2010

UNIVERSITY OF CALICUT

(Abstract)

M.Sc Programme in Statistics under Choice-based Credit Semester System, in the Department of Statistics-Modifications with effect from 2010 admission onwards-approved-implemented-orders issued.

GENERAL & ACADEMIC BRANCH-IV 'J' SECTION

No. GA IV/J2/4230/10 Dated, Calicut University PO, 26.07.2010

Read: 1. Item No.2 of the minutes of the meeting of the Board of Studies in Statistics (PG) held on 09.06.2010.

2 Item No.III a.30 of the minutes of the meeting of the Academic Council, held on 03.07.2010.

ORDER

The Board of Studies in Statistics (PG) vide paper referred to as 1st above, reviewed the syllabi for M.Sc Statistics programme under Choice based Credit Semester System in the University Teaching Department and decided to have the following modification.

(i) STA 2C05: Practical-I shall additionally include STA 1C05-sampling theory.

(ii) STA 4C15: Practical-II shall additionally include STA 3C 11: statistical inference II and STA 3C12: Multivariate Analysis.

(iii) The syllabi for courses STA 1C03: Probability Theory –I and STA2C06: Probability Theory-II shall be modified to enhance their contents. The Board further resolved that the revised syllabi shall apply with effect from 2010 admission.

The Vice-Chancellor, due to exigency, approved the minutes of the meeting of the Board of Studies in Statistics (PG) held on 09.06.2010, subject to ratification by the Academic Council and the Academic Council ratified the same, vide paper read as 2 above.

Sanction has therefore been accorded for implementing the modified syllabus of M.Sc programme in Statistics under Choice based Credit Semester System in the University Teaching Department with effect from 2010 admission onwards.

Orders are issued accordingly. Modified syllabus is appended.

Sd/-

ASSISTANT REGISTRAR(GA IV)

To

The Head of the Department of Statistics.
University of Calicut.

Copy to:

PS to VC/PA to Registrar/CE/ EX section/DR III/DR (PG)/LG I//Enquiry/GA I 'F' 'A' sections/GAII/GAIII/The Chairman, Board of Studies Statistics (PG)

Forwarded/By Order

Desktop Saji/UO Statistics

SECTION OFFICER.

M. Sc. Statistics Programme under CCSS
at the Department of Statistics, University of Calicut

Course Structure & Syllabi
(With effect from 2010 admission onwards)

Duration of programme: **Two years** - divided into **four semesters** of not less than **90** working days each.

Course Code	Type	Course Title	Credits
		I SEMESTER (Total Credits: 20)	
STA1C01	Core	Mathematical Methods for Statistics – I	4
STA1C02	Core	Mathematical Methods for Statistics – II	4
STA1C03	Core	Probability Theory – I	4
STA1C04	Core	Distribution Theory	4
STA1C05	Core	Sampling Theory	4
		II SEMESTER (Total Credits: 18)	
STA2C06	Core	Probability Theory – II	4
STA2C07	Core	Statistical Inference – I	4
STA2C08	Core	Design & Analysis of Experiments	4
STA2C09	Core	Regression Methods	4
STA2C10	Core	Practical – I	2
		III SEMESTER (Total Credits: 20)	
STA3C11	Core	Statistical Inference – II	4
STA3C12	Core	Multivariate Analysis	4
STA3C13	Core	Stochastic Processes	4
STA3E--	Elective	Elective-I	4
STA3E--	Elective	Elective-II	4
		IV SEMESTER (Total Credits: 18)	
STA4C14	Core	Project / Dissertation	8
STA4E--	Elective	Elective-III	4
STA4E--	Elective	Elective-IV	4
STA4C15	Core	Practical – II	2

Total Credits: **76** (Core courses-**52**, Project / Dissertation -**8** and Elective courses-**16**).

The courses Elective –I, Elective –II, Elective –III and Elective –IV shall be chosen from the following list.

LIST OF ELECTIVES

Sl. No.	Course Title	Credits
E01	Time Series Analysis	4
E02	Operations Research - I	4
E03	Lifetime Data Analysis	4
E04	Operations Research - II	4
E05	Queueing Theory	4
E06	Statistical Decision Theory	4
E07	Reliability Theory	4
E08	Actuarial Statistics	4
E09	Statistical Quality Assurance	4

For other P.G. Programmes under CCSS Scheme:

E10	Statistics for Biological Sciences	4

SYLLABI OF CORE COURSES

STA1C01: Mathematical Methods for Statistics – I
(4 Credits)

Unit I: Reimann – Stieltjes Integral- Definition, existence and properties. Integration by parts. Change of variable - Step functions as integrators. Reduction to finite sum. Monotone increasing integrators. Riemann's condition. Integrators of bounded variations. Mean value theorems. Improper integrals. Gamma and beta functions.

Unit II: Sequences and Series of Functions – Point wise convergence and uniform convergence. Tests for uniform convergence. Properties of uniform convergence. Weirstrass theorem.

Unit III: Multivariable functions. Limit and continuity of multivariable functions. Derivatives, directional derivatives and continuity. Total derivative in terms of partial derivatives. Taylor's theorem. Inverse and implicit functions. Optima of multivariable functions.
Determinants.

Unit IV: Elementary matrices. Determinants. Rank of matrix. inverse. Diagonal reduction. Transformations. Idempotent matrices. Generalized inverse.
Solution of liner equations. Special product of matrices. Characteristic roots and vectors. Definition and properties. Algebraic and geometric multiplicity of characteristic roots. Spectral decomposition. Quadratic forms. Classification and reduction of quadratic forms.

Text Books

1. **Apostol (1974).** Mathematical Analysis. Second edition. **Narosa, New-Delhi** Chapter 7 & 9.
2. **Khuri, A. T. (1993).** Advanced Calculus with Applications in Statistics. **John Wiley, New York,** Chapter 7.
3. **Rao, C.R. (2002).** Linear Statistical Inference & its applications. Second Edition. **John Wiley, New-York.**
4. **Graybill. F. A. (1983).** Matrices with Applications in Statistics. **John Wiley. New-York.**

References

1. **Malik, S.C. & Arora, S (2006).** Mathematical Analysis, Second edition. **New Age International.**
2. **Lewis, D. W. (1995).** Matrix Theory. Allied Publishers. Bangalore.

STA1C02: Mathematical Methods for Statistics –II
(4 Credits)

Unit –I: Classes of Sets – Field of sets, sigma field, monotone class and minimal sigma field. Borel sigma field and Borel sets in R and R^p. Set functions. Additivity and sigma additivity – Measures - examples and properties. Outer measure. Lebesgue measure in R and R^p. Lebesgue-Stieltjes measure.

Unit – II : Measurable function. Properties. Sequence of measurable functions, convergence, Egoroff's theorem. Integrals of simple, non-negative and arbitrary measurable functions. Convergence of integrals. Monotone convergence theorem, dominated convergence theorem and Fatou's lemma.

Unit – III : Product space and product measure. Multiple integral. Fubini's theorem (without proof). Absolute continuity and singularity of measures. Radon-Nikodym theorem (without proof) and its applications.

Unit IV: Vector space with real and complex scalars. Subspaces, liner dependence and independence, basis, dimension. Linear transformations and matrices. Jacobean of matrix transformations. Functions of matrix argument.

Text Books

Royden, H. L. (1995). Real Analysis. Third Edition Prentice Hall of India, New-York.

Bartle, R.G. (1996). The Elements of Integration. John Wiley and Sons, New York.

Lewis, D.W. (1996). Matrix Theory. Allied Publishers, Bangalore.

Rao,C.R. & Bhimsankar (1992). Linear Algebra. Tata-Mcgraw Hill, New-Delhi.

Rao, C.R. (2002). Linear Statistical Inference and Its Applications. Second Edn. John Wiley, New-York.

Mathai, A. M. (2001). Application of Matrix and Determinants - Module 3.

Reference Books

Kingman, J.F.C and Taylor, S.J. (1973). Introduction to Measure and Probability. Cambridge university press.

Bapat,R.B (1995). Linear Algebra and Liner Models. Hindustan Book Agency.

STA1C03: Probability Theory – I
(4 Credits)

Unit-I : Probability measure, measure, probability space, random variable, Inverse function and properties. Sequence of random variables and limit. Extension of probability measure - Caratheodory extension theorem (without proof). Distribution function, decomposition of distribution function. Vector valued random variables and its distribution function. Induced probability space of a random variable.

Unit–II: Mathematical expectation of simple, non-negative and arbitrary random variables - properties of expectation. Moment generating functions-moments. Inequalities. Cr-inequality, Jenson's inequality, Basic inequality, Markov inequality.

Unit–III: Different modes of convergence. Convergence in probability, convergence in distribution, rth mean convergence, almost sure convergence and their mutual implications.

Unit - IV: Independence of events, classes of events. Independence of random variables. Kolmogorow's 0-1 law, Borel's 0-1 criteria. Borel-Cantelli Lemma. Characteristic Functions- definition, properties, inversion theorem, inversion formula for lattice distributions, Characteristic functions and moments, Taylor's series for characteristic functions. Bochner's theorem (without proof).

Text Book

Bhat, B.R. (1999). Modern Probability Theory. Third Editiona. New-age international, New-Delhi.

Reference Books

Resnick, S.I. (1999). Probability Paths. Birkhauser, Boston.
Laha and Rohatgi (1979). Probability Theory. John Wiley and Sons, New York.
Billingsly (1995). Probability and Measure. Third Edition. John Wiley, New-York
Basu, A.K. (1999). Measure Theory and Probability. Printice Hall of India, New Delhi.
Rohatgi, V.K. (1976). An Introduction to probability Theory and Mathematical Statistics. John-Wiley, New York.

STA1C04: Distribution Theory
(4 Credits)

Unit - I: Discrete Distributions – Bernoulli, Discrete Uniform, Binomial, Negative Binomial, Geometric, Hyper geometric, Poisson Logarithmic Series and multinomial distributions, power series distribution and their properties.

Unit – II: Continuous Distributions – Systems of Distributions-Pearson system and Transformed Distributions, Uniform, Exponential, Gamma, Beta, Cauchy, Normal, Pareto, Weibull, Laplace, lognormal, Bivariate Normal Distributions and their properties.

Unit – III: Notion of Vector of Random Variables, distribution function marginal and joint distributions in the iid case. Functions of Random Vectors, Order Statistics and their Distributions

Unit – IV: Sample Moments and Their Distributions- Sample Characteristics and their distributions, Chi-Square, t and F distributions (Central and Non-Central). Applications of Chi square, t and F.

Text Books

1. **Rohatgi, V.K. (1976).** An Introduction to Probability Theory and Mathematical Statistics, John – Wiley, New York. Chapter 4, Sections 2, 4 and 5, Chapter 5, Sections 2, 3 and 4 Chapter 7 Sections 3, 4 and 5
2. **Krishnamoorthy, K. (2006).** Hand book of Statistical Distributions with Applications. Chapman & Hall, New York. Chapters 8,14,20,23 and 24 Sections 1,2 and 5.
3. **Johnson, N.L., Kotz, S. and Balakrishnan, N.(2004).** Continuous Univariate Distributions-Vol.1 Second Edition, John Wiley and Sons, New York. Chapter 12 Sections 4.1,4.3.

Reference Books

1. **Johnson, N.L., Kotz, S. and Balakrishnan,N.(1995).** Continuous Univariate Distributions-Vol. II, Second Edition, John Wiley and Sons, New York..
2. **Johnson, N.L., Kotz, S. and Kemp, A.W. (1992).** Univariate Discrete Distributions, Wiley, New York.
3. **Kendall and Stuart. (19)**
4. **Goon Gupta and Das Gupta (19).**

STA1C05: Sampling Theory
(4 Credits)

Unit – I: Census, Sampling, Probability sampling, and non-Probability sampling. SRSWOR and SRSWR. Estimation of population mean, Population total and population proportion. Variance of the estimates and standard error. Estimation of sample size. Stratified random sampling. Allocation problem. Various allocations. Construction of strata.

Unit – II: PPS sampling with and without replacement. Estimation of population mean, total and variance in PPS sampling with replacement. Desraj's ordered estimator. Murthy's unordered estimator. Horvitz – Thomson estimator. Their variances and standard error. Yates – Grundy estimator. Sen – Midzuno scheme of sampling. IPPS sampling.

Unit – III: Ratio estimators and Regression estimators. Comparison with simple arithmetic mean estimator. Optimality properties of ratio and regression estimators. Hartly – Ross unbiased ratio type estimator.

Unit – IV: Circular, linear and balanced systematic sampling. Estimation of population mean and its variance. Cluster sampling with equal and unequal clusters. Multi stage and multiphase sampling . Comparison with simple random sampling and Stratified random sampling. Relative efficiency of cluster sampling. Two-stage sampling. Non-sampling errors.

Text Books

Cochran (1977). Sampling Techniques. Wiley Eastern, New-Delhi.

Singh, D and Chaudhury, F.S. (1986). Theory and Analysis of Sample Survey Designs. Wiley Eastern, New-Delhi.

Reference Books

Des Raj (1976). Sampling Theory. McGraw Hill

Murthy, M. N. (1967). Sampling Theory and Methods. Statistical Publishing Society.

Mukhopadhyay, P. (1999). Theory and Methods of Survey Sampling. Prentice-Hall India, New-Delhi.

STA2C06: Probability Theory – II
(4 Credits)

Unit-I: Weak Convergence and Characteristic Functions - Helly's convergence theorem, Helly-Bray lemma, Scheffe's theorem, convergence of distribution functions and characteristic functions, Convergence of moments.

Unit-II: Laws of Large Numbers: Convergence in probability of sequence of partial sums, Kolmogorov inequality and almost sure convergence, almost sure convergence of a series, criterion for almost sure convergence, stability of independent random variables, WLLN (iid and non-iid cases), strong law of large numbers.

Unit-III: Central Limit Theorem (CLT) - CLT as a generalization of laws of large numbers, Lindeberge-Levy form, Liapounov's form, Lindeberg-Feller form (with out proof), Examples and relation between Liapounov's condition.

Unit-IV: Conditioning and Infinite Divisibility: Conditional expectation, properties, Martingales, smoothing properties, Infinite divisibility: Definition, Elementary properties and examples.

Text Book

1. **Bhat, B. R.** (1999). Modern Probability Theory, Third Edition, New Age International (P) Limited, Bangalore, John Wiley and Sons, New York.
2. **Lukacs and Rohatgi** (1979). Probability Theory, John Wiley and Sons, New York. (Chapter-4, Section-1)

Reference Books

1. **Rohatgi, V. K.** (1976). An Introduction to Probability Theory and Mathematical Statistics, John-Wiley Sons, New-York.
2. **Feller, W.** (1993). An Introduction to Probability Theory and its Applications, Wiley-Eastern, New-Delhi.
3. **Rao, C.R.** (2002). Linear Statistical Inference and its Applications, Second Edition, John Wiley and Sons, New – York.
4. **Basu, A.K.** (1999). Measure Theory and Probability, Prentice Hall of India, New Delhi.

STA2C07: Statistical Inference – I
(4 Credits)

Unit – I: Fisher Information- Sufficient statistic-Minimal sufficient statistic-Exponential family and minimal sufficient statistic Unbiasedness – best Linear Unbiased estimator – MVUE Cramer- Rao inequality and its application Rao-Blackwell theorem-Completeness-Lehman-Scheffe theorem and its application.

Unit – II: Consistent estimator-examples and properties-CAN estimator-invariance property-asymptotic variance- Multiparameter case- choosing between Consistent estimators.

Unit – III: Method of moments-method of percentiles-method of maximum likelihood-MLE in exponential family-Solution of likelihood equations-Bayesian method of estimation-Prior information-Loss functions (squared error, absolute error and zero-one loss functions) – Posterior distribution-estimators under the above loss functions.

Unit IV: Shortest expected length confidence interval-large sample confidence intervals-unbiased confidence intervals-examples-Bayesian and Fiducial intervals.

Text Books

Kale, B.K. (2005). A First Course on Parametric Inference. Second Edition, Narosa Publishing. New-Delhi.

Casella, G. and Berger, R.L. (2002). Statistical Inferences. Second Edition Duxbury. Australia.

Reference Books

Rohatgi,V. K. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley and Sons, new-York

Rohatgi,V.K. (1984). Statistical Inference, John-Wiley and Sons, New-York.

Lehman, E.L. (1983). Theory of Point Estimation, John-Wiley and Sons, New-York

Rao, C.R. (2002). Linear Statistical Inference and Its Applications, Second Edition John-Wiley and Sons, New-York.

STA2C08: Design and Analysis of Experiments
(4 Credits)

Unit – I: Application, basic principles, guideline of design of experiments. Statistical techniques. Experiments with single factor. ANOVA. Analysis of fixed effect models – comparison of individual treatment means. Random effect models. Model adequacy checking. Choice of sample size. Regression approach ANOVA

Unit –II: Completely Randomized Block design, randomized block design, Latin square design. Greaco-Latin square design. BIBD – Recovering of intra block information in BIBD - PBIBD – Youden square - Lattice design.

Unit – III: Factorial designs - definition and principles. Two factor factorial design. Random and mixed models. The general factorial designs- 2^k factorial experiments confounding two Level fractional factorial design.

Unit IV: Nested or hierarchical designs – response surface methods and design – ANCOVA.

Text Book

Montgomery, D.C. (2001). Design and Analysis of Experiments. 5th edition. John Wiley & Sons. New-York.

Reference Book

Das, M. N. and Giri, N. S. (2002). Design and Analysis of Experimental. 2nd Edition. New Age International (P) Ltd., New-Delhi.

STA2C09: Regression Methods
(4 Credits)

Unit – I: Least square estimation-properties of least square estimates-unbiased estimation of σ^2 distribution theory - maximum likelihood estimation - estimation with linear restrictions-design matrix of less that full rank-generalized least squares.

Unit – II: Hypothesis testing; Likelihood ratio test—F-test - multiple correlation coefficient-Confidence intervals and regions. Simultaneous interval estimation-confidence bands for the regression surface - prediction intervals and band for the response.

Unit – III: The straight line - weighted least squares for the straight line-Polynomials in one variable – piecewise polynomial fitting - Polynomial regression in several variables.

Unit – IV: Bias-incorrect variance matrix-effect of outliers-Diagnosis and remedies: residuals and hat matrix diagonals – nonconstant variance and serial Correlations-departures from normality - detecting and dealing with outliers-diagnosing collinearity, Ridge regression and principal component regression.

Text Books

1. **Seber.G. A. F. and Lee, A.J. (2003).** Linear Regression Analysis. 2nd Edition. Wiley Intersciencse, New Jersey.
2. **Draper, N.R. and Smith, H. (1988).** Applied Regression Analysis. 3rd Edition. John Wiley & Sons Inc., New-York.

Reference Books

1. **Searle, S.R. (1997).** Linear Models. Wiley paperback edition Wiley Interscience, New Jersey.
2. **Rao.C.R.(1973).** Linear Statistical Inference and Its Applications. Wiley Eastern.
3. **Abraham, B. and Ledolter, J. (2005).** Introduction to Regression Modeling Duxbury Press.
4. Sengupta.**D. and Jammalamadaka. S.R(2003).** Linear Models:An Integrated Approach, World Scientific.
5. **Montgomery, D.C., Peck, F.A. and Vining, G. (2001).** Introduction to Linear Regression Analysis. 3rd **Edition.** John-Wiley and Sons. New-York

STA2C10: Practical – I
(2 Credits)

The practical is based on the following core papers in the first and the second semesters.

1. STA1C04:Distribution Theory
2. STA1C05:Sampling Theory
3. STA2C07: Statistical Inference I
4. STA2C08:Design and Analysis of Experiments
5. STA2C09:Regression Methods

Practical are to be done using scientific programmable calculators or personal computers. The question paper for the external examination will be set by the external examiner in consultation with the chairman. The practical will be valued on the same day the examination is held out and the marks will be finalized on the same day.

STA3C11: Statistical Inference-II
(4 Credits)

Unit I: Tests of hypotheses – error probabilities – Most powerful tests – Neyman. Pearson Lemma – Generalized Neymann - Pearson Lemma

Unit II: Method of Finding Tests – Likelihood ratio tests – Bayesian tests – Union – intersection and intersection-union tests. Unbiased and invariant tests - Similar tests and locally most powerful tests

Unit III : Non-parametric Tests – Single sample tests – the Kolmogorov – Smirnov test – the sign test – the Wilcoxon signed rank test. Two sample tests – the chi-square test for homogeneity – the Kolmogorov – Simirnov test the median test – the Mann-Whitney-Wilcoxon test-Test for independence - Kendall's tau – Spearman's rank correlation coefficient – robustness

Unit IV: Sequential Inference – Some fundamental ideas of sequential sampling – sequential unbiased estimation - sequential estimation of mean of a normal population – the sequential probability tests (SPRT) – important properties – the fundamental identity of SPRT

Text Book

Casella, G. and Berger, R.L. (2002). Statistical Inference, Second Edition. Duxbury, Australia.

Rohatgi, V.K. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley Sons. New York.

Reference Books

Fraser, D.A. Non parametric Methods in Statistics.

Lehman, E.L. (1986). Testing of Statistical Hypotheses. John Wiley, New York.

Ferguson, T.S. (1967). Mathematical Statistics: A Decision – Theoretic Approach. Academic Press. New York.

STA3C12: Multivariate Analysis
(4 Credits)

Unit – I: Multivariate Normal Distribution – Definition properties, conditional distribution, marginal distribution. Independence of a linear form and quadratic form, independence of two quadratic forms, distribution of quadratic form of a multivariate vector. Partial and multiple correlation coefficients, partial regression coefficients. Partial regression coefficient.

Unit – II: Estimation of mean vector and covariance vector – Maximum likelihood estimation of the mean vector and dispersion matrix. The distribution of sample mean vector inference concerning the mean vector when the dispersion matrix is known for single and two populations. Wishart distribution – properties – generalized variance..

Unit – III: Testing Problems – Mahalnobis D^2 and Hotelling's T^2 Statistics Likelihood ratio tests – Testing the equality of mean vector, equality of dispersion matrices, testing the independence of sub vectors, sphericity test.

Unit IV: The problem of classification – classification of one of two multivariate normal populations when the parameters are known and unknown. Extension of this to several multivariate normal populations. Population principal components – Summarizing sample variation by principal components – Iterative procedure to calculate sample principal components

Text Books

Anderson, T.W. (1984). Multivariate Analysis. John – Wiley, New York.

Rao, C.R. (2002). Linear Statistical Inference and Its Applications, Second Edition. John Wiley and Sons, New York

Reference Books

Giri, N.C. (1996). Multivariate Statistical Analysis. Marcel Dekker, Inc., New York.

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

Rencher, A.C. (1998). Multivariate Statistical Analysis. Jon Wiley, New York.

STA3C13: Stochastic Processes
(4 Credits)

Unit-1: Concept of Stochastic processes, examples. Specifications. Markov chains-Chapman Kolmogorov equations – classification of states - limiting probabilities Gambler's ruin problem – mean time spent in transient states - branching processes Hidden Markov chains

Unit – II: Exponential distribution – counting process – inter arrival time and waiting time distributions. Properties of Poisson processes – Conditional distribution of arrival times. Generalization of poisson processes – non –homogenous Poisson process, compound poisson process, conditional mixed Poisson process Continuous time Markov Chains – Birth and death processes – transition probability function-limiting probabilities.

Unit-III Renewal processes-limit theorems and their applications. Renewal reward process. Regenerative processes, semi-Markov process. The inspection paradox Insurance ruin problem.

Unit – IV: Basic characteristics of queues – Markovian models – network of queues. The M/G/1 system. The G/M/1 model. Multi server queues. Brownian motion Process – Hitting time – Maximum variable - variations on Brownian motion – Pricing stock options – Gaussian processes – stationary and weakly stationary processes.

Text Book

Ross, S.M.(2007): Introduction to Probability Models. IXth Edition, Academic Press.

Reference Books

Medhi,J. (1996). Stochastic Processes Second Editions. Wiley Eastern. New-Delhi.

Karlin and Taylor (1975). A First Course in Stochastic Processes. Second Edition Academic Press. New-York.

Cinlar, E. (1975). Introduction to Stochastic Processes. Prentice Hall. New Jersey.

Basu, A.K.(2003). Introduction to Stochastic Processes. Narosa. New-Delhi

STA4C14: Project & Dissertation
(8 Credits)

As a part of the course work, during the fourth semester each student has to undertake a project work in a selected area of interest under a supervisor in the department. The topic could be a theoretical work or data analysis type. At the end of the fourth semester the student shall prepare a report/dissertation which summarizes the project work and submit to the H/D of the parent department positively before the deadline suggested in the Academic calendar. The project/ dissertation is of 8 credits for which the following evaluation will be followed:

The valuation shall be jointly done by the supervisor of the project in the department and an External Expert appointed by the University, based on a well defined scheme of valuation framed by them. The following break up of weightage is suggested for its valuation.

1. Review of letterature, formulation of the problem and defining clearly the objective: 20%
2. Methodology and description of the techniques used: 20%
3. Analysis, programming/simulation and discussion of results: 20%
4. Presentation of the report, organization, linguistic style, reference etc.: 20%
5. Viva-voce examination based on project/dissertation: 20%.

STA4C15: Practical - II
(2 Credits)

The practical is based on the following courses in the third and fourth semesters.

1. STA3C11: Statistical Inference – II
2. STA3C12: Multivariate Analysis
3. Elective – III
4. Elective – IV

Practical is to be done using scientific programmable calculators or personal computer. The question paper for the external examination will be set by the external examiner in consultation with the chairman. The practical will be valued on the same day the examination is carried out and the mark sheet will be given to the chairman on the same day.

LIST OF ELECTIVES

Course Code	Course Title	Credits
STA-E01	Time Series Analysis	4
STA-E02	Operations Research – I	4
STA-E03	Lifetime Data Analysis	4
STA-E04	Operations Research - II	4
STA-E05	Queueing Theory	4
STA-E06	Statistical Decision Theory	4
STA-E07	Reliability Theory	4
STA-E08	Actuarial Statistics	4
STA-E09	Statistical Quality Assurance	4

For other P.G. Programmes under CCSS Scheme:

E10	Statistics for Biological Sciences	4

STA-E01: TIME SERIES ANALYSIS
(4 Credits)

Unit-I. Motivation. Time series as a discrete parameter stochastic process. Auto – Covariance, Auto – Correlation and spectral density and their properties. Exploratory time series analysis. Test for trend and seasonality. Exponential and moving average smoothing. Holt – Winter's smoothing, forecasting based on smoothing. Adaptive smoothing.

Unit-II. Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR MA periods

Unit-III. Estimation of ARMA models: Yule – Walker estimation for AR Processes. Maximum likelihood and least squares estimation for ARMA Processes. Discussion (without proof) of estimation of mean. Auto-covariance and auto-correlation function under large samples theory. Residual analysis and diagnostic checking. Forecasting using ARIMA models. Use of computer packages like SPSS.

Unit-IV. Spectral analysis of weakly stationary process. Herglotzic Theorem. Periodogram and correlogram analysis. Introduction to no-linear time Series: ARCH and GARCH models.

Text Books

1. **Box G.E.P and Jenkins G.M.** (1970). Time Series Analysis, Forecasting and Control Holden-Day
2. **Brockwell P.J.and Davis R.A.** (1987). Time Series: Theory and Methods, Springer – Verlag.
3. **Abraham B and Ledolter J.C.** (1983). Statistical Methods for Forecasting, Wiely

References

1. **Anderson T.W** (1971) Statistical Analysis of Time Series, Wiely.
2. **Fuller W.A.** (1976). Introduction to Statistical Time Series, John Wiley.
3. **Kendall M.G.** (1978), Time Series. Charler Graffin
4. **K Tanaka** (1996). Time Series Analysis – Wiely Series

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STA-E02: Operations Research – I
(4 Credits)

Unit-I. Operations Research.-definition and scope. Linear programming, simplex method, artificial basis techniques, two phase simplex method, Big-M method, duality concepts, duality theorems, dual simplex methods.

Unit-II. Transportation and assignment problems, sensitivity analysis, parametric programming, + Sequencing and Scheduling problems-2 machine n-Job and 3 machine n-Job Problems.

Unit-III. Integer programming: Cutting plane methods, branch and bound technique, application of zero – one programming

Unit-IV. Game theory: two person zero sum games, minimax theorem, game problem as a linear programming problem. Co-operative and competition games

Text Book

1. K.V.Mital and Mohan, C (1996) – Optimization Methods in Operations Research and Systems Analysis, 3rd Edition, New Age International (Pvt.) Ltd.

Reference Books

1. Hadley, G (1964) – Linear Programming, Oxford & IBH Publishing Co., New Delhi.
2. Taha, H.A (1982) : Operation Research, An Instruction, Macmillan.
3. Miller, D. and Lieberman, G.J. (1995): Introduction to Operations Research, McGraw Hill
4. Kanti Swamp, Gupta, P.K and Johri, M.M (1985): O.R., Sultan Chand & Sons.

STA-E03: Lifetime Data Analysis
(4 Credits)

Unit-I. Lifetime distributions-continuous and discrete models-important parametric models. Exponential Weibull, Log-normal, Log-logistic, Gamma, Inverse Gaussian distributions. Log location scale models and mixture models. Censoring and statistical methods.

Unit-II. The product-limit estimate and it properties. The Nelson-Aalen estimate, interval estimation of survival probabilities, asymptotic properties of estimators, descriptive and diagnostic plots, estimation of hazard functions, methods for truncated and interval censored data. Life tables.

Unit-III. Inference: Under exponential model – large sample theory, type-2 censored test plans, comparison of two distributions, inference procedures for Gamma distribution, models with threshold parameters, inference for log-location scale distributions, likelihood based methods, exact methods under type 2 censoring, application to Weibull and extreme value distributions, conversion of distributions.

Unit-IV. Log-location scale (Accelerated Failure time) model. Proportional hazard models. Methods for continuous multiplicative hazard models, Semi-parametric maximum likelihood-estimation of continuous observations. Incomplete data: Rank test for comparing Distributions, Log-rank test, Generalized Wilcoxon test. A brief discussion on multivariate lifetime models and data.

Text Books

1. Lawless, J.F.(2003). Statistical Methods for Lifetime (Second Edition). John Wiley & Sons Inc., New Jersey.
2. Kalbfleisch, J.D. and Prentice, R.L. (1980). The statistical Analysis of Failure Time Data. John Wiley & Sons Inc., New Jersey.

References

1. Miller, R.G.(1981). Survival Analysis, John Wiley & Sons Inc.
2. Bain, L.G.(1978). Statistical Analysis of Reliability and Life testing Models. Marcel Decker.
3. Nelson, W. (1982). Applied Life Data Analysis.
4. Cox, D.R and Oakes, D (1984). Analysis of Survival Data Chapman and Hall
5. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis. John Wiley & Sons.

STA-E04: Operations Research – II
(4 Credits)

Unit I Non-linear programming: Lagrangian function, saddle point, Kuan-Tucker Theorem, Kuhn-Tucker conditions, Quadratic programming, Wolfe's algorithm for solving quadratic programming problem.

Unit II Dynamic and Geometric programming: A minimum path problem, single additive constraint, additively separable return, single multiplicative constraint, additively separable return, single additive constraint, multiplicatively separable return, computational economy in DP. Concept and examples of Geometric programming.

Unit III Inventory management: Deterministic models, the classical economic order quantity, nonzero lead time, the EOQ with shortages allowed, the production lot-size model. Probabilistic models, the newsboy problem, a lot size reorder point model.

Unit IV Replacement models: capital equipment that deteriorates with time, items that fail completely, mortality theorem, staffing problems, block and age replacement policies. Simulation modeling: Monte Carlo simulation, sampling from probability distributions, Inverse method, convolution method, acceptance-rejection methods, generation of random numbers, Mechanics of discrete simulation.

Text Books

1. K.V. Mittal and Mohan, C (1996) – Optimization Methods in Operations Research and Systems Analysis, 3rd Edition, New Age International (Pvt.) Ltd.
2. M.Sasieni, A.Yaspan and L.Friedman (1959) Operations Research, Methods and Problems, Wiley, New York.
3. Hamdy A. Taha, (1997) Operations Research – An Introduction, Prentice-Hall Inc., New Jersey.
4. Ravindran, Philips and Solberg(1987) : Operations Research- Principles and Practice, John Wiley & Sons, New York.

Reference Books

1. Sharma, J.K. (2003) : Operations Research, Theory & Applications, Macmillan India Ltd.
2. Manmohan, Kantiswaroop and Gupta (1999). Operation Research, Sultan Chand & Sons New Delhi.

STA-505: Queueing Theory
(4 Credits)

Unit I : Introduction to queueing theory. Characteristics of queueing processes, Measures of effectiveness. Markovian queueing models, steady state solutions of the M/M/1 model, waiting time distributions, Little's formula, queues with unlimited service, finite source queues.

UNIT II : Transient behavior of M/M/1 queues, transient behavior of M/M/∞. Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models. Bulk input $M^{[X]}$/M/1 model, Bulk service $M/M^{[Y]}/1$ model, Erlangian models, $M/E_k/1$ and $E_k/M/1$. A brief discussion of priority queues.

UNIT III : Queueing networks-series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks, Non Jackson networks.

UNIT IV: Models with general arrival pattern, The M/G/1 queueing model, The Pollaczek-khintchine formula, Departure point steady state systems size probabilities, ergodic theory, Special cases $M/P_k/1$ and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities.

References:

1. Gross, D. and Harris, C.M.(1985): Fundamentals of Queueing Theory, 2nd Edition, John Wiley and Sons, new York.
2. Kleinrock L. (): Queueing Systems, Vol. I & Vol 2. Joohn Wiley and Sons, New York.
3. Ross, S.M. (2007). Introduction to Probability Models, 9th Edition, Academic Press, New York.
4. Bose, S.K. (2002). An Introduction to Queueing Systems, Kluwer Academic/Plenum Publishers, New York.

STA-E06: Statistical Decision Theory
(4 Credits)

Unit–I: Statistical decision Problem – Decision rule and loss-randomized decision rule. Decision Principle – sufficient statistic and convexity. Utility and loss-loss functions-standard loss functions-vector valued loss functions.

Unit–II: Prior information-subjective determination of prior density-Non-informative priors-maximum entropy priors he marginal distribution to determine the prior-the ML-II approach to prior selection. Conjugate priors.

Unit–III: The posterior distribution-Bayesian inference-Bayesian decision theory-empirical Bayes analysis – Hierarchical Bayes analysis-Bayesian robustness Admissibility of Bayes rules.

Unit–IV: Game theory – basic concepts – general techniques for solving games Games with finite state of nature-the supporting and separating hyper plane theorems The minimax theorem Statistical games.

Text Book

Berger, O.J. (1985). Statistical decision Theory and Bayesian Analysis. Second Edition Springer-Verlag.

Reference Books

Ferguson, T.S. (1967). Mathematical Statistics: A Decision-Theoretic Approach. Academic Press, New-York.

Lehman, E.L. (1983). Theory of Point Estimation. John-Wiley, New York

STA-E07: Reliability Theory
(4 Credits)

Unit-1:
Reliability concepts and measures: components and systems, coherent systems; reliability of coherent systems, cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Unit-2:
Life distributions; reliability function, hazard rate, common life distributions-exponential, Weibull, Gamma etc. Estimation of parameters and tests in these models. Notions of ageing: IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals; closures of these classes under formation of coherent systems, convolutions and mixtures.

Unit-3:
Univariate shock models and life 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 estimation.

Unit-4:
Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process.
Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing.

REFERENCES:

1. **Barlow R.E. and Proschan F.** (1985) Statistical Theory of Reliability and Life Testing; Holt Rinehart and Winston.
2. **Bain L.J. and Engelhardt** (1991). Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
3. **Aven, T** and **Jensen,U.** (1999). Stochastic Models in Reliability. Springer-Verlag, New York Inc.
4. **Lawless, J.F.** (2003). Statistical Models and Methods for Lifetime (Second Edition). John Wiley & Sons Inc., New Jersey.
5. **Nelson, W** (1982) Applied Life Data analysis, John Wiley.
6. **Zacks, S.** (1992). Introduction to Reliability Analysis: Probability Models and Statistics Methods. New York. Springer-Verlag.

STA-E08: Actuarial Statistics
(4 Credits)

Unit-I. Utility theory, insurance and utility theory , models for individual claims and their sums, survival function, curate future lifetime, force or mortality. Life table and its relation with survival function, examples, assumptions, for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint life and last survivor status, insurance and annuity benefit through multiple life functions evaluation for special mortality laws.

Unit-II. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications.

Unit-III. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Life insurance: ;Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, inferred insurance and varying benefit insurance, recursions, commutation functions Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Unit-IV. Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, urns, commutation function accumulation type benefits. Payment premiums, apportionable premiums, commutations functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differemsal equations for reserves, commutation functions.

References

1. Atkinson, M E. and Dickson, D.C.M. (2000) : An Introduction to Actuarial Studies, Elgar Publishing.
2. Bedford, T. and Cooke, R. (2001): Probabilistic risk analysis,Cambridge.
3. Bowers,N. L.,Gerber, H.U., Hickman,J.C., Jones D.A. and Nesbitt, C.J.(1986): 'Actuarial Mathematics', Society of Actuaries, Ithaca, Illinois, U.S.A., Second Edition.
4. Medina, P. K. and Merino, S. (2003): A discrete introduction : Mathematical finance and Probability, Birkhauser.
5. Neill, A. (1977): Life Contingencies, Heineman.
6. Philip, M. et. al (1999): Modern Actuarial Theory and Practice, Chapman and Hall.
7. Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998): Stochastic Processes for Insurance and Finance, Wiley.
8. Spurgeon, E.T. (1972): Life Contingencies, Cambridge University Press
9. Relevant Publications of the Actuarial Education Co., 31, Bath Street, Abingdon, Oxfordshire OX143FF (U.K.)

STA-E09: Statistical Quality Assurance
(4 Credits)

Unit I : Quality and Quality assurance. Methods of Quality assurance. Introduction to TQM. Acceptance sampling for attributes. Single sampling, Double sampling, Multiple sampling and Sequential sampling plans. Measuring the performance of these sampling plans

Unit II : Acceptance sampling by variables, sampling plans for single specification limit with known and unknown and unknown variance, Sampling plans with double specification limits , comparison of sampling plans by variables and attributes. Continuous sampling plans I , II III

Unit III : Control charts. Basic ideas. Designing of control charts for the number of non-conformities. Mean charts. Median charts. Extreme value charts. R-charts. and S-charts ARL. Economic design of control charts.

Unit IV : Process capability studies. Control charts with memory – CUSUM charts. EWMA mean charts. OC and ARI for control charts. Statistical process control. Modeling and quality programming. Orthogonal arrays and robust quality.

Text Books

1. **Montgomery, R.C.** (1985), Introduction to Statistical Quality Control. 4th edition. Wiley. New - York.
2. **Mittage, H.J. and Rinne, H.** (1993).Statistical Methods for Quality Assurance. Chapman and Hall Chapters13 and 14.
3. **Oakland,J.S. and Followell, R.F.** (1990). Statistical Process Control. East-West Press Chapters 13 and 14
4. **Schilling, E.G.** (1982).Acceptance Sampling in Quality Control. Marcel Dekker.

Reference Books

1. **Duncan, A.J.** (1886). Quality Control and Industrial Statistics.
2. **Gerant, E.L. and Leaven Worth, R.S.** (1980). Statistical Quality Control. Mc-Graw Hill.
3. **Chin-Kuei Chao** (1987). Quality Programming. John Wiley.