Revised Syllabus for M.Sc. Statistics Semester Pattern in Affiliated Colleges

2018 Admission onwards

M.Sc Statistics (625): Course Structure and Marks distribution

Semester No:	Course code	Course Name	Distribution of Hours per semester (Theory + Practical)	Instructional hours per week		Duration of ESE hours	Maximum marks		
				L	P		CA	ESE	Total
1	ST211	Analytical tools for Statistics- I	108	6	-	3	25	75	100
	ST212	Analytical tools for Statistics- II	90+18	5	1	3	25	75	100
	ST213	Probability Theory - I	108	6	-	3	25	75	100
	ST214	Sampling Techniques	90+18	5	1	3	25	75	100
		R Programming*	18	-	1*	-	-	-	-
2	ST221	Distribution Theory	126+36	7	2	3	25	75	100
	ST222	Probability Theory - II	126	7	-	3	25	75	100
	ST223	Applied Statistics	144+18	8	1	3	25	75	100
	ST224	Practical -I Using R (covering topics of ST212,214,221 and 223)	-			3	25	75	100
3	ST231	Statistical Inference I	90+18	5	1	3	25	75	100
	ST232	Statistical Inference II	108+18	6	1	3	25	75	100
	ST233	Multivariate Analysis	90+18	5	1	3	25	75	100

	ST234	Elective - I	108	6	-	3	25	75	100
4	ST241	Design and Analysis of Experiments	144+36	8	2	3	25	75	100
	ST242	Stochastic Processes	126	7	-	3	25	75	100
	ST243	Elective - II	136+18	7	1	3	25	75	100
	ST244	Practical - IIUsing R (Covering topics of ST231,232,233, 241 and 243)	-	-	-	3	25	75	100
		Viva-voce	-	-	-	-	-	100	100[a]
		Project work and Viva-voce						100	100**

Abbreviations- L: Lecture, P: Practical, CA: Continuous Assessment, ESE: End Semester Examination,

*R programming will be introduced in the I Semester itself for purpose of doing practical problems in II and IV semesters and there is no examination for it.

a General viva voce based on all the courses

**80 marks for projectand 20 marks for viva voce examination based on it.

Pattern of Question Papers for the End Semester Examination and Project

Theory Papers:

For each paper the duration of the examination is 3 hours and maximum mark is 75. The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), each carrying 3 marks and a candidate has to answer any 5 of them. Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), each carrying 12 marks and the candidate has to answer 3 questions from this part. Part C will consist of 4 questions (2 questions each from unit 4 and unit 5) each carrying 12 marks and the candidate has to answer 2 questions from this part.

Practical Papers:

The practical paper will be conducted using R programme. For each practical paper, a record of work done by the student should be prepared and submitted for internal evaluation. The components of CA mark for the practical paper are Attendance (5 marks), Record book (10 marks) and class test (10 marks). The Board of examiners will prepare the question paper for the practical examination (ESE) covering the papers specified in the syllabus. An external examiner along with an internal examiner, appointed by the University will conduct the practical examination and its evaluation. For each practical paper, the duration of the examination is 3 hours and the maximum mark is 75.

The question paper of Practical – I Using R examination will consist of 4 parts: Part A, Part B, Part C and Part D. There will be 2 questions from Unit 1 in Part A and 2 questions from Unit 2 in Part B. There will be 3 questions from Unit 3 in Part C and 3 questions from Unit 4 in Part D. A candidate has to answer one question from Part A, one question from Part Band three questions from Part C and Part D without omitting any Part. Each question carries 15 marks.

The question paper of Practical - II Using R examination will consist of 4 parts: Part A, Part B, Part C and Part D. There will be 2 questions from Unit 1 in Part A and 2 questions from Unit 2 in Part B. There will be 3 questions from Unit 3 in Part C and 3 questions from Unit 4 in Part D. A candidate has to answer one question from Part A, one question from Part Band three questions from Part C and Part D without omitting any Part. Each question carries 15 marks.

Project Work:

A project work has to be done using primary or secondary data and to be submitted at the end of the fourth semester. For field survey project, a maximum of three students can do the survey jointly on the same topic and the data analysis and reporting can be done either jointly or independently. The project report of 30 to 40 pages should consist of literature review, methodology, data analysis and summary.

ST 211: ANALYTICAL TOOLS FOR STATISTICS – I

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Euclidean space R^n, open balls, open sets, closed sets, adherent points. Bolzano – Weierstrass theorem, Cantor intersection theorem, compactness in R^n, Heine-Borel theorem, Metric space (definition and examples). Compact subsets of a metric space, convergent sequence, Cauchy sequence, complete metric space, limit of real valued functions, continuous functions, continuity and inverse images of open and closed sets, Connected sets, uniform continuity and monotone functions (definition examples and applications only).

Apostol T. M (1974): Chapter 3 and 4 [Sections 4.1 – 4.5, 4.8, 4.9, 4.12, 4.13, 4.16, 4.19, 4.20, 4.23]

Unit 2

Functions of bounded variation, properties, total variation and additive property, continuous functions of bounded variation.

Definition and existence of Riemann integral, Riemann-Stieltjes integral, its reduction to Riemann integral, properties of Riemann-Stieltjes integrals (viz. linearity, product, quotient and modulus of integrals).Riemann's Condition, Fundamental theorem of integral calculus, mean value theorems,

Apostol T. M (1974): Chapter 6 [Sections 6.1- 6.8], Chapter 7 [Sections 7.1 – 7.5, 7.7, 7.11, 7.13, 7.14, 7.18, 7.19, 7.20]

Malik, S.C., Arora, S(2012):Chapter 9 [Sections 1 – 4]

Unit 3

Functions of several variables, partial derivatives, maximum and minimum of functions, conditional maxima and minima, Lagranges multiplier method.

Malik, S.C., Arora, S. (2012):Chapter 15 [Section 11] and Chapter 16 [Section 3].

Unit 4

Complex numbers and complex plane, functions of complex variables, analytic functions, Cauchy-Riemann equations (concepts and examples only). Cauchy's integral theorem, Cauchy's integral formula, Liouville's theorem, maximum modulus principle.

Levinson,N. and Redheffer ,M,R. (2015): Chapter 1, Chapter 2[Sections 1,2,3] and Chapter 3[Sections 1-7]

Unit 5

The zeros of analytic function, singularities and their types, residues, poles, Cauchy's residue theorem (statement and application only), contour integration (basic theory) and evaluation of integrals of the form:

$$\int_0^{2\pi} f(\sin\theta,\cos\theta)d\theta,\ \int_{-\infty}^{\infty} f(x)e^{imx}dx,\ \int_{-\infty}^{\infty} f(x)dx.$$

Levinson,N. and Redheffer ,M,R (2015):Chapter 3 [Sections 8-10], Chapter 4 [Sections 1-3]

Ahlfors, L.V.(2016): Chapter 5 [Section 3]

Texts:

1. Apostol T. M. (1974): *Mathematical Analysis*, Narosa Publishing House, New Delhi.
2. Malik, S.C., Arora, S. (2012): *Mathematical Analysis,* New Age International, New Delhi.
3. Levinson,N.,Redheffer ,M,R.(2015).*Complex Vaiables*.McGraw Hill Education(India) Limited.
4. Ahlfors, L.V.(2016). *Complex Analysis* .McGraw Hill Education(India) Limited.3rd Edition.

References:

1. Goldberg, R.R. (1970): *Methods of Real Analysis*, Oxford and IBH Publishing Company (P) Ltd, New Delhi.
2. Somasundaram,D, Chaudhary,B . (1999): First *Course in Mathematical Analysis*, Narosa Publishing House, New Delhi.
3. Lang, S.(1998). *Complex Analysis*. Springer ,New York.
4. Ponnusamy ,S(2015). *Foundations of Complex Analysis* .Narosa Publishing House, New Delhi

ST 212: ANALYTICAL TOOLS FOR STATISTICS – II

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Linear vector space, subspace, independence of vectors, basis and dimension, inner product, norm, orthonormal basis, orthogonal subspaces, Gram Schmidt orthogonalization, orthogonal transformation.

Unit 2

Matrices, Different types of matrices- Triangular, Idempotent, nilpotent, nonnegative, Unitary, Hermitian and skew Hermitian matrices. Determinants and their properties. Rank of a matrix, null space, nullity, partitioned matrices, Kronecker product, linear transformations, matrix representation of linear transformations, similarity of transformation.

Unit 3

Characteristic roots and vectors of matrices and their properties, determination of characteristic roots- power method and Jacobi method, spectral decomposition of matrices, Cayley Hamilton theorem, algebraic and geometric multiplicity of characteristic roots.

Unit 4

Quadratic forms- definition, classification and reduction of quadratic forms, real, symmetric and orthogonal reduction, simultaneous reduction, scalar valued functions of vectors and their derivatives with respect to a vector/matrix, Jacobian transformation.

Unit 5

Methods of computation of inverse of a non-singular matrix, generalized inverse, reflexive inverse, solutions of matrix equations, Moore- Penrose g-inverse- properties, determination of Moore- Penrose g-inverse, solution of a system of linear equations-methods of solution (inversion, elimination, iterative).

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A quick review of Numerical Analysis (**Not for University Examination**). -- Numerical solutions of algebraic equations- method of iteration and Newton Raphson Method, Finite differences, Lagrange, Hermite and Spline interpolation, Numerical differentiation and integration, Numerical solutions of differential equations using Picard, Euler, Modified Euler and Range-Kutta methods.

Text Books:

1. Biswas, S. (2012). Textbook of Matrix Algebra, Third edition, PHI Learning Pvt Ltd, New Delhi.
2. Sundarapandian, V. (2008). Numerical Linear Algebra, PHI Learning Pvt. Ltd, New Delhi.

Reference Texts:

1. Banerjee, S and Roy, A (2014). Linear Algebra and Matrix Analysis for Statistics, CRC Press, New York

2. Healy, M. J. R. (1986). Matrices for Statistics, Oxford Science Publications.
3. Lay, D. C. (2006). Linear Algebra and its Applications, Pearson Education.
4. Lipschutz, S. and Lipson, M. (2005). Linear Algebra. Tata McGraw- Hill Publishing Co. Ltd. New Delhi.
5. Monahan J.F. (2001). Numerical Methods of Statistics, Cambridge University Press.
6. Rao, C.R. (1973). Linear Statistical Inference and its Applications, Wiley Eastern
7. Sastry S.S. (1998). Introductory Methods of Numerical Analysis. Third edition, Printice Hall, New Delhi.
8. Srimanta Pal (2009). Numerical Methods - Principles, Analysis and Algorithms. Oxford University Press.

ST 213: PROBABILITY THEORY – I

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

A brief review of limit supremum, limit infimum and limit of sequence of real numbers.Sequence of sets, limit supremum, limit infimum and limit of sequence of sets, Monotone sequence of sets. Class of sets- Semi ring, ring, sigma ring (definition and examples only), field and sigma field. Borel sigma field and monotone class. Definition of minimal sigma field, generated sigma field and induced sigma field. Set functions, additive set functions and sigma additive set functions. Measure and its properties. Measure space. Probability measure, finite measure, sigma finite measure, complete measure, counting measure and signed measure (definition and examples only).

Unit 2

Outer measure, Lebesgue measure, Lebesgue –Stieltjes measure and its application in probability theory.Caratheodory extension theorem (statement only). Cantor set, Construction of cantor set, Measure and uncountability of a Cantor set. Measurable functions and properties (viz. linearity, product, maxima, minima, limit sup, limit inf, and modulus of measurable functions). Simple functions. Sequence of measurable functions. Point-wise convergence, almost everywhere convergence, uniform convergence, convergence in measure, convergence in p^{th} mean (concept only).

Unit 3

Integral of non- negative simple function, integral of non-negative measurable functions and integral of measurable functions. Lebesgue integral and its properties. Monotone convergence theorem, Fatou's theorem, Lebesgue dominated convergence theorem. Lebesgue –

Stieltjesintegral and its reduction to Riemann-Stieltjes integral and Riemann integral. Absolute continuity and singularity of measures (definition only). Lebesgue decomposition theorem and Radon-Nykodym theorem (statement and applications only).

Unit 4

Sample space and events, probability measure, probability space. Limit of sequence of events, monotone and continuity properties of probability measure. Independence of sequence of events, conditional probability and Bayes theorem. Borel- Cantelli lemma, Borel zero-one law and Kolmogorov 0-1 law.

Unit 5

Random Variables, discrete and continuous-type random variables, induced probability measure and induced probability space, probability distribution and distribution function, properties of distribution function., mixture of distribution functions (concept only). Decomposition of distribution function-Jordan decomposition theorem. Functions of a random variable, random vectors, distribution function of random vector (concept only). Independence of sequence of random variables.

Text books:

1. Jain, ,P.K. and Gupta, V.P.(2000). Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi (For Unit 2).
2. Kingman, J.F.C. and Taylor, S.J. (1977). A text book of Introduction to Measure Theory and Probability, 3rdEdn., Cambridge University Press, London (For Unit 1, Unit 2 and Unit 3).
3. Laha, R.G. and Rohatgi, V.K. (1979). Probability Theory, John Wiley, New York (For Unit 4 and Unit 5).
4. Rohatgi, V.K. and Saleh, Ehsanes (2014). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd. (For Unit 4 and Unit 5)
5. Roussas, G.G.(2014). An Introduction to Measure-Theoretic Probability, Academic Press, USA.

References:

1. Malik, S.C. and Arora, S.(2011) Mathematical Analysis, 4th Edn New Age international (P) Ltd, New Delhi.

2. Bhat, B.R.(1991). Modern Probability Theory, 2ndEdn., Wiley Eastern Ltd., New Delhi.

3. De Barra, G. (2000). Measure Theory and Integration, New Age International (P) Ltd.,
   New Delhi.

4. Feller W. (1968) Introduction to Probability Theory and Its Applications Vol. 1 and 2, John Wiley, New York.
5. Loeve, M (1968) Probability Theory Allied East-West Press.
6. Mukhopadhyay, P. (2011). An Introduction to the Theory of Probability, World Scientific Publishing Company.

ST 214: SAMPLING TECHNIQUES

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Concept of population and sample, sampling and non-sampling errors, sampling frame, probability and non-probability sampling, concept of sampling design, sampling strategy, simple random sampling with and without replacement, procedures for selection of simple random sample, Estimation of population mean, population total, population proportion, and the variance of these estimators. Estimation of their standard errors. Confidence limits for population mean and population proportion. Estimation of sample size.

Unit 2

Sampling with varying probabilities: PPS sampling with replacement, method to select PPSWR sample, estimation of population mean and variance of the estimator, PPS sampling without replacement, Des Raj's ordered estimator, mean of the estimator for the case of two draws and general case, Murthy's unordered estimator(Definition only), Horvitz-Thompson estimator of population mean and variance of the estimator, Yates- Grundy form of estimated variance, Zen-Midzuno scheme of sampling (concept only), πps sampling (definition only)

Unit 3

Stratified sampling, procedure of sample selection, estimation of population mean and variance of the estimator, choice of the sample size in different strata (optimum allocation, Neyman allocation and proportional allocation), variance of the estimator of population mean under these allocations, comparison of these variances, comparison of stratified sampling with SRS.Systematic sampling- sample selection procedure, estimation of the population mean and variance of the estimator, comparison of systematic sampling with SRSWOR, comparison of systematic sampling with stratified sampling, comparison of systematic sampling with SRSWOR and stratified random sampling for population with linear trend, circular systematic sampling- sample selection procedure.

Unit 4

Ratio method of estimation - Ratio estimator, bias and MSE of the ratio estimator, first order approximation to the bias of ratio estimator, approximate variance of ratio estimator.

Regression method of estimation – Difference estimator, the regression estimator, bias and MSE of the regression estimator, comparison of regression estimator with ratio estimator, approximate variance of the regression estimator

Unit 5

Cluster sampling- cluster sampling with clusters are of equal size, estimation of population mean and variance of the estimator, efficiency of cluster sampling. Two stage sampling-Two stage sampling with equal first stage units, estimation of the population mean and the variance of the estimator. Comparison of two-stage with one stage sampling. Multistage sampling (concept only).

Text Books

1. Bensal A (2017). Survey Sampling, Narosa Publishing House Pvt. Ltd.
2. Cochran, W. G. (1977). Sampling Techniques, Third edition, Wiley Eastern Ltd.

References

1. Gupta A K and Kabe D G (2011), Theory of Sample Surveys, World Scientific.
2. Mukhopadhyay, M. (2009). Theory and Methods of Survey Sampling, Second Edition, PHI Learning Pvt. Ltd.
3. Murthy, M. N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Sampath, S. (2001). Sampling Theory and Methods, Second edition, Narosa Publishing Company, New Delhi.
5. Singh, D. and Chaudhary, F.S. (1986). Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.
6. Sukhatme, P.V. and Sukhatme, B.V. (1970). Sampling Theory of Surveys with Applications, second edn, Asia Publishing House, Bombay.

ST 221: DISTRIBUTION THEORY

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Generating functions- probability generating function, moment generating function, cumulant generating function and characteristic function (concepts and examples only), bivariate distributions- joint, marginal and conditional distribution. Independence of random variables, bivariate mgf, pgf and moments, functions of random variables and their distributions, concepts of Compound, truncated and mixture distributions, Singular distribution, Cantor distribution (definition and examples only).

Unit 2

Discrete distributions- Degenerate, binomial, Poisson, negative binomial, geometric, uniform, hypergeometric distributions, Power series distributions- generalized power series and modified power series distribution, multinomial distribution, bivariate Poisson distribution.

Unit 3

Continuous distributions- uniform, normal, exponential, double exponential, beta, gamma, Cauchy, Weibull, Pareto, log-normal and logistic distributions. Pearson system of distributions, bivariate normal and Gumbel's bivariate exponential distribution.

Unit 4

Order Statistics- definition and basic distribution theory of order statistics - joint, marginal and conditional distributions of order statistics of a random sample arising from continuous distributions, distribution of sample median and range, order statistics of sample from uniform and exponential distributions.

Unit 5

Sampling distributions- distribution of the mean and variance of a random sample from normal population, Chi-square, t, and F distributions (both central and Non-central), their properties and applications.

Text books:

1. Rohatgi, V. K. and Saleh, (2003). An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons.
2. Mukhopadhyay, P. (2006). Mathematical Statistics, Books and Allied (P) Ltd., Kolkatta.

3. Johnson, N.L. Kotz, S. and Balakrishnan, N.(1997). Discrete Multivariate Distributions, Wiley, New York.
4. Balakrishnan, N. and Lai, C.D.(2009). Continuous Bivariate Distributions, Second Edition, Springer, New York.

References:

1. Hogg, R.V. and Craig, A.T. (1995). Introduction to Mathematical Statistics, Fifth Edition, Prentice Hall N J
2. Johnson, N. L., Kotz, S. and Balakrishnan, N. (2004). Continuous Univariate Distributions, Vol I Second Edition, John Wiley and Sons (Asia), PVT Ltd, Singapore.
3. Johnson, N. L., Kotz, S. and Balakrishnan, N. (2004). Continuous Univariate Distributions, Vol II Second Edition, John Wiley and Sons (Asia), PVT Ltd, Singapore.

ST 222: PROBABILITY THEORY – II

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Expectation of random variables and its properties. Moments and factorial moments. Probability generating function, moment generating function and cumulant generating function. Inequalities-Markov, Chebychev's, Lyapunov (for moments), Jensen, Holder's, C_r–inequality, Minkowski and basic inequality.

Unit 2

Stochastic convergence of sequence of random variables: - convergence in probability, almost sure convergence, convergence in p^{th} mean, weak and complete convergence of distribution functions and their interrelations. Slutsky's theorem and its applications. Helly-Bray lemma (statement only) and Helly-Bray theorem (statement only).

Unit 3

Characteristic function (c.f.) and their elementary properties, uniform continuity and non-negative definiteness of characteristic function. Uniqueness theorem. Inversion theorem (without proof). Fourier inversion theorem. Convolution theorem. Levy's continuity theorem (without proof) and Bochners theorem (without proof).

Unit 4

Stochastic series of sequence of random variables: - Law of large numbers, weak law of large numbers due to Bernoulli, Tchebyhev and Khintchine. Kolmogorov inequality, Kolmogorov three-series theorem. Strong law of large numbers- Kolmogorov's strong law of large numbers for independent random variables and Kolmogorov's strong law of large numbers for independent and identically distributed random variables (statement and applications only).

Unit 5

Central limit theorem: Classical Central limit theorem, De Moivre-Laplace Central limit theorem, Lyapunov Central limit theorem (without proof) and Lindberg-Feller Central limit theorem (without proof). Applications of various central limit theorems.

Text books

1. Bhat, B.R. (1991).Modern Probability Theory, 2nd Edn., Wiley Eastern Ltd., New Delhi
2. Laha, R.G and Rohatgi, V.K. (1979). Probability Theory, John Wiley, New York.
3. Rohatgi, V.K. and Saleh, Ehsanes (2014). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd.
4. Roussas, G.G.(2014). An Introduction to Measure- Theoretic Probability, Academic Press, USA.

References

1. Cacoullos, T. (1989). Exercise in Probability, Springer-Verlag, New-York.
2. Feller W. (1968). Introduction to Probability Theory and Its Applications Vol. 1 and 2, John Wiley, New York.
3. Gnedenko, B.V. (1969). The Theory of Probability, Mir Publishers, Mosko.
4. Loeve, M. (1968). Probability Theory Allied East-West Press.
5. Mukhopadhyay, P. (2011). An Introduction to the Theory of Probability, World Scientific Publishing Company

ST 223: APPLIED STATISTICS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Time Series Analysis- Economic Time series, its different components, Illustrations, additive models, determination of trend, Growth curves, Analysis of seasonal fluctuations, construction of seasonal indices.

Unit 2

Index numbers-definition and application of index numbers, price and quantity relatives, link and chain relatives. Computation of index numbers. use of averages, simple aggregate and weighted average methods, Laspeyre's, Paache's, Marshall-Edgeworth, Kelly's, Dorbish-Bowley and Fisher's index numbers. Criteria of a good index number. Consumer price index number. Base shifting, splicing and deflating index numbers.

Unit 3

Reliability- System reliability- series and parallel systems, k out of n systems and its reliability, coherent systems, reliability of coherent systems, cuts and paths. Survival function, hazard rate, mean residual life function and evaluation of these functions for exponential, Weibull, Gamma distributions. Concept of left and right censoring, Kaplan-Meier estimator for survival function (definition and examples only).

Unit 4

Statistical process control-chance and assignable causes of variation, statistical basis of control charts, OC function and ARL of a control chart. Control chart for variables- mean, range and S charts. Construction and operation of these charts, OC curve and ARL of these charts. Control chart for attributes- chart for fraction non-conforming (p-chart), np chart Chart for non-conformities (c-chart, u-chart). OC curve and ARL of these charts. CUSUM chart.

Unit 5

Acceptance sampling by attributes- Single, Double, Multiple and Sequential sampling plans.

Text Books:

1. Mukhopadhyay, P. (1999), Applied Statistics, New Central Book Agency Pvt. Ltd, Calcutta.

2. Goon A.M., Gupta.M.K., and Dasgupta, B. (1986). Fundamentals of Statistics, Vol 2, World Press, Calcutta
3. Barlow.R.E and Proschan, F (1985). Statistical theory of reliability and life testing, Holt, Rinehart and Winston.
4. Lawless J.F. (1982), Statistical Models and Methods of lifetime data, John Wiley & Sons, New York.
5. Montgomery, D.C. (2012). Introduction to Statistical Quality Control, 7th edn, John Wiley & Sons, New York.

References:

1. Anderson, T.W. (1971). Statistical Analysis of Time Series, John Wiley & Sons, New York.
2. Chatfield, C. (1980). The Analysis of Time Series-An introduction, 2nd edn, Chapman and Hall.
3. Medhi, J. (1992). Statistical Methods-An Introductory Text, New Age, Delhi.
4. Gupta, S.C. and Kapoor, V.K. (2007). Fundamentals of Applied Statistics, Sultan Chand & Sons
5. Grant. E. L. and Leavenworth, R.S. (1996). Statistical Quality Control, 7th edn, McGraw Hill Education (India) Private Limited, New Delhi.

ST 224: PRACTICAL – I Using R

(Problems covering papers ST 212, ST 214, ST 221 and ST 223)

The question paper of Practical – I Using R examination will consist of 4 parts: Part A, Part B, Part C and Part D. There will be 2 questions from Unit 1 in Part A and 2 questions from Unit 2 in Part B. There will be 3 questions from Unit 3 in Part C and 3 questions from Unit 4 in Part D. A candidate has to answer one question from Part A, one question from Part Band three questions from Part C and Part D without omitting any Part. Each question carries 15 marks.

Unit 1

Matrix Inverse, characteristic roots and vectors; Solution of system of linear equations

Unit 2

Drawing a sample of specified size from a given continuous distribution, fitting of univariate distribution to the given data.

Unit 3

Simple random sampling, stratified sampling, systematic sampling.

Unit 4

Variable control charts - $\overline{X}$, R and S, Attribute control charts – p and c charts Single and double sampling plans. Computation of Laspeyre's, Pasche's and Fisher's index numbers, tests on index numbers - time and factor reversal tests, chain index numbers, consumer price index numbers, determination of trend, analysis of seasonal fluctuation and seasonal indices.

ST 231: STATISTICAL INFERENCE I

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Problem of point estimation, unbiasedness, consistency (strong, weak and squared error), Definition and examples of Bias of an estimator, asymptotically unbiased estimator, Sufficient condition for weak consistency. Invariance property of consistent estimator. mean square error, CAN estimator, BAN estimator.

Unit 2

Sufficiency, Complete sufficient statistic, complete sufficient statistics for exponential family of distributions, Factorization criterion for sufficiency. Construction of minimal sufficient statistic (example). UMVU estimators. Rao-Blackwell theorem, Lehman-Scheffe theorem and its applications. Ancilliary statistic and Basu's theorem.

Unit 3

Fisher's information measure- (i) in a random variable (ii) in a random sample (iii) in a statistic. Cramer- Rao inequality and its generalizations (i) through higher order derivatives and (ii) in the multi parameter case, applications. Chapman-Robin's bound. Efficient estimators.

Unit 4

Methods of estimation- maximum likelihood, method of moments, method of minimum Chi-square, modified minimum Chi-square. Properties of MLE (such as function of sufficient statistic, invariance property, uniqueness). Theorems regarding consistent solution of likelihood equations (viz. uniqueness, asymptotically normal and efficient and MLE).

Unit 5

Limitations of classical inference, decision rule, loss function. Bayes and minimax decision rules. Types of loss (squared and modulus) . Prior distribution, Posterior distribution, Bayes

solution (Theorem associated to quadratic loss and problems in case of binomial and Normal). Conjugate prior family. Jeffrey's Prior.

Text Books:

1. Rohatgi, V. K. and Saleh, A.K.M (2003). An Introduction to Probability and Statistics, John Wiley and Sons.
2. Mukhopadhyay, P. (2006). Mathematical Statistics, Books and Allied (P) Ltd., Kolkatta.
3. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt Ltd, New Delhi.
4. Bansal, A.K. (2006). Bayesian Parametric Inference, Narosa Publishing House, New Delhi.
5. Srivastava, M.K., Khan, A.H. and Srivastava, N. (2014). Statistical Inference, Prentice Hall India, New Delhi.

References:

1. Casella, G. and Berger, R.L. (2002). Statistical Inference, 2nd edn. Cengage Learning, New Delhi
2. Lehmann, E.L. (1983). Theory of Point Estimation, Wiley, New York.
3. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern Ltd.
4. Wasan, M.T. (1970). Parametric Estimation, Mc-Graw Hill, New York.
5. Ferguson, T.S. (1967). Mathematical Statistics. Academic Press, New York.
6. Kale B.K. (1999). A First Course on Parametric Inference. Narosa Publishing House.
7. Mood, A.M, Graybill F.A. and Boes D.C. (2001). Introduction to the Theory of Statistics, 3rd edn., Mc- Graw Hill Inc, New York.

ST 232 STATISTICAL INFERENCE II

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Fundamental concepts of hypothesis testing: Hypotheses- Null and alternative, simple and composite, problem of testing of hypothesis, critical region, two kinds of errors, level of significance, test function, randomized and non- randomized tests, size and power function of a test, most powerful (MP) test and uniformly most powerful (UMP) test; Test of a simple

hypothesis Neyman-Pearson Lemma, Generalization of Neyman-Pearson Lemma (Statement and applications only).

Unit 2

Test of a composite hypothesis: Family of distributions with monotone likelihood ratio, UMP test for certain one sided hypothesis concerning a real valued parameter, UMP tests for some two sided hypothesis in case of one parameter exponential family. Unbiased tests, UMPU test, α- similar test and LMP tests.

Unit 3

Likelihood ratio test (LRT), asymptotic properties; LRT for the parameters of binomial and normal distributions. Interval estimation, UMA confidence sets, shortest length confidence interval.

Unit 4

Sequential methods: Sequential Probability Ratio Test (SPRT), Wald's fundamental identity, OC and ASN functions; Applications to Binomial, Poisson and Normal distributions.

Unit 5

Non parametric tests: Chi-square goodness of fit test, Kolmogrov-Smirnov test, Sign test, Wilcoxon signed rank test and run test; Two sample tests- Kolmogorov-Smirnov test, Wald-Wolfowitz run test, median test and Mann-Whitney- Wilcoxon test, Kruskal -Walli's test, Friedmann Test. Tests for association based on Kendall's Tau and Spearman's rank correlation coefficient.

Text Books:

1. Rohatgi, V. K. and Saleh, A.K.M. (2003). An Introduction to Probability and Statistics, John Wiley and Sons.
2. Mukhopadhyay, P. (2006). Mathematical Statistics, Books and Allied (P) Ltd., Kolkatta.
3. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt Ltd, New Delhi.
4. Gibbons, J.D. (1985): Non Parametric Statistical Inference, 2nd edn. Marcel Dekker Inc.

References:

1. Lehmann E.L. (1986): Testing Statistical Hypotheses, 2nd edn. John Wiley & Sons, New York.
2. Ferguson, T.S. (1967). Mathematical Statistics. Academic Press, New York
3. Kendall, M.G. and Stuart, A. (1967). The Advanced Theory of Statistics, vol 2, 2nd edn. Mc-Millan, New York.

4. Shao, J. (2003). Mathematical Statistics, 2n edn. Springer-Verlag, New York.
5. Srivastava, M.K., Khan, A.H. and Srivastava, N. (2014). Statistical Inference- Testing of Hypothesis, Prentice Hall India, New Delhi.

ST 233: MULTIVARIATE ANALYSIS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Bivariate distributions, marginal and conditional distributions, independence, conditional mean and variance.Random vectors and their distributions, expectation and covariance of random vectors and quadratic forms; Characteristic functions in higher dimensions. Multiple regressions and multiple correlation, partial regression and partial correlation (illustrative examples).

Unit 2

Multivariate normal distribution- marginal and conditional distribution, characteristic function, singular normal distribution, additive property, distribution of linear combination of normal random vectors. Characterization of normal distribution based on linear combination of random variables, distribution of quadratic forms, Cochran's theorem (statement only).

Unit 3

Samples from multivariate normal distribution, MLE of mean vector and dispersion matrix. Distribution of sample mean vector, Wishart distribution: definition and properties, analogy with chi-square distribution, characteristic function, additive property, generalized variances, partitioned Wishart matrix, distribution of sample dispersion matrix.

Unit 4

Sampling distribution of multiple correlation coefficient and tests of significance of multiple corelation. Tests of hypothesis about mean vector of multivariate normal distribution, equality of mean vectors of two multivariate normal distributions- Hotelling's T^2 and Mahalanobis' D^2.

Unit 5

Classification problems: Classifying to one of k multivariate normal populations, Bayes' solution, Fisher's discriminant function, Definition of principal components-extraction of

principal components, definition and derivation of canonical variables and canonical correlation, Application of factor analysis and cluster analysis- Othogonal factor model.

Text Books:

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, John Wiley, New York.
2. Johnson, R.A. and Wichern, D.W. (1992). Applied Multivariate Statistical Analysis, 3rd edn., Prentice- Hall, London.
3. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley, New York.

References:

1. Graybill,F.A. (1961). An Introduction to Linear Statistical Model, Vol 1, Mc Graw Hill, New York.
2. Kendall, M.G. (1958). A Course in Multivariate Analysis, Griffin, London.
3. Rohatji, V.K. and Saleh, A.K.M.E. (2003). An Introduction to Probability Theory and Mathematical Statistics, 2nd edn., John Wiley & Sons, New York.
4. Srivastava, M.S. and Khatri, C.G. (1979). An Introduction to Multivariate Statistics, North Holland.

ST 234: ELECTIVE-I

ELECTIVE – I (1): OPERATIONS RESEARCH

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Linear Programming Problem: basic feasible solution, graphical method, Standard form of an LPP, Simplex method of solving an LPP, Fundamental Theorem of an LPP, Two-phase method and Big-M method, degeneracy, duality in LPP, Fundamental Theorem of Duality and Integer LPP (branch and bound method only).

Unit 2

Assignment problem, Hungarian method of assignment, transportation problem: basic feasible solution (North-West Corner Method, Least Coast Method and VAM Method) methods of finding optimum solution, degeneracy in transportation problem. Replacement

models: Types of failure, replacement of items deteriorates with time, replacement of items that fail completely.

Unit 3

Non-linear programming: General non-linear programming problems - Constrained optimization with equality and inequality constraints, Kuhn – Tucker conditions (statement only) and applications. Dynamic programming - Characteristics of dynamic programming problem, different models - Single additive constraint and multiplicative separable return, single additive constraint and additively separable return, single multiplicative constraint and additively separable return, dynamic programming approach for solving a LPP.

Unit 4

Queueing Theory: Characteristics of queueing processes, role of Poisson distribution and exponential distribution in queueing theory, steady state solution of M/M/1 model, Waiting time distribution of M/M/1 model, steady state solution of M/M/C model and steady state solution of M/EK/1 queueing model, measures of effectiveness of these models, Little's Formula, M/G/1 model (description only) and Pollaczek– Khintchine formula.

Unit 5

Inventory models: Meaning of inventory control, inventory costs, concept of EOQ, deterministic inventory models without shortages - Economic lot size model with constant demand, economic lot size model with different rates of demand in different cycles and economic lot size model with finite replenishment rate. Deterministic inventory models with shortages. Probabilistic inventory models - Single period model without setup cost, single period model with setup cost. The EOQ models with quantity discounts (one price break and two price breaks).

Text Books:

1. Gross, D. and Hariss, C.M. (2009). Fundamentals of Queueing Theory, John Wiley & Sons.
2. Kanthi Swarup, Gupta, P.K, and Man Mohan (2012). Operations Research, Sulthan Chand & Sons.
3. Sharma, J.K. (2009). Operations Research Theory and Applications, Macmillan India Limited

References:

1. Medhi J (2014) Introduction to Queueing Systems and Applications, New Age International Publishers
2. Mittal, K.V. and Mohan, C. (1996). Optimization Methods in Operations Research and System Analysis, New Age Publishers.

3. Paneerselvam, R. (2006). Operations Research, Prentice hall of India.
4. Rao S S. (1984), Optimization Theory and Applications, New Age Publishers, Wiley Eastern.
5. Ravindran, A., Philips, D.T. and Solberg, J. (2007). Operations Research: Principles and Practice, John Wiley & Sons, New York.
6. Taha, H. A. (2010). Operations Research, Macmillan India Limited

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ELECTIVE – I (2) STATISTICAL DECISION THEORY

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Basic concepts: decision problem, statistical decision problem, expected loss, decision rules and risk randomized decision rules, decision principles, sufficient statistics- convexity-utility theory, loss functions, standard loss function, illustrative examples.

Unit 2

Prior information and subjective probability-subjective determination of prior density- non informative prior, maximum entropy priors- using the marginal distribution to determine the prior- the ML11 approach to prior selection.

Unit 3

Bayesian analysis: Bayes' theorem, posterior distributions, Bayesian decision theory, empirical Bayes' analysis, hierarchical Bayesian analysis, Bayesian robustness, admissibility of Bayes, rules, Bayesian sufficiency.

Unit 4

Minimax analysis: game theory -basic concepts general techniques for solving games, games with finite states of nature, the supporting and separating hyper plane theorem, the minimax theorem, statistical games, classes of minimax estimators, evaluation of minimax principles, admissibility – rationality with minimax principle- comparison with Bayesian approach.

Unit 5

Complete and essentially complete classes; basic concepts, decision rule based on sufficient statistics, non randomized decision rules, finite parameter space, the Neyman-Pearson lemma,

one sided testing, monotone decision problems, monotone multiple decision problems, monotone estimation problems, limits of Bayes' rules, - two sided tests, generalized Bayes' estimators, identifying generalized Bayes' estimators, continuous risk functions.

Text Books:

1. Berger, J.O. (1988). Statistical Decision Theory and Bayesian Analysis, Second edition, Springer - Verlag, New York

References:

1. Ferguson, T.S. (1967). Mathematical Statistics - A Decision Theoretic Approach. Academic Press, New York.
2. Leonard, T. (1999). Bayesian Methods, Cambridge University Press.

ELECTIVE – I (3): ACTUARIAL STATISTICS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Utility theory, insurance and utility theory, model for individual claims and their sums, survival function, curtate future, lifetime force of mortality. Life tables and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Unit 2

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws. Multiple decrement tables, central rates of multiples decrement, net single premiums and their numerical evaluations.

Unit 3

Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest, nominal and effective rate of interest and discount, force of interest and discount. Compound interest, accumulation factor, continuous compounding.

Unit 4

Life insurance: insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance. Deferred insurance and varying benefit insurance, recursions, commutation functions. Life annuities: single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities- immediate and apportionable annuities due.

Unit 5

Net premiums: continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation types benefits, payment premiums, apportionable premiums, commutation functions, accumulation types of benefits.

References:

1. Beard, R.E., Penlikumen, T. and Pesomen, E. (1984). Risk Theory: The Stochastic Basis of Insurance, 3rdedn., Chapman and Hall.
2. Bowers, N.L., Geber, H.U., Hickman, J.C., Jomes, D.A. and Nesbitt, C.J. (1977). Actuarial Mathematics, 2ndedn, society of Actuaries, Illiois, USA.
3. Neil, A. (1977). Life Contingencies, Heimemin

ST 241: DESIGN AND ANALYSIS OF EXPERIMENTS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Linear estimation, estimable function and conditions for estimability. Linear models - Principle of least squares, Gauss-Markov theorem. ANOVA for the general Gauss-Markov model, Tukey's test of additivity, Duncan's multiple range test.

Unit 2

Principles of experimentation,,CRD, RBD (one observation per cell, multiple observations per cell), LSD (models- assumptions-analysis of variance-comparison of efficiencies-criteria for connectedness), balance and orthogonality. Incomplete block designs: BIBD, PBIBD (definition and examples only).

Unit 3

Factorial experiments: Testing of significance of factorial effects of 2^2, 2^3 and 3^2 experiments, Yates procedure for estimating the effects. Complete confounding, partial confounding.

Unit 4

Fixed effect - random effect - mixed effect models: Random effect one-way model estimation of variance components. Mixed model - Two fixed factors and one random effect (description of model and computation of components of variance). Nested fixed effect and nested random effects models (models and examples only).

Unit 5

Split plot, split-split plot and strip plot designs. Analysis of covariance of CRD. Estimation of missing observations in CRD and RBD

Text Books:

1. Das, M.N. and Giri, N. (1986). Design and Analysis of Experiments, New Age International, New Delhi
2. Montgomery, C.J. (2013). Design and Analysis of Experiments, 8thEditionWiley Eastern.
3. Joshi, D.D. (1987). Linear Estimation and Design and Analysis of Experiments, Wiley Eastern.
4. Dean, A. and Voss, D. (2006). Design and Analysis of Experiments, Springer.

References:

1. Chakravarthi, M.C. (1962). Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.
2. Hinkelmann, K., Kempthorne, O.(2007). Design and Analysis of Experiments, Volume 1: Introduction to Experimental Design, 2nd Edition, Wiley.
3. Hinkelmann, K., Kempthorne, O.(2005). Design and Analysis of Experiments, Volume 2: Advanced Experimental Design, Wiley.

ST 242: STOCHASTIC PROCESSES

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Introduction to stochastic processes - time and state space, classification of stochastic processes, processes with independent increments, Gaussian process, Martingales, Markov process, random walk and Wiener process (examples).

Unit 2

Markov chain, transition probabilities and stationary transition probabilities, transition probability matrix, Chapman - Kolmogorov equation: classification of states, first passage time distribution, stationary distribution, irreducible Markov chain, aperiodic chain, ergodic theorem and Gamblers ruin problem.

Unit 3

Poisson process - Properties of Poisson process and related distributions, compound Poisson process, pure birth process, birth immigration process, time dependent Poisson process, pure death process and birth and death process.

Unit 4

Renewal process - definition and examples, renewal function and renewal density, renewal equation, statement and applications of renewal theorems, stopping time, Wald's equation, residual and excess life times, backward and forward recurrence times, Poisson process as a renewal process, branching process - definitions and examples, generating function of branching process, Galton - Watson branching process, probability of ultimate extinction, distribution of total number of progeny.

Unit 5

Stationary process - weakly stationary and strongly stationary processes, auto correlation and applications, purely random process, moving average process, autoregressive process, Yule process, autoregressive moving average process, periodic process and exponential smoothing.

Text books:

1. Karlin, S. and Taylor, H.M. (1975). A First Course in Stochastic Processes, Second Edition, Academic Press.
2. Medhi, J. (2009). Stochastic Processes, New Age International Publishers, New Delhi.

References:

1. Bhat, U.N. and Miller, G.K. (2002). Elements of Applied Stochastic Processes, Third Edition, John Wiley, New York
2. Cinlar, E. (1975). Introduction to Stochastic Processes, Prentice Hall, Inc, New York.
3. Bhat,
4. Feller, W. (1968). Introduction to Probability Theory and Applications, Vol. I, John Wiley, New York
5. Feller, W. (1971). Introduction to Probability Theory and Applications, Vol. II, John Wiley, New York

ST 243- ELECTIVE II

ELECTIVE II (1): ECONOMETRICS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Definition, scope and divisions of econometrics, methodology of econometric analysis. Linear models - Exogenous and endogenous variables - assumptions, structural equations, Ordinary Least Square (OLS) estimators and their properties. Test of significance of parameter estimates- confidence interval and predictions.

Unit 2

Multiple Linear regression models. Mean and variance of estimators, tests of significance. The adjusted coefficient of determination. Regression and ANOVA. Test for overall significance of regression. Improvement of the model with additional explanatory variables. Homoscedasticity and Heteroscedasticity and its tests.

Unit 3

Auto - correlation - sources and consequences, test of autocorrelation, solution for the case of autocorrelation, Multi collinearity - meaning, assumptions and consequences - tests for detecting multi collinearity. Stochastic regressors - instrumental variables - assumptions and consequences of violation of assumptions.

Unit 4

Simultaneous equation models - methods based on limited and full information. ILS, 2 SLS and 3 SLS estimators and their properties. Instrumental variables techniques- recursive

models on estimators, maximum likelihood methods. LIML and FIML and their properties. Structural and reduced forms. The problem of identification: identifying restrictions.

Unit 5

Distributed lag models and methods of estimation, statistical analysis of demand, cost input-output analysis, Leontief's open and Walras closed systems. Prediction based on econometric models. Mean square error analysis of prediction and estimates.

Text Books:

1. Gujarati, D.N. (1995). Basic Econometrics, Mc Graw Hill Ltd.
2. Johnston, J. (1963). Econometric Methods, Mc Graw Hill, Tokyo.

References:

1. Choudhary, K.R. (2001). Modern Micro Economics, Tata Mc Graw Hill, Ltd
2. Koutsoyiannis, A. (1973). Theory of Econometrics, Harper & Row, New York.
3. Theil, H. (1971). Principles of Econometrics, Wiley, New York.

ELECTIVE II(2): REGRESSION METHODS

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Linear regression with one independent variable, estimation, inference on regression coefficients, residual analysis, joint estimation of the structural parameters, prediction, residual analysis.

Unit 2

Multiple regression models, least square estimation, ANOVA, inference on regression parameters, prediction, residual analysis. Generalized least squares and weighted least squares.

Unit 3

Polynomial regression models, estimation and inference on structural parameters, Estimating the maximum or minimum of a quadratic regression function, search for "Best" set of

independent variable in multiple linear regression, all possible regressions, Step-wise regression.

Unit 4

Generalized linear models- definition, components of GLM, Examples of normal, binomial and Poisson models. Exponential family of distributions- derivation of score statistic and information. Maximum likelihood estimation of GLM, Sampling distribution of maximum likelihood estimator, test of goodness of fit.

Unit 5

Indicator variable models, binary logistic regression, Dose response models- quantal response, probit model- median lethal dose, logit model; count data- Poisson regression- estimation and testing of parameters; log-linear models (two-way contingency table only).

Text Books:

1. Draper, N.R. and Smith, R. (2003). Applied Regression Analysis, John Wiley and Sons inc., New York
2. Montgomery, D.C. , Peck, E.A. and Vining, G.G. (2003). Introduction to Linear Regression Analysis, John Wiley & Sons, Asia
3. Seber, G.A.F. (1977). Linear Regression Analysis, John Wiley and Sons, New York
4. Dobson, A.J. (2002) An Introduction to Generalized Linear models, Second edition, CRC Press. (chapter 3 and sections: 4.3, 4.4, 5.4, 7.1, 7.2, 7.3, 9.1, 9.2, 9.5 for units 4 and 5)

References:

1. Mc Cullagh, P. and Nelder, J.A. (1989). Generalized Linear Models, Chapman and Hall.
2. Neter, J. and Wasserman, D.W. (1983). Applied Linear Statistical Models, Richard, D. Irwin, Inc., Illinois.
3. Rao, C.R. (1973). Linear Statistical Inference and its Applications, Wiley, New York.
4. Srivastava, V.L. and Giles, D.E.A. (1987). Seemingly Unrelated Regression Equations Models- Estimation and Inference, Marcel Dekkar Inc., New York

ELECTIVE II(3) : RELIABILITY THEORY

The question paper will have 3 parts: Part A, Part B and Part C. Part A will consist of 10 short answer questions (two questions from each of the 5 units), Part B will consist of 6 questions (2 questions each from unit 1, unit 2 and unit 3), Part C will consist of 4 questions (2 questions each from unit 4 and unit 5)

Unit 1

Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them; Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications; TTT transforms and characterization of ageing classes.

Unit 2

Non-monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma, Makeham, Rayleigh with reference to basic concepts and ageing characteristics; Bathtub and upside down bathtub failure rate distributions.

Unit 3

Discrete time failure models: - Definition of basic functions and their properties; Ageing classes and their mutual implications (IFR and DFR, IFRA and DFRA, NBU (NWU), NBUE, DMRL and IMRL, Discrete Time Failure Models- geometric distribution, negative binomial distribution, discrete Weibull distributions,

Unit 4

Bivariate ageing classes - bivariate failure rate, bivariate IFR, bivariate IFRA, bivariate NBU, bivariate exponential distributions and their properties. concepts and measures of dependence in reliability - RCSI, LCSD, PF2, WPQD.

Unit 5

Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non-censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models.

Text Books:

1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer.
2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern.

References:

1. Barlow R.E. and Proschan F. (1965). Mathematical Theory of Reliability, Wiley, New York.
2. Barlow, R.E. and Proschan, F. (1975). Statisical Theory of Reliability and Life Testing, Holt, Reinhart and Winston.
3. Marshall, A.W. and Olkin, I. (2007). Life Distributions, Springer.

ELECTIVE II(4) ST-244: OFFICIAL STATISTICS

Unit 1

Introduction to Indian Statistical systems- Role, function and activities of Central Statistical organization and State Agencies. Role of National Sample Survey Organization. General and special data dissemination systems. Scope and Contents of population census of India.

Unit 2

Population growth in developed and developing countries, Evaluation of performance of family welfare programmes, projections of labour force and man power. Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Unit 3

Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach, income approach and expenditure approach.

Unit 3

Measuring inequality in income: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Sen etc.

Unit 5

Vital statistics- measurement of population, rates and ratios of vital events, mortality and fertility, their measurement, mortality table, stationary and stable population, central mortality rate, force of mortality. construction of abridged life tables.

Suggested Readings:

1. Basic Statistics Relating to Indian Economy (CSO) 1990

2. Guide to Official Statistics (CSO) 1999

3. Statistical System in India (CSO) 1995

4. Principles and Accommodation of National Population Census, UNEDCO.

5. Panse, V.G.: Estimation of Crop Yields (FAO)

6. Family Welfare Year Book. Annual Publication of D/O Family Welfare.

7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

8. CSO (1989)a: National Accounts Statistics- Sources and Methods.

9. Keyfitz, N (1977): Applied Mathematical Demography- Springer Verlag.

10. Sen, A (1977): Poverty and Inequality.

11. UNESCO: Principles for Vital Statistics Systems, Series M-12.

12. CSO (1989)b: Statistical System in India

13. Chubey, P.K (1995): Poverty Measurement, New Age International.

ST: 244: PRACTICAL - II

(Problems covering papers ST 231, ST 232, ST 233, ST 241 and ST 243)

The question paper of Practical - II Using R examination will consist of 4 parts: Part A, Part B, Part C and Part D. There will be 2 questions from Unit 1 in Part A and 2 questions from Unit 2 in Part B. There will be 3 questions from Unit 3 in Part C and 3 questions from Unit 4 in Part D. A candidate has to answer one question from Part A, one question from Part Band three questions from Part C and Part D without omitting any Part. Each question carries 15 marks.

Unit 1

Uniformly minimum variance unbiased estimator, minimum variance bound estimator. Methods of estimation – MLE, MLE by scoring method, method of moments, confidence interval estimation

Problems based on power functions, SPRT, OC curve and ASN curve of SPRT, Non - parametric tests.

Unit 2

Multivariate normal distribution, Estimation of mean vector and variance – covariance matrix, Test of hypothesis about mean vector of a multivariate normal population and equality of mean vectors of two multivariate normal populations, Applications of Hotelling's T^2, Principal components.

Unit 3

Estimation of a parametric function, ANOVA - CRD, RBD and LSD. Testing significance of factorial effects of 2^2, 2^3 and 3^2 experiments, split plot design using R built-in commands

Unit 4

General linear regression models, estimation and testing of significance of parameter estimates, residual analysis and checking assumptions.

OR

General linear regression models, estimation and testing of significance of parameter estimates, residual analysis and checking assumptions. Logistic and Poisson regressions.

OR

Reliability estimation using MLE, UMVUE, Bayesian reliability estimation