinations shall be 40 and 60 respectively. A student is declared passed in a given subject when he/she secures

(a) a minimum of 40% in the end semester examination and
(b) a minimum of 50% marks in aggregate when Internal Assessment and End-Semester marks are added

Continuous Internal Assessment

The weightage of 40 marks for Continuous Internal Assessment component shall consist of the following:

a)	Internal Assessment Tests (two)	(2 x 15)	= 30 marks
b)	Seminars/Assignments/Presentations/Viva etc.	(1 x 10)	= 10 marks
		Internal Total	= 40 marks

Supplementary Exam

(a) A failed student who meets the attendance requirement (70%) and has a minimum of 40% in the Internal Assessment marks may be permitted to register for the next End Semester examination in the following semester itself
(b) Students who have failed due to insufficient attendance and / or less than 40% in the Internal Assessment marks should repeat the course as and when it is offered.

PONDICHERRY UNIVERSITY
CHOICE BASED CREDIT SYSTEM
M.Sc. STATISTICS SYLLABUS
Effective from the Academic Year 2014 – 2015

SEMESTER	COURSE CODE	TITLE OF THE COURSE	NATURE OF THE COURSE	NO. OF CREDITS
I	STAT 411	Linear Algebra and Matrix Theory	Hard Core	4
	STAT 412	Probability Theory	Hard Core	4
	STAT 413	Statistical Quality Control	Hard Core	4
	STAT 414	Distribution Theory	Hard Core	4
	STAT 415	Programming in R	Hard Core	4
II	STAT 421	Theory of Estimation	Hard Core	4
	STAT 422	Sampling Theory	Hard Core	4
	STAT 423	Stochastic Processes	Hard Core	4
	STAT 424	Statistical Laboratory – I (Based on STAT 421 and STAT 422)	Hard Core	3
		Soft Core	Soft Core	3
III	STAT 531	Multivariate Statistical Analysis	Hard Core	4
	STAT 532	Testing of Statistical Hypotheses	Hard Core	4
	STAT 533	Linear Models and Regression Analysis	Hard Core	4
	STAT 534	Statistical Laboratory – II (Based on STAT 531 and STAT 532)	Hard Core	3
		Soft Core	Soft Core	3
IV	STAT 541	Design and Analysis of Experiments	Hard Core	4
	STAT 542	Statistical Laboratory – III (Based on STAT 541)	Hard Core	3
		Soft Core	Soft Core	3
		Soft Core	Soft Core	3
		Soft Core	Soft Core	3

Soft Core Papers

	Semester II		Semester III
STAT 425	Biostatistics	STAT 535	Reliability Theory
STAT 426	Decision Theory	STAT 536	Time Series Analysis
STAT 427	Econometrics	STAT 537	Actuarial Statistics
STAT 428	Demographic Techniques	STAT 538	Simulation Techniques
STAT 429	Total Quality Management	STAT 539	Elements of Queuing Theory
	Semester IV		
STAT 543	Project and Viva-Voce/ Dissertation		
STAT 544	Survival Analysis		
STAT 545	Advanced Operations Research		
STAT 546	Statistical Data Mining Methods		
STAT 547	Bayesian Inference		
STAT 548	Data Analysis with SPSS		

STAT 411 - LINEAR ALGEBRA AND MATRIX THEORY CREDITS: 4

Unit I

Vector Spaces, Sub-spaces, Basis of a vector space – Vector spaces with inner products - Gram-Schmidt orthogonalization.

Unit II

Linear transformation (LT) – Properties – Matrix of a linear transformation – Matrix of composite transformation – Matrix of an inverse transformation – Change of basis - Orthogonal transformation - Dual space.

Unit III

Linear equations – Solution space and null space – Sylvester's law of nullity – Generalized inverse of a matrix – Moore – Penrose inverse

Unit IV

Eigen values and eigen vectors of an LT – left eigen vectors, right eigen vectors, Diagonalizable LT – Lambda matrix, Composition of lambda matrices, Operator polynomial, Cayley-Hamilton theorem and minimal polynomial for an LT – Eigen values of matrix polynomials.

Unit V

Bilinear forms - Canonical reduction – Sylvester's law of inertia - Definitions of quadratic form - Lagrange's reduction – Kronecker's reduction - Reduction involving the eigen values of the matrix, Generalized eigen value problem.

Text books:

1. Biswas S, (1997), A Text Book of Matrix Algebra, 2/e, New Age International Publishers, New Delhi
2. Bhattacharya, Jain and Nagpaul, S.K (2007), First Course in Linear Algebra, New Age International Publishers, New Delhi
3. Rao, C.R (1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd.,.
4. B.P.Parashar (1989), Linear Algebra, CBS Publishers and Distributors, Delhi

Reference Books:

1. Gilbert and Gilbert (2005): Linear Algebra and Matrix Theory, Elsevier Publications.
2. Seymour Lipschutz and Marc Lipson (2003), Schaum's Easy Outline of Linear Algebra, Tata Mc Graw Hill
3. Graybill, F.A.(1983): Matrices with applications in statistics.
4. Rao, A.R.and Bhimasankaran: Linear Algebra TMH.
5. Searle, S.R (1997) : Linear Models, John Wiley and Sons.
6. Searle, S.R.(1982): Matrix Algebra useful for statistics, John Wiley.
7. Stephen H. Friedberg, Arnold J. Insel and Lawrence E. Spence (2004): Linear Algebra PHI, New Delhi.

STAT 412 - PROBABILITY THEORY **CREDITS: 4**

Unit I

Algebra of sets - fields and sigma-fields, Inverse function – Measurable function – Probability measure on a sigma field – simple properties - Probability space - Random variables and Random vectors – Induced Probability space – Distribution functions – Decomposition of distribution functions.

Unit II

Expectation and moments – definitions and simple properties – Moment inequalities – Holder, Jenson Inequalities– Characteristic function – definition and properties – Inversion formula.

Unit III

Convergence of a sequence of random variables - convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean - Weak and Complete convergence of distribution functions – Helly-Bray theorem.

Unit IV

Definition of product space – Fubini's theorem (statement only) - Independence of two events – Independence of classes – Independence of random variables – properties – Borel zero –one law.

Unit V

Law of large numbers - Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (statement only) – Central Limit Theorem – Lindeberg – Levy theorem, Linderberg – Feller theorem (statement only), Liapounov theorem – Relation between Liapounov and Linderberg – Feller forms – Radon Nikodym theorem and derivative (without proof) – Conditional expectation – definition and simple properties.

Text Books

1. Billingsley, P. (1979): Probability and Measure, Wiley

Reference Books

1. Ash, R.B. (1972): Real Analysis and Probability, Academic Press.
2. Bhat, B. R. (2007). Modern Probability Theory – 3rd edition, New Age International Pvt. Ltd.
3. Tucker, H.G. (1967): A Graduate course in Probability, Academic Press.
4. Burill, C.W. (1972): Measure, Integration and Probability, McGraw Hill.
5. Chow, Y.S. and Teicher, H. (1979): Probability Theory, Springer.
6. Loeve, M. (1985). Probability Theory, 3rd edition, Springer..
7. Resnick S.I. (2001): A Probability Path, Birkauser.
8. Basu A K. and A Bandopadhyay (2012): Measure Theory and Probability, PHI Learning Pvt. Ltd.

STAT 413 – STATISTICAL QUALITY CONTROL CREDITS: 4

Unit I

Definition of Quality – Dimension of quality – Quality problem - Quality improvement – Basis of Control charts – Attributes Control Chart – p-chart, d-chart, c-chart – Interpretation of control charts

Unit II

Control chart for variables - and R charts, and S charts - Modified control charts for mean – CUSUM chart – technique of V-mask – Weighted Moving average charts – Slopping control charts and group control charts

Unit III

Process Capability analysis: Meaning, Estimation technique for capability of a process – Capability Indices: Process capability ratios C_p; C_{pk}, C_{pm}, C_{mk}, C_{pc} – Process capability analysis using a control chart – Process capability analysis using design of experiments, Gage and measurement system capability studies

Unit IV

Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves –MILSTD -105E Tables

Unit V

Acceptance sampling variables for process parameter – Sequential plans for process parameter (σ known and unknown) – Sampling variables for proportion non-conforming - method, K method – Double specification limits – M-method, Double sampling by variables - MILSTD -414 Tables – Continuous Sampling plan – CSP-1, CSP-2, CSP-3

Text Books

1. Douglas C. Montgomery (2009): Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis
3. Oakland, J.S.(1989): "Total Quality Management", Butterworth–Hcinemann Ltd., Oxford

Reference Books

1. Mittage, H.J and Rinne, H(1993): Statistical Methods of Quality Assurance, Chapmann Hall, London, UK
2. Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.
3. Juran J.M and Frank M.Gryna Jr .(1982): "Quality Planning and Analysis", TMH, India.

STAT 414 – DISTRIBUTION THEORY **CREDITS: 4**

Unit I
Brief review of distribution theory, distribution of functions of random variables - Laplace, Cauchy, Inverse Gaussian, Lognormal, Logarithmic series and Power series distributions - Multinomial distribution

Unit II
Bivariate Binomial – Bivariate Poisson – Bivariate Normal- Bivariate Exponential of Marshall and Olkin - Compound, truncated and mixture of distributions, Concept of convolution

Unit III
Multivariate normal distribution (Definition and Concept only) - Sampling distributions: Non-central chi-square, t and F distributions and their properties - Distributions of quadratic forms under normality-independence of quadratic form and a linear form - Cochran's theorem

Unit IV
Order statistics, their distributions and properties- Joint and marginal distributions of order statistics - Distribution of range and mid range - Extreme values and their asymptotic distributions (concepts only)

Unit V
Empirical distribution function and its properties - Kolmogorov-Smirnov distributions - Life time distributions - Exponential and Weibull distributions - Mills ratio - Distributions classified by hazard rate.

Text Books

1. Mood M., Graybill F.A. and Boes D.C.(2001) : Introduction to the Theory of Statistics, Tata McGraw-Hill, New Delhi.
2. Johnson, N.L, Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol.1 &2, Wiley Series in Probabilty and Statistics.
3. Johnson, N.L , Kemp A.W. & Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probabilty and Statistics
4. David H. A. and Nagaraja H.N.(2003): Order Statistics, 3/e, John Wiley & Sons.

Reference Books

1. Rao C. R.,(1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd, New Delhi.
2. Dudewicz, E.J and Mishra, S.N(1980): Mathematical Statistics, John Wiley, NY.
3. Kocherlakota S and Kocherlakota K(1992): Bivariate Discrete distributions, M. Dekker.
4. Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.
5. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
6. Parimal Mukhopadhyay(2006): Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.

STAT 415 – PROGRAMMING IN R **CREDITS: 4**
(Lab. Based)

Unit I
R language Essentials: Expressions and objects, Assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection ; examples.

Unit II
R Programming: conditional statements - if and if else; loops - for, while, do-while; functions – built-in and user defined; Data entry – reading from text file, data editor; examples.

Unit III
Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises.

Unit IV
Probability and Distributions: Random sampling and combinatory; obtaining density, cumulative density and quantile values for discrete and continuous distributions; generating samples from discrete and continuous distributions; Plotting density and cumulative density curves; Q-Q plot.

Unit V
Correlation: Pearson, Spearman and Kendall's correlation; Regression – fitting, obtaining residuals and fitted values; one and two sample tests for mean and variance – one way and two way ANOVA.

Text Books

1. Introductory Statistics with R by Peter Dalgaard, Springer, 2nd edition, 2008.
2. The R Book by Michael J.Crawley, John Wiley and Sons, Ltd., 2007.

Lab Exercises:

1. Operations on vectors and matrices
2. Creating and manipulating data frames.
3. Writing user defined functions for finding arithmetic mean, median, factorial, matrix addition and multiplication.
4. Bar and Pie charts.
5. Box plots for single and multiple groups.
6. Density and cumulative density plots for Binomial, Poisson, Normal and exponential distributions.
7. Checking Normality using Histogram and Q-Q plot.
8. Correlation coefficient – Pearson's, Spearman and Kendall's Tau.
9. Fitting simple linear and multiple linear regressions.
10. One sample and two sample t test.
11. One way and two way ANOVA.

STAT 421 - THEORY OF ESTIMATION CREDITS: 4

Unit I

Parametric point estimation – properties of estimators – Consistency and its different forms Sufficient condition for consistency- Unbiasedness – sufficient statistics – Factorization theorem - Distributions admitting sufficient statistic – Exponential and Pitman families procedure for finding minimal sufficient statistic.

Unit II

The information measure – Cramer - Rao (CR) inequality - Chapman - Robbins (KCR) inequality (single parameter case only) - Bhattacharya inequality (single parameter case only) - minimum variance bound estimator- Invariant (equivariant) estimators (concepts only)

Unit III

Uniformly minimum variance unbiased estimators (UMVUE)- condition for the existence of UMVUE- Completeness and Bounded completeness- Relation between complete statistic and minimal sufficient statistic- Rao - Blackwell Theorem- Lehmann – Scheffe's theorem.

Unit IV

Methods of estimation – method of moments and its properties - method of maximum likelihood and its properties-Large sample properties of MLE - Method of minimum chi-square and its properties – Methods of least squares – Optimum properties of least square estimates in linear model.

Unit V

Interval estimation – Pivotal method of construction - shortest confidence intervals and their construction (minimum average width) - Construction of shortest confidence intervals in large samples. Decision Theory: Simple problems involving quadratic error loss function - Elementary notions of minimax estimation - Simple illustrations.

Text Books

1. Rohatgi, V.K. (1986): Statistical Inference, Wiley Eastern Ltd,.
2. Kale, B.K. (1999): A First course on parametric inference , Narosa Publishing House.
3. Zacks,S. (1981): Parametric Statistical Inference, John Wiley, NY.

Reference Books

1. Goon, A.M, Gupta,M.K, and Das Gupta, B.C(1980) : An outline of Statistical Theory, Vol. II,The World Press, Calcutta.
2. Lehmann, E.L and Casella G(1998) :Theory of Point Estimation, 2/e, Wiley Eastern Ltd.
3. Mood, A.M., Graybill, F.A and Boers, D.C(1974) : Introduction to Theory of Statistics, Mc Graw-Hill Book Company.
4. Rao, C.R(1998): Linear Statistical Inference and its Applications, Wiley Eastern Ltd,.
5. Casella, G. and Berger, R.L. (2002):Statistical Inference, Duxubury Process, Belmont, USA.
6. Parimal Mukhopadhyay (2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.

STAT 422 – SAMPLING THEORY **CREDITS: 4**

Unit I

Preliminaries – Sampling Designs – Simple random sampling– Stratified Random Sampling – Allocation problems - Systematic Sampling Schemes – Linear, Circular, Balanced and Modified systematic sampling methods

Unit II

Probability Proportional to size sampling- Inclusion Probabilities – Horvitz-Thompson estimator – Yates –Grundy Form –Midzuno Sampling design - PPSWOR- Des-Raj's Ordered estimator - Murty's unordered estimators

Unit III

Ratio estimators and their properties in Simple Random Sampling - Ratio estimators in Stratified Random sampling - Regression Estimators, Regression estimates with pre assigned "b" - Sample estimate of variance and Bias in Simple Random Sampling – Regression estimators in Stratified Random Sampling - Multivariate Ratio estimators and Multivariate Regression Estimators

Unit IV

Cluster Sampling: Equal cluster sampling – Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance, varying probability cluster sampling - Two stage sampling – variance of the estimated mean – Double Sampling for stratification and Ratio estimation

Unit V

Randomized response methods – Warner's, Simmon's and Two Stage response methods - Sources of errors in Surveys - Mathematical model for the effects of call-backs and the errors of measurement – Official Statistical Systems in India – Role of NSSO and CSO and their activities – Organization of Large Scale Sample Surveys.

Books for Study

1. Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley Eastern Ltd,. (Chapter 6 for Unit I, Chapter 7 for Unit II and Chapter 13 for Unit V)
2. Gupta, A. K. and Kabe D.G, (2011): Theory of Sample Surveys, World Scienific Publishing Co. Pte. Ltd., Singapore
3. Singh, D. and Choudhary, F.S (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd,. (Chapter 5 for Unit III and Chapter 8 for Unit IV)
4. Sukhatme PV. etal. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and IARS

Reference Books

1. Desraj and Chandhok P.(1998): Sampling Theory, Narosa Publications, New Delhi
2. Kish, L(1995) : Survey Sampling, John Wiley and Sons.
3. Murthy, M.N (1979): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Sarjinder Singh (2004): Advanced Sampling - Theory with Applications, Kluwer Publications

STAT 423 – STOCHASTIC PROCESSES **CREDITS: 4**

Unit I
Stochastic processes and their classification – Markov chain– Examples (Random walk, Gambler's ruin problem)- classification of states of a Markov chain-Recurrence-Basic limit theorem of Markov chains-Absorption probabilities and criteria for recurrence.

Unit II
Markov chains continuous in time – General pure birth processes and Poisson process, birth and death processes, finite state continuous time Markov chains.

Unit III
Branching processes discrete in time – Generating functions relations – Mean and variance – Extinction probabilities – Concept of Age dependent Branching process

Unit IV
Renewal processes – Definition and examples – key renewal theorem – Study of residual life time process

Unit V
Stationary process – weakly and strongly stationary process – Moving average and Autoregressive processes and their covariance functions - Brownian Motion process – Joint probabilities for Brownian motion process – Brownian motion as a limit of random walk

Text Books

1. Karlin, S and Taylor, H.M(1975): A First Course in Stochastic Processes, Academic Press, New York.
2. Medhi,J (2009): Stochastic Processes, 3/e, New age International.
3. Bhat B.R.(2002): Stochastic Processes, 2/e, New Age Publications

Reference Books

1. Bhattacharya and Waymire, E.C. (1992): Stochastic Process with Applications John Wiley and sons.
2. Jones,P.W and Smith,P(2001): Stochastic Processes: An Introduction, Arnold Press.
3. Cinlar, E(1975): Introduction to Stochastic Processes, Prentice-Hall Inc., New Jersey.
4. Cox, D.R and Miller, H.D(1983) : Theory of Stochastic Processes – Chapman and Hall, London, Third Edition
5. Prabu N.U. (1965): Stochastic Processes Macmillan.
6. Ross S.M (1983): Stochastic Process, Wiley.
7. Sidney I. Resnick (1992):Adventures in Stochastic Processes, Birkauser, Boston.

STAT 424 – STATISTICAL LABORATORY – I **CREDITS: 3**
(Based on STAT 421 and STAT 422)

I. Estimation (30 marks)

1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean, difference of means and ratio of variances.

II. Sampling Theory (30 marks)

1. Simple random sampling without replacement – Estimation of the population total and its variance.
2. Ratio, Regression and Difference estimation.
3. Stratified sampling – SRS- Equal, Proportional, Neyman and Optimum allocations
4. Linear and circular systematic sampling
5. PPSWR – Hurwitz Thompson estimator - Des Raj ordered estimator – Murthy’s unordered estimator – Midzuno-Sen scheme.
6. Cluster sampling of equal sizes.

STAT 531 – MULTIVARIATE STATISTICAL ANALYSIS CREDITS: 4

Unit I

Multivariate normal distribution– Marginal and conditional distributions – characteristic function. Maximum likelihood estimation of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known

Unit II

Total, Partial, Multiple correlation in the Multivariate setup – MLEs of Total, Partial and Multiple correlation coefficients. Sampling distributions of Total and Multiple Correlation in the null case. Hotelling T^2 statistic, derivation and its distribution - Uses of T^2 statistic - relation between T^2 and D^2 - Mahalanobis D^2 statistic and its distribution

Unit III

Generalized variance - Wishart distribution (statement only) – Properties of Wishart distribution - Test for covariance matrix – Test for equality of covariance matrices

Unit IV

Classification problems - Classification into one of two populations (known and unknown dispersion matrix) - Classification in to one of several populations – Fisher's Linear discriminant function

Unit V

Principal components – properties, Extraction of Principal components and their variances Canonical correlation – Estimation of canonical correlation and variates. Factor analysis - Mathematical model- Estimation of Factor Loadings — Concept of factor rotation – Varimax criterion

Text Books

1. Anderson, T.W(2003) : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2. Johnson, R. A and. Wichern D.W (2007): Applied Multivariate Statistical Analysis, 6 /e, Prentice-Hall of India Private Ltd., New Delhi.

Reference Books

1. Giri, N.C(1977): Multivariate Statistical Inference, Academic Press, NY
2. Morrison, F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
3. Rao, C.R(1998): Linear Statistical Inference and its Applications, Wiley Eastern Ltd,.
4. Jolliffe I.T.(2002): Principal Component Analysis, 2/e, Springer.
5. Alvin C. Rencher(2002): Methods of Multivariate Analysis, 2/e, Wiley Interscience
6. Kshirsagar A.M.(1972): Multivariate Analysis, M.Dekker.
7. Srivastava M.S. and Khatri C.G.(1979):Introduction to Multivariate Analysis, Elsevier

STAT 532 – TESTING OF STATISTICAL HYPOTHESES CREDITS: 4

Unit I

Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, Most powerful tests, Uniformly most powerful test, Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma and its applications

Unit II

Unbiasedness for hypothesis testing, Uniformly most powerful unbiased tests, Unbiased tests for one parameter exponential family, Similar test and complete sufficient statistics, Similar tests with Neyman structure, Locally most powerful tests.

Unit III

Invariant tests, maximal invariants, Uniformly most powerful invariant tests, Consistent tests, Likelihood ratio test, its properties and its asymptotic distribution, Applications of the LR method.

Unit IV

Non-parametric tests: Goodness of fit test : Chi-square and Kolmogorov Smirnov test - Test for randomness, Wilcoxon Signed rank test – Two sample problem: Kolmogrov-Smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test

Unit V

Sequential tests: Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications – Determination of the boundary constants – Operating Characteristic and expected sample size of SPRT - Optimum properties of SPRT.

Text Books

1. Lehmann, E.L and Joseph P. Romano (2005): Testing Statistical Hypotheses, 3/e, Springer.
2. Rohatgi, V.K. (1986): Statistical Inference, Wiley Eastern Ltd,.
3. Kale, B.K. (1999) :A First course on Parametric Inference , Narosa Publishing House.
4. Gibbons, J.D. (1985) : Non Parametric Statistical Inference , 2/e , Marckel Decker.

Reference Books

1. Rao, C.R (1998): Linear Statistical Inference and its Application, John Wiley, Second Edition.
2. Casella, G & Berger, R.L (1990): Statistical Inference , Duxubury Press, Belmont. USA
3. Wald, A(1949): Sequential Analysis, John Wiley, NY
4. Ghosh,B.K(1970): Sequential Tests of Statistical Hypotheses, Addison Wesley.
5. Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
6. Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India

STAT 533 - LINEAR MODELS AND REGRESSION ANALYSIS CREDITS: 4

Unit I

Full rank linear model – least square estimators of the parameters and their properties – Gauss-Markov theorem - Model in centered form – Estimators under normality assumption and their properties – Coefficient of determination – Generalized least squares – misspecification of the error structure and the model.

Unit II

Test for overall regression and for a subset of the parameters – test in terms of R^2 – General Linear Hypothesis testing – special cases – confidence region for the parameters and the mean – prediction intervals – likelihood ratio tests for the parameters – study of the residual outliers and influential observations

Unit III

Selection of input variables and model selection – Methods of obtaining the best fit - Stepwise regression, Forward selection and backward elimination – Multicollinearity – Collinearity diagnostics – Causes, Consequences and Remedy –Departure from normality

Unit IV

Introduction to general non-linear regression – Least squares in non-linear case – Estimating the parameters of a non-linear system – Reparametrisation of the model – Non-linear growth models – Concept of non-parametric regression

Unit V

Robust regression – Linear absolute deviation regression – M estimators – Robust regression with rank residuals – Resampling procedures for regression models – methods and its properties (without proof) - Jackknife techniques and least squares approach based on M-estimators.

Text Books

1. Alvin C. Rencher (2000): Linear Models in Statistics, John Wiley & Sons, New York (Chapters 7,8 & 9 for Unit I & II)
2. Draper, N and Smith, H (1998): Applied Regression Analysis, 3rd Edition, Wiley-Interscience.
3. Elizabeth C. Peck, Douglas C. Montgomery, G. Geoffry Vinning (2006): Introduction to Linear Regression Analysis, 3/e, John Wiley & Sons.
4. David G Kleinbaum, Lawrence L. Kupper, Azhar Nizam and Keith E. Muller (2009): Applied Regression Analysis, Cengage Learning

Reference Books

1. Chaterjee, S, Ali S. Hadi and Price, B (1999): Regression Analysis by Example, 3rd edition, John Wiley.
2. Gunst, R.F and Mason, R.L (1980): Regression Analysis and Applications – A Data Oriented Approach, Marcel Dekker.
3. Guttman, I (1982): Linear Models - An Introduction, John Wiley.
4. Kshirsagar, A.M (1972): Course in Linear Models, Marcel Dekker.
5. Wetherill, G.B (1986): Regression Analysis.
6. Searle, S.R. (1997): Linear Models, John Wiley.
7. Thomas P.Ryan(2006): Modern Regression Methods, John Wiley and Sons,Inc.

8. Seber G.A.F and Wild C.J. (2003): Nonlinear Regression, John Wiley & Sons

STAT 534 – STATISTICAL LABORATORY – II CREDITS: 3
(Based on STAT 531 and STAT 532)

I Multivariate Statistical Analysis (30 marks)

1. Test for Mean vector when dispersion matrix in known (Single and Two sample)
2. Hotelling T^2 test (One and two sample)
3. Test for covariance matrices
4. Discriminant Analysis
5. One way MANOVA
6. Principal Component Analysis
7. Canonical Correlation Analysis

II Testing of hypothesis (30 marks)

1. Construction of randomized and nonrandomized MP, UMP and UMPU tests of hypotheses and drawing the power curves.
2. Non parametric tests: Kolmogorov Smirnov test, Mann-Whitney U test, Median test for k-sample problem, Kruskal Wallis test and Friedman's test
3. Construction of SPRT and its OC and ASN curves.

STAT 541 - DESIGN AND ANALYSIS OF EXPERIMENTS CREDITS: 4

Unit I

Notion of design matrix- general analysis of design models (Inter and Intra Block analysis) – C Matrix and its properties – Expected Mean Squares (EMS) and its uses- Algorithm for calculating EMS - Two way elimination of heterogeneity – Orthogonality – Connectedness and resolvability

Unit II

Principles of scientific experimentation – Basic Design: Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) - Analysis of RBD (with one observation per cell, more than one but equal number of observations per cell) – Derivation of one and two missing values: Iterative and non-iterative methods – Loss of Efficiency due to missing values- Multiple comparison test: Least Significant Difference, Student Newman Kuel , Duncan's Multiple Range, Tukey tests.

Unit III

Factorial experiments: 2^n and 3^n experiments and their analysis – Complete and Partial Confounding - Fractional Replication in Factorial Experiments – Split plot and strip plot design and their analysis.

Unit IV

Balanced Incomplete Block Design (BIBD) - Types of BIBD - Simple construction methods - Concept of connectedness and balancing – Intra Block analysis of BIBD – Recovery of Inter Block information – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only.

Unit V

Youden square and lattice design and their analysis – Analysis of Covariance with one concomitant variable in CRD and RBD only

Text Books

1. Das, M.N. and Giri, N.C(1979): Design and Analysis of Experiments, Wiley Eastern Ltd, (Relevant Chapters for Units II, III, IV and V)
2. Douglas C. Montgomery (2009) : Design and Analysis of Experiments, 7/e, John Wiley and Sons, (Chapter 16 for Parts of Unit IV and Unit V)
3. Graybill, F.A(1961) : An Introduction to Linear Statistical Models, Mc Graw Hilll Book Company,(Chapter 5 & Parts of Chapter 6 for Unit I)

Reference Books

1. John, P.W.M (1971): Statistical Design and Analysis of Experiments, Mc Graw Hill Book Company.
2. Kempthorne, O(1966): The Design and Analysis of Experiments, John Wiley and Sons.
3. Ragahavarao, D(1971): Constructions and Combinatorial Problems in Design of Experiments, John Wiley and Sons.
4. Searle, S.R(1987) : Linear Models, John Wiley and Sons.
5. Cochran .W.G. and Cox .G.M. (1995): Experimental designs, 4/e, Wiley.
6. Cobb G.W.(1998): Introduction to Design and Analysis of Experiments.
7. Parimal Mukhopadhyay(2005):Applied Statistics, 2/e, Books and Allied (P) Ltd, Kolkata.

STAT 542 – STATISTICAL LABORATORY – III **CREDITS: 3**
(Based on STAT 541)

I. Design of Experiments (60 marks)

1. Multiple Comparison tests- Fisher LSD, Tukey, DMR and SNK
2. 2^4 , 3^2, 3^3 factorial experiment
3. Complete and partial confounding in 2^4, 3^2, 3^3 factorial experiments
4. Fractional factorial
5. Split plot design and Strip plot design
6. Missing data analysis- one and two missing values in RBD and LSD
7. Balanced Incomplete Block Design- Intra Block analysis
8. Partially Balanced Incomplete Block Design with two associate classes- Intra Block analysis
9. Youden Square Design
10. Analysis of Covariance – CRD and RBD

SOFT CORE PAPERS

SEMESTER - II

STAT 425 - BIO STATISTICS **CREDITS: 3**

Unit I

Statistical Methods in Clinical Trials: Introduction to clinical trial and it's phases I, II, III and IV, statistical designs-fixed sample trials: simple randomized design, stratified randomized crossover design; Sequential design - open and close sequential design. Randomization-Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple.

Unit II

Biological Assays: Introduction, parallel-line assay, slope- ratio assays and quantal- response assay, Feller's theorem. Dose-response relationships-qualitative and quantitative response, dose response relation- estimation of median effective dose.

Unit III

Data editing and transformations: Transformation in general - logarithmic, square root and power transformations; transformations for proportions – angular, probit and logit transformations. Outlying observations – box plot, M- estimators. Test for normality - p-p plot and q-q plot and Kolmogorov-Smirnov test.

Unit IV

Categorical Data Analysis: Categorical response data, logistic regression-odds ratio, Wald's statistic, logistic regression and its diagnostics, ROC Curve analysis - Estimation of Binormal Model and the Area under the Curve, its applications, poison regression and its applications.

Unit V

Repeated Measures ANOVA – One Way and Two Classified Data – Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias – information bias and selection bias

Text Books

1. Elisa T.Lee & John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley
2. Jerrold H. Zar (1999): Biostatistical Analysis, 4th edition, Pearson
3. Armitage, P, Berry G and Mathews J.N.S (2002): Statistical Methods in Medical Research, 4/e, Blackwell Scientific Publications
4. Krzanowski, W and Hand, D.J.(2009): ROC Curves for Continuous Data, Chapman and Hall

Reference Books

1. Hosmer and Lemeshow (2000): "Applied Logistic Regression", 2/e, Wiley Series
2. Alan Agresti (2002): Categorical Data analysis, 2/e, John Wiley
3. Sylvia Wasserthial and Smoller, (2004): Biostatistics and Epidemiology – A Primer for Health and Biomedical professionals, 3rd Edition, Springer
4. Rastogi, V.B. (2006): Fundamentals of Biostatistics, ANE Books, India

STAT 426 – DECISION THEORY CREDITS: 3

Unit I

Basic elements of a decision problem - Randomized and non-randomized decision rules - Estimation and testing of hypothesis as decision problems - Bayes approach to inference and decision -

Unit II

Loss functions - Prior and Posterior distributions - Prior-Posterior analysis for Bernoulli, Poisson, and normal processes - Decision principles and Baye's risk

Unit III

Utility theory - axioms, construction of utility functions, sufficiency, equivalence of classical and Bayesian sufficiency, complete and essentially complete classes of decision rules

Unit IV

Minimax analysis - Basic elements of game theory - General techniques of solving games - Finite games - Supporting and separating hyperplane theorems - Minimax theorem - Minimax estimation for normal and Poisson means

Unit V

Admissibility of Bayes and minimax rules, General theorems on admissibility, Robustness of Bayes rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.

Text Books:

1. James O. Berger (1980): Statistical Decision Theory and Bayesian Analysis, Springer Verlag
2. M.H. DeGroot (1970): Optimal Statistical Decisions, John Wiley
3. H. Raiffa and R. Schlaifer (2000): Applied Statistical Decision Theory, Wiley

Reference Books:

1. Zellener (1971): An Introduction to Bayesian Inference in Econometrics, Willey
2. Hayes J. G and Winkler R I (1976): Probability, Statistics and Decision, Dower
3. Anthony O' Hangan (1994): Kendall's Advanced theory of Statistics Vol. 2B, Bayesian Inference, John Wiley

STAT 427 – ECONOMETRICS **CREDITS: 3**

Unit I

Nature and Scope of Econometrics - Review of General Linear Model (GLM), Ordinary Least Squares (OLS), Generalized Least Squares (GLS) and Multicolloinearity

Unit II

Heteroscedasticity - Autocorrelation, its consequences and tests - Ridge regression - Linear regression with stochastic regressors - Instrumental variable estimation - Errors in variables - Autoregressive linear regression - Distributed lag models.

Unit III

Simultaneous linear equations model - Identification problem - Restrictions on structural parameters - rank and order conditions - Restrictions on variances and covariances - Estimation in simultaneous equations model

Unit IV

Forecasting - Univariate forecasting methods - Forecasting in regression models - Forecasting with Simultaneous equations model - Evaluation of forecasts - Combination of forecasts

Unit V

Definition of casuality - Granger casuality - testing of casuality - Cointegration, Bivariate cointegration tests - multivariate cointegration.

Text Books:

1. Gujarati, D.N. (2003): Basic Econometrics, McGraw Hill.
2. Johnston, J. (1984): Econometric methods, Third edition, McGraw Hill.
3. Nachane. D.M. (2006): Econometrics: Theoretical Foundations and Empirical Perspective, Oxford University Press.

Reference Books:

1. Apte, P.G. (1990): Text book of Econometrics. Tata McGraw Hill.
2. Intrulligator, M.D. (1980): Econometric models - Techniques and Applications, Prentice Hall of India.
3. Kleiber, C. and Zeileis, A. (2008): Applied Econometrics with R, Springer, NY.

STAT 428 - DEMOGRAPHIC TECHNIQUES **CREDITS: 3**

Unit I

Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Labour force participation rates, Density of population, Probability of dying.

Unit II

Life tables: Construction of a life table, Graphs of l_x, q_x, d_x, Funtions L_x, T_x, and E_x. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity.

Unit III

Fertility: Measures of Fertility, Reproductively formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable Populations, Calculation of the age distribution of a stable population, Model Stable Populations.

Unit IV

Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections.

Unit V

Ageing of the population, Estimation of demographic measures from incomplete data.

Text Books:

1. Pollard, A. H. Yusuf, F. and Pollard, G.N. (1990). Demographic Techniques, Pergamon Press, Chapters 1-8, 12.

Reference Books:

1. Keyfitz, N. (1977) Applied Mathematical Demography A Willey-Interscience Publication.
2. Keyfilz, N. (1968) Introduction to the Mathematic of Population Ready, Mass: Addition-Wesley.
3. Keyfilz, N. and Caswell, H. (2005) Applied Mathematical Demography, Third edition, Springer.

STAT 429 -TOTAL QUALITY MANAGEMENT CREDITS:3

Unit I

Need for TQM, evolution of quality, Definition of quality, TQM philosophy – Contributions of Deming, Juran, Crosby,Taguchi and Ishikawa.

Unit II

Vision, Mission, Quality policy and objective, Planning and Organization for quality, Quality policy Deployment, Quality function deployment, Analysis of Quality Costs.

Unit III

Customer focus, Leadership and Top management commitment, Employee involvement – Empowerment and Team work, Supplier Quality Management, Continuous process improvement, Training, performance Measurement and customer satisfaction.

Unit IV

PDSA, The Seven QC Tools of Quality, New Seven management tools, Concept of six sigma, FMEA, Bench Marking, JIT, POKA YOKE, 5S, KAIZEN, Quality circles.

Unit V

Need for ISO 9000 Systems, clauses, Documentation, Implementation, Introduction to QS 9000 , Implementation of QMS, Case Studies.

Text Books

1. Dale H.Besterfiled(2002): “Total Quality Management”, Pearson Education Asia
2. Oakland.J.S(1989): “Total Quality Management”, Butterworth–Hcinemann Ltd., Oxford

Reference Books

4. Narayana V. and Sreenivasan, N.S.(1996): “Quality Management – Concepts and Tasks”, New Age International.
5. Zeiri(1991): “Total Quality Management for Engineers”, Wood Head Publishers.
6. Juran J.M and Frank M.Gryna Jr.(1982): “Quality Planning and Analysis”, TMH, India.
7. Brain Rethery(1993): ISO 9000, Productivity and Quality Publishing Pvt.Ltd.
8. D.Mills(1993): Quality Auditing, Chapman and Hall.

SEMESTER III

STAT 535 – RELIABILITY THEORY **CREDITS: 3**

Unit I

Introduction to Reliability and its needs; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Modules of coherent systems; Reliability of a coherent systems; Reliability importance of components; Bounds on System Reliability.

Unit II

Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; loss of memory property of Exponential distribution - parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.

Unit III

Notions of Ageing; Classes of life distributions and their duals - preservation of life distribution classes for reliability operation - Formation of coherent systems, convolutions and mixtures.

Unit IV

Univariate stock models and life distributions arising out of them: cumulative damage model, shock models leading to univariate IFR, Successive shock model; bivariate shock models; common bivariate exponential distributions due to shock and their properties.

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

Unit V

Stress-Strength reliability - Concepts and its estimation; Reliability growth models; probability plotting techniques; Hollander –Proschan and Deshpande tests for exponentiality – Basic ideas of accelerated life testing.

Text Books:

1. Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston.
2. Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.

Reference Books:

1. Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
2. Nelson, W (1982): Applied Life Data Analysis; John Wiley.
3. Zacks, S(1992): Introdcution to Reliability Analysis, Springer Verlag.
4. Marshall, A.W. and Olkin I(2007): Life Distributions, Springer

STAT 536 - TIME SERIES ANALYSIS **CREDITS: 3**

Unit I

Exploratory Time Series Analysis: Forecasting trend and seasonality based on smoothing. Methods of Exponential and moving average smoothing; Types and implications of interventions; Outliers, additive and innovational outliers, procedure for detecting outliers

Unit II

Stationary Stochastic models: weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, Conditions for stationarity and invertibility,

Unit III

Models for Time Series: Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods

Unit IV

Spectral analysis and decomposition: Spectral analysis of weakly stationary process, Periodogram and correlogram analysis, Spectral decomposition of weakly AR process and representation as a one-sided MA process – necessary and sufficient conditions, implication in prediction problems.

Unit V

Modeling Seasonal Time Series: seasonal ARIMA models, estimation and forecasting, Fitting ARIMA models with Box-Jenkins procedure, Identification, Estimation, Verification, Test for white noise, Forecasting with ARMA models.

Text Books:

1. Nicholas T. Thomopoulos, 1980, Applied Forecasting Methods, Prentice Hall
2. Box G E P, Jenkins G M and Reinsel G C (2004): Time Series Analysis – Forecasting and Control, Pearson Education.
3. Brockwell P J and Davis R A (2002): Introduction to Time Series and Forecasting, Springer.
4. Montgomery D C and Johnson L A (1977): Forecasting and Time Series analysis, McGraw Hill.

Reference Books:

1. Chatfield C (1996): The Analysis of Time Series: Theory and Practice, fifth edition, Chapman and Hall.
2. Nachane D.M.(2006): Econometrics: Theoretical Foundations and Empirical Perspective, Oxford University Press
3. Diggle, P.J Time Series: A Biostatistical Introduction, Oxford University Press (1990).
4. Hamilton, J., 1994, Times Series Analysis, Princeton University Press.
5. Harvey, A.C., 1993, Time Series Models, MIT Press.
6. Kendall, Sir Maurice and Ord J K (1990): Time Series, Edward Arnold.
7. Tsay, R., 2002, Analysis of Financial Time Series, Wiley Series

STAT 537 - ACTUARIAL STATISTICS **CREDITS: 3**

Unit I

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

Unit II

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

Unit III

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

Unit IV

Multiple life contracts: Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances

Unit V

Multiple decrement theory: Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

Text Books

1. Promislow, S.D(2006): Fundamentals of Actuarial Mathematics, John Willey, Chapters 2- 11 &14.

Reference Books

1. Neill, A. (1977): Life contingencies, Heinemann, London.
2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil J. Nesbitt (1997): Actuarial Mathematics, The Society of Actuaries.
3. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
4. Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.
5. Jordan, C.W. Jr. (1967): Life Contingencies, Second edition, Chicago Society of Actuaries.
6. Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
7. Spurgeon, E.T. (1972): Life Contingencies, Third edition, Cambridge University Press.

STAT 538 – SIMULATION TECHNIQUES **CREDITS: 3**

Unit I

Introduction, need of simulation, physical versus digital simulation, Bufferies needle problem, Use of simulation in defence, inventory problems and other fields.

Unit II

Random number generation: Congruential generators, Metropolis Hasting algorithm, Statistical tests for pseudo random numbers. Random number generation from mixture of distributions, compound distributions.

Unit III

Random Variate Generation Methods: Inverse transform method, acceptance rejection method, Composition method. Generating random variables from continuous and discrete univariate distributions. Generation of random vectors from multivariate distributions.

Unit IV

Monte Carlo integration and variance reduction techniques. Hit or Miss Monte Carlo Method, Sample mean Monte Carlo method.

Unit V

Resampling techniques: Bootstrap, Jackniffe techniques and their applications. Machine Learning: Supervised and unsupervised learning techniques.

Text Books

1. Rubinstein, R.Y. (1981): Simulation and Monte Carlo Method, John Wiley and Sons.
2. Gorden, G. (2001): System Simulation, Prentice Hall of India, New Delhi.
3. Fishman, G.S. (1996): Monte Carlo Concepts, Algorithms and Applications, Springer Verlag, New York.

Reference Books

1. Deo, Narshingh (1991): System simulation with digital computer, Prentice Hall of India Pvt. Ltd, New Delhi.
2. Lewis, P.A.W. and Orav, E.J. (1988): Simulation Methodology for Statisticians, Operations Analysis and Engineering, Wadsworth and Brooks Cole Advanced Books and Software, Vol. 1.
3. Sethi, I.K. and Jain, A.K. (1991): Artificial Neural Networks and Statistical pattern recognition, North-Holland, Amsterdom.
4. McLachlan, G. and Krishnan, T. (2007): The EM Algorithm and Extensions, John Wiley and Sons.

STAT 539 - ELEMENTS OF QUEUEING THEORY CREDITS: 3

Unit I

Queuing Models: Basic characteristics of a Queueing Model – Role of Poisson and Exponential distributions, Stochastic Processes, Markov chains, Poisson Processes, Generalized Birth and Death Processes, steady state Birth and death processes.

Unit II

Poisson Queuing Models with single server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/1): (∞/FIFO) and (M/M/1): (N/FIFO) Models, simple numerical problems

Unit III

Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/C): (∞/FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, simple numerical problems

Unit IV

Non Poison Queuing Models (Erlangian): Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/Ek/1), (Ek/M/1), simple numerical problems

Unit V

General Queuing Models: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/G/1), (G/M/1), Simple numerical problems

Text Books

1. Donald Gross & Carl M Harris (1998): Fundamentals of Queuing theory, John Wiley & Sons, Inc.
2. Hamdy A.Taha(2006): Operations Research – An Introduction, 8/e , Prentice Hall of India Private Ltd., New Delhi

Reference Books

1. S.D.Sharma (2003)Operations Research , Kedar Nath Ram Nath & Co, Meerut, India
2. Kanthi Swarup, P.K.Gupta and Man Mohan (2004), Operations Research, Sultan Chand & Sons, New Delhi
3. Prabhu N.U. (1965) Applied Stochastic Processes, Mc.Millan
4. J.Medhi (2009), Stochastic Processes, 3/e, New Age International
5. Bhat. B.R. (2002), Stochastic Processes, 2/e, New Age International

SEMESTER - IV

STAT 543 – PROJECT AND VIVA-VOCE/DISSERTATION CREDITS: 3

1. A project work is compulsory and shall be offered in semester IV. It will have 4 credits.
2. A project work may be taken individually or by a group of two students.
3. Project work shall be supervised by a faculty member assigned by the Head of the Department in the beginning of the semester.
4. The project work should be selected in such a way that there is enough scope to apply and demonstrate the statistical techniques learnt in the course.
5. At the end of the semester, a report on the work done should be submitted (two copies). If a team of two students jointly do a project work then they must submit individual reports separately (not copy of the same report).
6. The project report shall clearly state the selected problem, the statistical methodologies employed for data collection and analysis and the conclusions arrived at. Details of previous studies in the area and related references should also be given.
7. The project work will be assessed for a maximum of 100 marks. Each student will give a seminar before the end of the semester on their project work which will be evaluated internally for a maximum of 40 marks. There will be an external viva-voce examination for a maximum of 10 marks by an internal and an external examiner. The project report will be valued by the same external and internal examiner for a maximum of 50 marks.

STAT 544- SURVIVAL ANALYSIS **CREDITS: 3**

Unit I

Concepts of time, order and random censoring and likelihood in these cases - Life distributions – Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate Parametric inference (Point estimation, Scores, MLE)

Unit II

Life tables, failure rate, mean residual life and their elementary properties - Ageing classes and their properties - Bathtub Failure rate

Unit III

Estimation of survival function – Actuarial Estimator - Kaplan- Meier Estimator - Estimation under the assumption of IFR / DFR - Tests of exponentiality against non-parametric classes – Total time on test, Deshpande test

Unit IV

Two sample problem: Gehan test, Log rank test. Mantel –Haenszel test, Tarone – Ware tests. Semi- parametric regression for failure rate – Cox's proportional hazards model with one and several convariates - Rank test for the regression coefficients

Unit V

Competing risks model - parametric and non- parametric inference for this model - Multiple decrement life table

Text Books

1. Miller, R.G. (1981) : Survival analysis, John Wiley
2. Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
3. Elisa T.Lee, John Wenyu Wang and Timothy Wenyu Patt (2003): Statistical Methods for Survival Data Analysis, 3/e, Wiley InterScience
4. Klein P. John and Moeschberger(2003): Survival Analysis: Techniques for Censored and Truncated Data, 2/e, Springer.

Reference Books

1. Gross, A.J. and Clark, V.A. (1975): Survival distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.
2. Elandt –Johnson, R.E. Johnson N.L.(1999): Survival Models and Data Analysis, John Wiley and sons.
3. Kalbfleisch J.D. and Prentice R.L.(2003), The Statistical Analysis of Failure Time Data, John Wiley.
4. Lawless J.F. (2002): Statistical Models and Methods for Life Time Data, 2/e, John Wiley & Sons.
5. Xian Liu(2012): Survival Analysis Models and Applications- John Wiley & Sons.

STAT 545 – ADVANCED OPERATIONS RESEARCH **CREDITS: 3**

Unit I

(Review of Linear Programming Problem (LPP) – Simplex, Big M and Two Phase methods) - Revised simplex method - Duality in LPP – Dual Simplex method – Some important theorems on duality - Sensitivity Analysis – Variation in cost vector and requirement vector – Addition and deletion of single variable and single constraint

Unit II

Integer Programming Problem (IPP) - Gomory's cutting plane algorithm – Mixed IPP – Branch and Bound technique - Dynamic programming problem (DPP) - Bellman's principle of optimality - General formulation - computation methods and application of DPP - Solving LPP through DPP approach

Unit III

Inventory models – Deterministic inventory models – Classic EOQ model – EOQ with price breaks – EOQ with storage limitations – Probabilistic Inventory models – Continuous review model – Single period model - No setup model – setup model (s-S policy)

Unit IV

Non-linear programming problem – Kuhn Tucker conditions – Quadratic Programming Problem (QPP) - Wolfe's and Beale's algorithms for solving QPP – Convex programming

Unit V

Queuing theory – Basic characteristics of queuing models – Arrival and service distribution – steady state solution of M/M/1 and M/M/C models with associated distribution of queue length and waiting time - M/G/1 queue-steady results using embedded Markov chain Methods - Pollazcek Khinchin formula.

Text Books

1. Hamdy A. Taha (1987): Operations Research – An Introduction, 4/e, Prentice Hall of India,Private Ltd, New Delhi.
2. Hillier F S and Libermann G J(2002): Introduction to Operations Research, 7^{th} Edition, McGraw Hill
3. Kanti Swarup, P.K. Gupta and Man Mohan(2004): Operations Research, Sultan Chand and Sons, New Delhi.
4. Gross D, Shortle J.F. , Thompson J.M. and Harris C.M. (2011): Fundamentals of Queuing Theory, John Wiley & Sons

Reference Books

1. Sinha S M (2006): Mathematical Programming : Theory and Methods, Elsevier Publications.
2. Kombo N.S.(1997): Mathematical Programming Techniques, Affiliated East-West Press
3. Kapoor V.K.(2008): Operations Research, 8/e, Sultan Chand & Sons
4. Sharma .S.D(1999): Operation Research , Kedar Nath Ram Nath & Co., Meerut.

STAT 546 - STATISTICAL DATA MINING METHODS CREDITS: 3

Unit I

Introduction to data mining – data types – Measures of similarity and dissimilarity – Data mining tools – supervised and unsupervised learning – Introduction to Cluster Analysis – Types of clustering – Agglomerative Hierarchical clustering algorithm – Issues – strength and weaknesses.

Unit II

Basic k-means algorithm – Issues – Bisecting k-means – fuzzy clustering – fuzzy c means algorithm - cluster evaluation – unsupervised and supervised measures - Introduction to classification – Decision Trees – Building a decision tree – Tree induction algorithm – Splitting of nodes based on information gain and Gini index – model over fitting – Evaluating the performance of a classifier

Unit III

Nearest Neighbor classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression

Unit IV

Association rules mining – Basics – Apriori algorithm – Pruning and candidate generation – Rule mining.

Unit V

Case studies based on k means clustering, fuzzy c means clustering, kNN classification, Binary logistic regression using R programming language or Excel Miner.

Text Books

1. Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education. (relevant portions of Chapters 1, 2, 4, 5 and 8).
2. Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd. (relevant portions of Chapter 2)
3. Daniel T. Larose (2006): Data Mining: Methods and Models, John Wiley and sons. (relevant portions of Chapter 4).
4. Rajan Chattamvelli (2009): Data Mining Methods, Narosa Publishing House, New Delhi.

Reference Books

1. Han, J. and Kamber, M. (2006): Data Mining: Concepts and Techniques, 2^{nd} Edition, Morgan Kaufmann Publishers.
2. Paolo Gludici (2003): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley and sons.

STAT 547 - BAYESIAN INFERENCE **CREDITS: 3**

Unit I

Subjective Interpretation of probability in terms of fair odds - Evaluation of Subjective probability of an event using a subjectively unbiased coin - 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 exponential family models - models admitting sufficient statistics of fixed dimension - Enlarging the natural conjugate family by enlarging hyper parameter space - 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: Prediction problem from posterior distribution - Bayes estimators for absolute error loss, squared error loss and 0 -1 loss - Generalization to convex loss functions - Evaluation of the estimate in terms of the posterior risk - Bayesian interval estimation : Credible intervals - Highest posterior density regions - Interpretation of the confidence coefficient of an interval

Unit IV

Bayesian Testing of Hypothesis: Prior and Posterior odds - Bayes factor for various types of testing hypothesis problems - Lindley's paradox for testing a point hypothesis for normal mean

Unit V

Bayesian prediction problem: Prediction for Exponential family of Distributions - Predictive Distributions and Reliability Estimation - Predictive Interval - Ideas on Bayesian Robustness, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof)

Text Books

1. Bansal A.K.(2007): Bayesian Parametric Inference, Narosa Publications
2. Sinha S K (1998): Bayesian Estimation, New Age International(P) Ltd, New Delhi

Reference Books

1. Berger, J.O.(1985): Statistical Decision Theory and Bayesian Analysis, 2/e, Springer Verlag.
2. Robert C.P. and Casella, G.(2004): Monte Carlo Statistical Methods, 2/e,Springer Verlag.
3. DeGroot, M.H.(2004): Optimal Statistical Decisions, Wiley-InterScience.
4. Gamerman, D. and Lobes H.F. (2000): Stochastic Simulation for Bayesian Inference, Taylor and Francis.
5. Box, G.P. and Tiao, G.C.(1973): Bayesian Inference in Statistical Analysis, Addison – Wesley.

STAT 548 - DATA ANALYSIS WITH SPSS **CREDITS: 3**

1. Basics – Import and Export of data files, Recoding, computing new variables – Descriptive statistics.
2. Selection of cases, splitting and merging of files.
3. Computation of simple, multiple, partial and rank correlation coefficients.
4. Computation of simple regression.
5. Fitting of curves – Linear, parabola, cubic and exponential.
6. Testing of Hypothesis – t, F, Chi square,
7. One way and Two way ANOVA.
8. Hotelling's T^2 test (Two sample)
9. Test for covariance matrix
10. Discriminant Analysis
11. One Way MANOVA.
12. Factor Analysis.
13. Non Parametric tests: Kruskal – Wallis, Friedman, Kolmogorov – Smirnov, Median tests for k-samples.
14. Fitting of Multiple linear regression- variable selection - diagnostics.
15. Residual Analysis for model adequacy, detection of outliers and influential observations
16. Multiple Comparison tests
17. 2^4 , 3^2, 3^3 factorial experiment
18. Split plot design

SOFT CORE COURSE FOR OTHER DEPARTMENTS

STAT 416 - STATISTICAL METHODS **Credits: 3**

Unit I

Definition of statistics – Scope and limitations of statistics – Primary and Secondary data and its sources - Simple Random, Stratified and Systematic sampling techniques - preparation of a questionnaire -Collection and classification of data – Frequency tables – Diagrammatic and Graphical representation of data

Unit II

Measures of central tendency – Mean, Median and Mode – Measures of dispersion – Range, Quartile deviation and Standard deviation – Coefficient of variation and skewness

Unit III

Study of relationship between variables: Quantitative: Correlation and Regression – Partial and Multiple correlation (three variables only) – Qualitative: Contingency tables – Measures of Association.

Unit IV

Elementary Probability theory: Addition theorem – Conditional probability and Multiplication theorem - Bayes' Theorem – Random variables and probability distributions – Binomial, Poisson , Normal (simple applications of the distribution) – Sampling distributions: t, F and chi-square (definition only)

Unit V

Hypothesis testing: Basic concepts in Hypothesis Testing – Types of error – Tests for Mean and Proportion based on Normal and Student t-distribution - Chi-square test for independence of attributes – One-way and two-way Analysis of Variance

Text Books

1. Hooda.R.P.(2003) : Statistics for Business and Economics , 3/e, Mac Millan .
2. Medhi.J. (1992) : Statistical Methods an Introductory Text , Wiley Eastern Ltd.,.
3. Kapoor.V.K. and Gupta.S. (1978): Fundamentals of Applied Statistics,Sultan Chand and Sons.
4. Sharma J.K.(2004): Business Statistics, Pearson Education

Reference Books

1. Agarwal.B.L(1996): Basic statistics , 3/e, New Age International (P) Ltd.,.
2. Anderson.R, Sweeney.J and Williams.A (2002): Statistics for Business and Economics, 8/e, Thomson.
3. Sheldon M.Ross (2006): Introductory Statistics, 2/e, Elsevier Publications.
4. Murray R. Spiegel and Larry J. Stephens (2005): Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.