KANNUR UNIVERSITY

(Abstract)

M.Sc Statistics programme– Scheme, Syllabus and model question papers - Core/Elective Courses under Credit Based Semester System - Affiliated Colleges – Implemented with effect from 2014 Admission – Orders issued.

ACADEMIC BRANCH

U.O.No.Acad/C4/4988/2014 Dated, Civil Station (P.O), 01 -09-2014

Read:1.U.O No.Acad/C1/11460/2013 , dated 12.3.2014

2.Minutes of the meeting of the Board of Studies in Statistics (PG) held on 20-01-2014

3. Minutes of the meeting of Faculty of Statistics held on 25-03-2014

4. Letter dated 14-08-14 from the Chairman, Board of Studies in Statistics (PG)

ORDER

1.Revised Regulations for Credit Based Semester System for PG Programmes in affiliated Colleges have been implemented in this University with effect from 2014 admission vide paper read (1)above.

2. The Board of Studies in Statistics (PG), vide paper read read(2) above, has finalized the Scheme, Syllabus and Model Question Papers for M.Sc. Statistics under Credit based Semester System with effect from 2014 admission.

3. As per paper read (3) above, the meeting of Faculty of Science, approved the Scheme, Syllabus and Modern question papers for M.Sc. Statistics with effect from 2014 admission.

4. The Chairman, Board of Studies in Statistics (PG) vide paper (4) above, has forwarded the Scheme, Syllabus and Model Question Papers for M.Sc. Statistics for implementation with effect from 2014 admission.

5. The Vice-Chancellor, after considering the matter in detail, and in exercise of the powers of the Academic Council, conferred under Section 11 (1) of Kannur University Act, 1996 and all other enabling provisions read together with, has accorded sanction to implement the Scheme, Syllabus and Model Question papers(Core/Elective Courses) for M.Sc. Statistics Programme in affiliated Colleges under Credit Based Semester System with effect from 2014 admission subject to report Academic Council.

6. Orders are, therefore, issued accordingly.

7. The implemented Scheme, Syllabus and Model Question papers are appended.

Sd/-

DEPUTY REGISTRAR (ACADEMIC)

For REGISTAR

(PTO)

To:

The Principals of Colleges offering M.Sc. Statistics Programme.

Copy to:

1. The Examination Branch (through PA to CE)
2. The Chairman, BOS in Statistics (PG)
3. PS to VC/PA to PVC/PA to Registrar/PA to CE.
4. DR/AR-I (Academic).
5. SF/DF/FC

Forwarded /By Order

SECTION OFFICER

- ***For more details log on to www kannur university.ac.in***

3.9.14

M.Sc. Statistics Programme under Credit based Semester System (CBSS-PG) for Affiliated Colleges of Kannur University.

Programme Structure & Syllabi

(With effect from the academic year 2014-15 onwards)

1. Eligibility for Admission: Candidates who have successfully completed any of the following three degree programmes are eligible for admission to M.Sc Statistics Programme, as per the existing University/Government orders.

- B.Sc. Degree with Statistics or Applied Statistics as the Core Course (Main) with not less than 50% marks or equivalent grade excluding subsidiaries/complementary
- B.Sc. Degree with Statistics & Mathematics double main and B.Sc. Degree with Mathematics as Core Course (Main) and Statistics as one of the complimentary Courses (Subsidiary) with not less than 55% marks or equivalent grade

The index score for preparing the rank list shall be calculated on the basis of the marks/grade points of Main (Core Courses) and Subsidiaries (Complimentary courses) scored by the candidates in the B.Sc degree programme. 50% of the total seats in each category shall be reserved for the B.Sc degree holders in Statistics single main or Statistics and Mathematics double main if there are claimants.

2. Duration of the Programme: The duration of M.Sc Statistics Programme shall be a minimum of 2 years consisting of 4 Semesters. Each Semester consists of a minimum of 450 contact hours distributed over 90 working days.

3. Structure of the Programme: The total credits for the Programme is 80. Core courses have a total credit of 68 and elective have 12 credits. Core Course is a Course that every student admitted to the Programme must successfully completes to receive the degree and cannot be substituted by any other Course. An Elective Course is a Course which can be substituted by an equivalent Course from the Subject. The Programme includes 17 Core Courses and 3 Elective Courses. Odd Semesters carry 20 Credits each and the credits for second and fourth semesters are 18 and 22 respectively. The Programme Structure is as shown below.

CREDIT AND MARK DISTRIBUTION FOR MSc STATISTICS

Semester	Course Code	Course	Marks			Credit
			Internal	External	Total	
I	STA1C01	Course 1.1	15	60	75	4
	STA1C02	Course 1.2	15	60	75	4
	STA1C03	Course 1.3	15	60	75	4
	STA1C04	Course 1.4	15	60	75	4
	STA1C05	Course 1.5	15	60	75	4
Total			**75**	**300**	**375**	**20**
II	STA2C06	Course 2.1	15	60	75	4
	STA2C07	Course 2.2	15	60	75	4
	STA2C08	Course 2.3	15	60	75	4
	STA2C09	Course 2.4	15	60	75	4
	STA2P01	Course 2.5	10	40	50	2
Total			**70**	**280**	**350**	**18**
III	STA3C10	Course 3.1	15	60	75	4
	STA3C11	Course 3.2	15	60	75	4
	STA3C12	Course 3.3	15	60	75	4
	STA3C13	Course 3.4	15	60	75	4
	STA3E01	Course 3.5	15	60	75	4
Total			**75**	**300**	**375**	**20**
IV	STA 4C14	Course 4.1	15	60	75	4
	STA4E02	Course 4.2	15	60	75	4
	STA4E03	Course 4.3	15	60	75	4
	STA4P02	Course 4.4	10	40	50	2
	STA4Pr	Course 4.6	Project Work	20	80	100
	STA4C15	Course 4.5	Viva Voce	5	20	25
Total			**80**	**320**	**400**	**22**
Grand Total			**300**	**1200**	**1500**	**80**

Course Code	Course	Course Title	Hrs. per Week	Credits	Marks
I Semester (Total Credits : 20)					
STA1C01	Course 1.1	Probability Theory - I	4	4	75
STA1C02	Course 1.2	Mathematical Methods for Statistics - I	4	4	75
STA1C03	Course 1.3	Mathematical Methods for Statistics – II	4	4	75
STA1C04	Course 1.4	Distribution Theory	4	4	75
STA1C05	Course 1.5	Sampling Theory	4	4	75
II Semester (Total Credits: 18)					
STA2C06	Course 2.1	Probability Theory – II	4	4	75
STA2C07	Course 2.2	Stochastic Processes	4	4	75
STA2C08	Course 2.3	Statistical Inference – I	4	4	75
STA2C09	Course 2.4	Design & Analysis of Experiments	4	4	75
STA2P01	Course 2.5	Practical - I (based on Courses 1.4, 1.5, 2.2, 2.3 & 2.4)	8	2	50
III Semester (Total Credits: 20)					
STA3C10	Course 3.1	Regression Methods	4	4	75
STA3C11	Course 3.2	Multivariate Analysis	4	4	75
STA3C12	Course 3.3	Statistical Inference – II	4	4	75
STA3C13	Course 3.4	Time Series Analysis	4	4	75
STA3E01	Course 3.5	Elective – I	4	4	75
IV Semester (Total Credits: 22)					
STA 4C14	Course 4.1	Official Statistics	4	4	75
STA4E02	Course 4.2	Elective – II	4	4	75
STA4E03	Course 4.3	Elective – III	4	4	75
STA4P02	Course 4.4	Practical - II (based on courses 3.1, 3.2, 3.3 and 3.4)	8	2	50
STA4Pr	Course 4.6	Project Work	8	6	100
STA4C15	Course 4.5	Viva Voce	-	2	25

List of Electives

	Sl. No.	Course Title	Credits
Group I	01	Operations Research	4
	02	Queuing Theory	4
	03	Reliability Theory	4
Group II	04	Econometrics	4
	05	Statistical Quality Assurance	4
	06	Statistical Decision Theory	4
Group III	07	Biostatistics	4
	08	Demography	4
	09	Lifetime Data Analysis	4
	10	Actuarial Statistics	4
	11	Statistics using SAS	4

Electives I, II and III are chosen from Groups I, II and III respectively

4. Evaluation Scheme: Evaluation scheme of each course shall contain two parts: (i) Continuous Evaluation (CE) and (ii) End Semester Evaluation(ESE). 20% weightage shall be given for CE and 80% weightage shall be given for ESE.

4.1 Continuous Evaluation (CE): CE of a course shall be based on a transparent system consisting of periodic written tests, assignments, seminars and attendance in respect of theory courses and lab skill, record, tests and attendance in respect of practical courses. The weightage assigned to various components for CE for theory and practical are as follows.

Components of CE (Theory)

	Component	% of internal marks
a	Two test papers	40
b	Assignment	20
c	Seminar	20
d	Attendance	20

Components of CE (Practical)

	Component	% of internal marks
a	Two test papers	40
b	Lab skill	20
c	Record	20
d	Attendance	20

4.2 End-Semester Evaluation (ESE): The End Semester Evaluation in Core Courses, Elective Courses, Practical Courses and Project Work is to be conducted by the University

according to the PG Regulation (CCSS-PG), 2011. End-semester Evaluation in practical Courses shall be conducted and evaluated by two examiners - one internal and one external.

Components of ESE (Practical)

	Component	% of marks
a	Procedure	40
b	Solution	40
c	Conclusion/ Interpretation	20

A candidate shall be permitted to appear for the ESE of a Practical Course only if she/he has submitted the Record certified by the concerned Head of the Department.

4.3 Evaluation of Project Work: There shall be Continuous Evaluation and End Semester Evaluation in the case of Project Work. Each candidate has to submit a project report/dissertation by the end of the IV semester. The ESE of the Project Work shall be conducted by two External Examiners, at the end of the Programme only. The components and corresponding weightage of CE and ESE for the evaluation of Project Work shall be as follows.

Internl (Viva) 20% of total	
Components	**% of internal Marks**
Punctuality	20
Use of Data	20
Scheme/Organisation of Report	40
Viva - voce	20

External (80% of total)	
Components	**% of external Marks**
Relevance of the Topic	5
Statements of Objectives	10
Methodology/Referene/Bibliography	15
Presentation of Facts/Figures/ Language style/Diagrams etc.	20
Quality of analysis/Use of statistical tools	15
Findings and recommendations	10
Viva - voce	25

4.4 Indirect Relative Grading: Each core and elective course is evaluated by assigning a total of 75 marks (CE =15, ESE =60) to that course, practical course 50 marks (CE =10, ESE =40) and 125 marks (CE =25, ESE =100) for the project and viva.

4.5 Minimum Grade for a Pass:

A candidate with 40% of aggregate marks and 40% separately for ESE for each course shall be declared to have passed in that course. Those who secure not less than 40 % marks (both ESE and CA put together) for all the courses of a semester shall be declared to have successfully completed the semester. The marks obtained by the candidates for CA in the first appearance shall be retained (irrespective of pass or fail).

The candidates who fail in theory unit shall reappear for theory unit only, and the marks secured by them in practical unit, if passed in practicals, will be retained. A candidate who fails to secure a minimum for a pass in a course will be permitted to write the same examination along with the next batch. For the successful completion of a semester, a candidate should pass all courses.

5. PATTERN OF QUESTIONS

5.1 Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/she shall also submit a detailed scheme of evaluation along with the question paper.

5.2 Question papers for the ESE of Theory Courses shall have three parts: Part A, Part B and Part C. There shall be 8 questions(without omitting any unit of the concerned syllabus) of 2 marks each in Part-A, 8 questions (without omitting any unit of the concerned syllabus)of 4 marks each in Part -B and 8 questions(without omitting any unit of the concerned syllabus) of 7 marks each in part C. The students shall answer all 8 questions from Part A, any 4 questions from Part B and 4 questions from Part C.

6. Assignments: Assignments (weight=1) shall be graded on the basis of their quality. Every student shall submit at least two assignments as an internal component for every course. The Topic for the assignment shall be allotted to the students within six weeks of the commencement of the semester. The teacher shall define the expected quality of an assignment in terms of structure, content, presentation etc. and inform the same to the students. Due weight may be given for punctuality in submission

7. Seminar: Every student shall deliver one seminar as an internal component for every course with a weightage 20% and must be evaluated by the respective Course Teacher in terms of structure, content, presentation, interaction, etc..

8. Test Papers: Every student shall undergo two class tests as an internal component for every Course with a Weightage of 40% each. The weighted average shall be taken for awarding the grade for class tests. Test papers shall be graded by the same procedure adopted

for End Semester Evaluation (ESE) of Theory Courses. To ensure transparency of the evaluation process, the CE grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of ESE. There shall be no provision for improvement of CE grade.

9. Attendance: With regard to attendance (Weight = 1), the following grading scheme shall be followed:

Attendance	Grade
90% and above	A
85-89%	B
80-84%	C
75-79%	D
Less than 75%	E

10. Appearance for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are compulsory and no Grade shall be awarded to a candidate if he/she is absent for CE/ESE or both.

11. For the successful completion of a Programme and award of the degree, a student must pass all Courses satisfying the minimum credit requirement (80) and must complete all Semesters successfully.

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Syllabi of courses offered in Semester I

STA1 C01- Probability Theory-I (4 Credits)

Unit 1 : Class of sets, fields and sigma fields, Borel class and Borel fields in one and higher dimension , Limits of sequence of sets, monotone sequence of sets,. Set function, additive and sub-additive set functions. Measure, axioms of measure, measure space, different types of measures-Counting measure, probability measure, properties, probability space, continuity theorem, extension of probability measure, Caratheodory extension theorem (without proof), Lebesgue- Stieltjes measure.

Unit 2 :Measurable function, Random variables, simple, non-negative and arbitrary random variables, Inverse function and properties. Sequence of random variables and limit. Distribution function, decomposition of distribution function, vector valued random variables and its distribution function, induced probability space of a random variable.

Unit 3: Lebesgue integration and properties, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem, Lebesgue-Stiltjes integral, Expectation and its properties.

Unit 4: Absolute continuity of a measure with respect to another measure, Radon-Nikodym theorem (without proof) and its applications. Lebesgue decomposition theorem, Product space and product measure, Fubini's theorem (without proof), Conditional probability measure and independence events.

Books for study

1. Bartle, R. G.(1966). Elements of Integration
2. Basu, A.K.(1999). Measure Theory and probability, Prentice Hall of India, Pvt. Lt.., New Delhi
3. Bhat, B.R.(1999). Modern probabiltity Teory, Wiley Eastern, New Delhi.
4. Jain, P.K & Gupta.(2011). Lebesgue Measure and Integration, New Age International.

Books for Reference

1. Ash, R. B.(1972). Real Analysis and Probability, Academic Press.
2. Billingsely, P.(1991) Probability and Measure, 2nd edition, John Wiley.
3. Kingmann, J. F. C. & Taylor, S. J. Introduction to Probability and Measure.

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STA1 C02- Mathematical Methods for Statistics - I (4 Credits)

Unit 1. Real number system, open sets, closed sets, limit points of a set, Bolzano Weierstras theorem, Hein-Borel theorem, sequences and their convergence, Cauchy sequences, Limit of functions, continuous functions, convergence of series of functions. Continuity, uniform continuity, differentiability and mean value theorem.

Unit 2. Differentiability of a function, Darboux's theorem, Rolles theorem, Lagrange's mean value theorem, Taylor's theorem for higher order derivatives, Extreme values, indeterminate forms, maxima and minima of functions of several variables, Lagrange's method for constrained optimum.

Unit 3. Riemann-Stieltje's integral, necessary and sufficient condition for integrability, fundamental theorem of integral calculus, convergence of improper integrals, multiple integrals, Laplace transforms.

Unit 4. Functions of complex variables, analytic function, Cauchy-Riemann equations, necessary and sufficient conditions for analyticity, integration of a complex valued function, Cauchy fundamental theorem. Singularity of complex functions, residues and poles, Cauchy residue theorem, evaluation of real definite integrals by contour integration(standard cases only)

Books for Study

1. Churchill, R. V. & Brown, J. W.(1975). Complex Variables and Applications, Mc Graw Hill
2. David V Widder. Avdanced Calculus, Prentice Hall of India
3. Malik, S. C. & Arora, S.(2006). Mathematical Analysis, 2nd edition, New Age International

Books for Reference

1. Apostol, T. M.(2002). Mathematical Analysis, 2nd edition, Addison Wiley
2. Rudin, W.(2007). Real and Complex Analysis, Mc Graw Hill Education (India), Ltd.
3. Spiegel, M. R.(2009) Complex Variables, Tata Mc Graw Hill, New Delhi.

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STA1 C03- Mathematical Methods for Statistics - II(4 Credits)

Unit 1. Linear vector space and sub spaces, dependence and independence, basis and dimensions, orthogonal basis, Gram-Schmidt orthogonalisation, linear transformation and orthogonal transformation, symmetric, orthogonal, and idempotent matrices, rank and inverse of a matrix.

Unit 2 Partition of a Matrix. Generalised inverse and its properties. Computation of G-inverse. Classification of g-inverse. Properties of M-P g-inverse ; Quadratic forms- Definition and classification. Diagonalisation, Characteristic value problem. Reduction of quadratic forms. Derivative of quadratic forms.

Unit 3. Spectral decomposition, numerical determination of characteristic roots, solution of system of linear equations- Test for consistency. Numerical solution of algebraic and transcendental equations- Formula and applications. Acceleration of convergence- Newton Raphson method and Iteration method. Graeffe's root squaring method.

Unit 4. Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples; Solution of linear differential equations with constant coefficients.

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Books for Study

1. Biswas, S. Introduction to the theory of Matrices
2. Mathai,A.M. Linear Algebra Part I,II & III, Centre for Mathematical Sciences
3. Scarborough An Introduction to Numerical mathematics.
4. Malik, S. C. & Arora, S.(2006). Mathematical Analysis, 2nd edition, New Age International
5. ShantiNarayanan, Text book of Matrices
6. Sastry, S. S. Introduction to Methods of Numerical Analysis

Books for Reference

1. Jain,M.K,Iyenkar,S.R.K. & Jain,R.K.(2005). Numerical methods for Scientific and Engineering Computation, 4th edition, John Wiley & Sons Inc., New Jersey
2. Pringle & Rayner, M.. Generalised inverse of matrices with application to Statistics, Griffin, London
3. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wiley & Sons, New York.
4. Apostol, T. M.(2002). Mathematical Analysis, 2nd edition, Addison Wiley

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STA1 C04- Distribution Theory (4 Credits)

Unit1.Discrete distributions: pgf, convolution, distribution of random sum of random variables, factorial moments, simple properties and applications of the following distributions- Power series, Logarithmic series and their particular cases, multinomial, hyper geometric. Generation of random samples from these distributions.

Unit 2.Continuous distributions: Pareto, Lognormal, Logistic, Weibull and Laplace; Convolution of distributions, compound and mixture distributions, functions of random variables and random vectors and transformations, censoring and truncation of distributions. Orthogonal polynomials.

Unit 3. Quadratic forms in normal variables, distribution of quadratic forms, Fisher-Cochran theorem and its applications. Sampling distributions: Joint distributions of mean and variance from normal population, Chi-square, t and F distributions (central and non-central) and their properties and applications.

Unit 4. Standard errors of means, moments and that of a function of statistics in large samples; order statistics, the distributions and properties, asymptotic distribution of sample median and range.

Books for Study

1. Balakrishnan, N. & Rao, C. R.(2003). Hand book of Statistics, Vol. XVI , Elsevier
2. Johnson, Kotz and Balakrishnan.(2000). Distributions in Statistics,Vol. 1,2 & 3, John Wiley
3. Karian, Z. A & Dudewicz, E. J.(2010). Fitting of Statistical distributions with R, Crc Press
4. Rohatgi, V. K.(1976). An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons

Books for Reference

1. Kendall, M.G and Stuart, A.(1977). The Advanced Theory of Statistics, Vol. 1,
2. Ord, J. K.. Families of frequency distributions, Charles Griffin & Co.
3. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wley & Sons.

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STA1 C05- Sampling Theory (4 Credits)

Unit 1. Planning and execution of survey sampling- Sampling and non sampling errors, SRSWOR and SRSWR- Estimation of population mean and variance, estimation of their standard errors, estimation of population proportion and sample size. Quota sampling, systematic sampling- method of selection, estimation of population mean and variance, comparison of systematic sampling with SRS

Unit 2. Stratified sampling- Estimation of population mean and variance, proportional, Neymann and optimum allocations, comparison of stratified sampling with srs and systematic sampling.
Cluster sampling- with equal and unequal cluster size, estimation of their mean and variance Two stage sampling with equal first stage units, estimation of its mean and variance. Concept of double sampling. Multi stage and multi phase sampling.

Unit 3. Sampling with varying probabilities- pps sampling with and without replacement, Midzuno scheme of sampling, ordered and unordered estimators- Desraj's ordered estimator, Horvitz-Thompson and Yates-Grundy estimators. Murthy's unordered estimator.

Unit 4. Ratio and regression estimators, bias of ratio estimator, approximate variance of ratio estimator, comparison of ratio estimator with mean per unit, unbiased ratio estimator. Linear regression estimator, bias of regression estimator, approximate variance of regression estimator, comparison of regression estimator with mean per unit and ratio estimator. Ratio and regression estimation in stratified sampling.

Books for Study

1. Cochran, W. G. (1992).Sampling Techniques , Wiley Eastern, New York
2. Desraj.(1979).Sampling Theory, Tata Mc Graw Hill
3. Parimal Mukopadhyay.(2008). Theory & methods of survey sampling, Prentice Hall of India, New Delhi

Books for Reference

1. Hansen, Hurwitz & Madow.(1993).Sample Survey Methods and Theory
2. Murthy, M. N.. Sampling Theory and Methods
3. Som, K. S. & Som, R. K.(1976). Practical sampling techniques, Crc Press

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Syllabi of courses offered in Semester II

STA2 C06- Probability Theory-II (4 Credits)

Unit 1 : Inequalities involving moments-Holder and Jensen inequalities, Cr-inequality, basic inequality, Markov inequality, Liapounov's inequality. Independence of events, classes of events, Independence of random variables, Kolmogorov's 0-1 law, Borel –Cantelli Lemma. Characteristic function, definition, properties, Inverssion theorem, characteristic function and moments, Taylor's series for characteristic functions, Bochner's theorem (without proof)

Unit 2 :Different modes of convergence- convergence in probability, almost sure convergence, convergence in r^{th} mean, convergence in distribution, relationships among different forms of convergence, Slutsky's theorem, Helly Bray lemma, Continuity theorem on characteristic functions- applications .

Unit 3: Law of large numbers (LLN) , WLLN and SLLN-Khinchin's weak law of large numbers, Kolmogrov's strong law of large numbers I and II , Kolmogorov's three series theorem (without proof), Law of iterated logarithm and Glivenko –Cantelli Lemma (Concepts and statements only)

Unit 4: Central Limit theorem (CLT)- CLT as a generalization of law of large numbers, Lindberg –Levy form, Liapounov's form, Lindberg-Feller form (without proof) Infinite divisible distributions, Definition, elementary properties and examples, Conditional expectation, properties, Martingales

Books for Study

1. Bhat, B.R.(1999). Modern probability theory, Wiley Eastern, New Delhi.
2. Gnedenko, B. V.(2005). The theory of probability, AMS Chelsea Publishing, U. S. A.
3. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wley & Sons.

Books for Reference

1. Ash, R. B.(2008). Basic Probability Theory, Dover Publications, New York.
2. Bellingsely.. Probability Theory
3. Laha, R. G & Rohatgi, V. K.(1979). Probability Theory, John Wiley, New York.

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STA2 C07 - Stochastic Processes (4 Credits)

Unit 1. Introduction to Stochastic Processes, time and state space, classification of stochastic processes, distributions with examples, Kolmogorov consistency theorem (without proof), processes with stationary independent increments, Weak and strong stationary processes,

Time series models, Markov Processes, Martingales, Wiener Processes, Gaussian Processes (definitions and examples).

Unit 2. Markov Chains, random walk and gambler's ruin problem, transition probabilities, stationary transition probabilities, transition probability matrix, n-step transition probabilities, Chapman Kolmogorov equations, classification of states, ergodic chains, stationary distributions, absorption probabilities, occupation times.

Unit 3. Continuous time discrete state space Markov processes, Chapman Kolmogorov equations, Poisson processes, compound Poisson processes, birth and death processes, stationary solution and applications.

Unit 4. Branching processes- discrete time branching processes, offspring distribution and probability of extinction.

Renewal processes, renewal equation, renewal theorems (continuous case only).

Books for Study

1. Bhat, U. N.(2002). Elements of Applied Stochastic Processes, 3rd edition, Wiley Interscience
2. Karlin, S & Taylor, H. E.(1975). A First Course in Stochastic Processes, Academic Press
3. Medhi, J.(2009). Stochastic Processes, New Age International
2. Ross, S. M.(2008). Stochastic Processes, Wiley India Pvt. Ltd.

Books for Reference

1. Cinlar.. Introduction to Stochastic Processes
2. Cox, D. R.(1962). Renewal Theory, Methuen & Co.
3. Doob, J. L.. Stochastic Processes.
4. Feller, W.(1991). An Introduction to Probability Theory and Applications, John Wiley

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STA2 C08- Statistical Inference- I (4 Credits)

Unit 1. The problem of point estimation, desirable properties of an estimator- unbiasedness, consistency, efficiency and sufficiency. factorization theorem. minimal sufficiency, completeness.

Unit 2. Methods of estimation- maximum likelihood, properties of mle. minimum chi-square, modified minimum chi-square, method of moments, method of least squares, method of minimum variance. Comparison of the methods and their characteristics. Principle of Bayes' method of estimation.

Unit 3. Minimum Variance Bound Estimators(M.V.B.E.)- Cramer- Rao bound. Distributions admitting M.V.B. estimators, Battacharya bound. Fisher's information measure in a random sample and statistics. Minimum Variance Unbiased Estimator (M.V.U.E.)- Rao- Blackwell theorem, Lehman- Scheffe theorem, comparison of MVBE and MVUE. CAN and BAN estimators.

Unit 4. Interval Estimation- Confidence interval, shortest confidence and unbiased confidence intervals, central and non central confidence intervals, confidence intervals for large samples, uniformly most shortest confidence interval. Fiducial interval.

Books for Study

1. Lehmann, E.(1983). Theory of Point Estimation, John Wiley, New York.
2. Mood, A. M & Graybill, F. A.(2009). Introduction to the theory of statistics, Tata McGraw Hill.
3. Rohatgi, V. K.(1976). An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons.
4. Kale, B. K.(2005). A First Course on Parametric Inference, 2nd edition, Narosa

Books for Reference

1. Kendall, W. G. & Stuart, A.(1977). The Advanced Theory of Statistics, Vol.2
2. Rao, C. R(2003). Linear Statistical Inference and its Applications, John Wley & Sons
3. Parimal Mukopadhyay.( ). Mathematical Statistics.

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STA2 C09- Design & Analysis of Experiments (4 Credits)

Unit 1. Review of Gauss-Markoff set up, Gauss-Markoff theorem, Principles of experimentation, uniformity of trials. One way and two way classification models. Standard designs- CRD, RBD, LSD and Graeco Latin Square design. Comparison of designs. Construction of orthogonal LSD, missing plot analysis in RBD and LSD.

Unit 2. Factorial experiments- 2^n and 3^n experiments, total and partial confoundings in symmetrical factorial designs. Concept of fractional replication.

Unit 3. Split plot and strip plot designs, BIBD and PBIBD with only two associate classes, intra and inter block analysis of BIBD. Missing plot analysis in BIBD.

Unit 4. Connectedness and orthogonality of designs. ANCOVA in RBD and LSD. Mixed plot analysis. Optimality criteria for experimental design, estimation of residual effects.

Books for Study

1. Das, M. N & Giri, N. C.(2002). Design & Analysis of Experiments, 2nd edition, New Age International Pvt. Ltd., New Delhi.

2. Douglas, G. Montgomery.(1976). Design & Analysis of Experiments, John Wiley & Sons
3. Parimal Mukopadhyaya. Applied Statistics.

Books for Reference

1. Cochran, W.G & Cox, G.M.(1957). Experimental Designs, Wiley International
2. Federer, W. T.(1963). Experimental Design- Theory & Applications
3. Giri, N. Analysis of variance
4. Henry Sheffe.(1999). The Analysis of variance, Wiley Interscience.
5. Joshi, D. D.(1987). Linear estimation & design of experiments, Wiley Eastern Ltd.

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STA2P01**- Practical I(2 Credits)**

The practical is based on the following core courses in the first and second semester:

1. STA1C04: Distribution Theory
2. STA1C05: Sampling Theory
3 STA2C07: Stochastic Processes
4. STA2C08: Statistical Inference I
5. STA2C09: Design & Analysis of Experiments

Practical is to be done using computer. The question paper for the external examination will be set by the external examiners 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.

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Syllabi of courses offered in Semester III

STA3C10- - Regression Methods (4 Credits)

Unit 1. Least square estimation- properties of least square estimates- unbiased estimation of σ^2- distribution theory- maximum likelihood estimation- estimation with linear restriction- design matrix of less than full rank- generalized least square.

Unit 2. 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 3. The straight line- weighted least square for the straight line- polynomials in one variable- piece wise polynomial fitting- polynomial regression in several variables.

Unit 4. Bias- incorrect variance matrix- effect of outliers- diagnosis and remedies: residuals and hat matrix diagonals- non constant variance and serial correlations- departures from normality- detecting and dealing with outliers- diagnosing collinearity, ridge regression and principal component regression.

Books for Study

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

Books for Reference

1. Abraham, B and Ledolter, J(2005). Introduction to Regression Modelling, Duxbury Press
2. Montgomery, D. C, Peck, F. A and Vining, G(2003). Introduction to Linear Regression Analysis, 3rd edition, John Wiley and Sons, New York.
3. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wiley & Sons, New York.
4. Searls, S. R(1997). Linear Models, Wiley, Paper back edition, Wiley Intersciences, New Jersey.
5. Sengupta, D and Jammalamadaka, S. R((2003). Linear Models: An Integrated Approach, World Scientific

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STA3C11- Multivariate Analysis (4 Credits)

Unit 1. Multivariate normal distribution, marginal and conditional distributions, independence, characteristic function, singular normal distribution, additive property, characterization of normal distribution based on linear combination of the vectors.

Unit 2. Estimation of mean vector and covariance matrix, MLE of mean vector and dispersion matrix, distribution of sample mean vector, , inference concerning the mean vector when the dispersion matrix is known for single and two populations. Wishart distribution, characteristic function of Wishart distribution, additive property, generalized variance, h^{th} moment of the generalized variance and distribution of sample generalized variance.

Unit 3. Likelihood Ratio Criterion for testing independence of sets of variates, proportionality of covariance matrix, significance of a mean vector, covariance matrix, equality of mean vectors and covariance matrices, asymptotic distributions of the test statistics (without proof), Hotelling's T^2 and Mahalanobis' D^2 statistics, uses of T^2 and D^2in testing problems, Fisher Behren problem.

Unit 4. Classification problem, classification into one of k multivariate normal populations, Baye's solution, Fisher's discriminant function, principal components: definition and derivation, canonical correlation: definition and derivation, factor analysis.
Principal components, Dimension reduction, Canonical variables and canonical correlation - definition, use, estimation and computation.

Books for Study

1. Anderson, T. W.(2003). An Introduction to Multivariate Statistical Analysis, 3rd edition Wiley.
2. Johnson, R A, Wichern, D. W.(1998). Applied Multivariate Statistical Analysis, Prentice hall.
3. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wley & Sons.

Books for Reference

1. Barbera, G, Tabachnick and Linda, S. Fidell.(2006). Using Multivariate Statistics, 5th edition, Harper & Row
2. Johnson, N.L. & Kotz, S.(2000). Continuous Multivariate Distributions, Wiley-Interscience.
3. Morrison, D. F.(1990). Multivariate Statistical Methods, Mc Graw Hill.
4. Takeuchi, Yanai, H, Mukherjee.( ). The Foundations of Multivariate Analysis

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STA3 C12- Statistical Inference- II (4 Credits)

Unit 1. Problem of testing of hypotheses- The classical & Neymann- Pearson approaches, Parametric & Nonparametric tests. Simple & composite hypotheses, size & power of a test, randomized & non randomized tests. The Neymann Pearson lemma and its generalization. M.P tests & UMP tests, one sided & two sided tests.

Unit 2. UMPU tests- completeness & bounded completeness, Similar regions, Neyman's structure & its applications.Likelihood ratio tests & their properties. Asymptotic distribution of likelihood ratio tests.

Unit 3. Sequential probability ratio tests- O.C & A.S.N functions, properties of SPRT, Wald's identity and its applications. Tests based on Binomial, Poisson & Normal. Ranking and selection procedures.

Unit 4. Non parametric tests- Chi-square tests, Kolmogorov-Smirnov test, Sign test, Signed Rank test, Wald-Wolfowitz run test, Median test, Wilcoxon test, Mann Whitney U-test, one & two sample cases. Nonparametric confidence interval. Kruskal Wallis test and Friedmann test

Books for Study

1. Gibbons, J. D. and Chakraborti, S..(2003). Nonparametric Statistical Inference, 4th edition
2. Kale, B. K.(2005). A First Course on Parametric Inference, 2nd edition, Narosa
3. Rohatgi, V. K.(1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons.
4. Wald.. Sequential Probability Ratio Tests.

Books for Reference

1. Lehmann.E and Romano, J. P.(2010). Testing Statistical Hypotheses, Springer
2. Kendall, M. G. & Stewart, A. The Advanced Theory of Statistics, Vol. 2
3. Mood, A. M.& Graybill, F. A.(2009). Introduction to the theory of statistics, Tata McGraw Hill
4. Rao, C. R(2002). Linear Statistical Inference and its Applications, John Wley & Sons, New York.
5. Siegal.( ). Nonparametric methods
6. Zacks, S. (1971). Theory of Statistical Inference(Probability & Mathematical Statistics), John Wiley & Sons.

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STA3C13 - Time Series Analysis (4 Credits)

Unit 1. 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 smoothing, forecasting based on smoothing, adaptive smoothing.

Unit 2. Detailed study of the stationary processes: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR MA periods.

Unit 3. 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 4. Spectral analysis of weakly stationary process. Herglotzic theorem. Periodogram and correlogram analysis. Introduction to non-linear time series: ARCH and GARCH models.

Books for Study

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

Books for Reference

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

STA3E01- Elective I (4 Credits)

Shall be chosen from the list of electives given under item 3.

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Courses offered in Semester IV

STA 4C14 - Official Statistics (4 Credits)

Unit 1. Introduction to Indian and International Statistical Systems. Role, function and activities of Central and State statistical organizations. Organizations of large scale sample suirvey. Role of National Sample Survey Organization. Central and special data, dissemination systems, scope and contends 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, and balance of payment, cost of living, inflaction, educational and social statistics

Unit 3. Economic development: growth in per capital income and distributive justice indices of development and human development index
National income estimation- product approach, income approach and expenditure approach.

Unit 4. Measuring inequality in incomes: Gini coefficient, Theils measure,
Poverty measurements: Different issues, measures of incidence and intensity
Combined measure: Indices due to Kakwani and Sen

Books for Study

1. Panse, V.G. Estimation of crop yields (FAO)
2. Keyfitz, N. (1997) Applied mathematical Demography- Springer verlag
3. Sen, A (1977), Poverty and Inequality
4. Chubey, P.K. (1995): Poverty Measurements, New Age International

Official Publications

1. Basic Statistics Relating to Indian Economy(CSO) 1990
2. Guide Official Statistics (CSO) 1999
3. Statistical system in India (CSO) 1995
4. Principles and accommodation National Population Census- UNEDCO
5. Family Welfare Year Book. Annual Publications of D/O Family Welfare
6. Monthly Statistics of Foreign Trade in India, DGCIS, Culcutta and other Government Publications
7. CSO(1989) a: National Accounts Statistics –Sources and Methods
8. CSO(1989) b: Statistical System In India
9. UNESCO: Principles For Vital Statistics System, Series M-12

STA4 E02- Elective II (4 Credits)

Shall be chosen from the list of electives given under item 3.

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STA4 E03- Elective III (4 Credits)

Shall be chosen from the list of electives given under item 3.

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STA4 P02 - Practical II (2 Credits)

The practical is based on the following courses.

STA3C10	Regression Methods
STA3C11	Multivariate Analysis
STA3C12	Statistical Inference – II
STA3C13	Time Series Analysis

Practical is to be done using 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.

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STA4Pr **– Project Work (6 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.O.D. of the parent department positively before the deadline suggested in the academic calendar. 100 marks shall be for project work (CE =20, ESE =80).

STA4C15- Viva Voce (2 Credits)

General viva-voce based on all the core and elective papers in the four semesters. The external viva -voce shall be conducted by a board of examiners consisting of at least two external experts appointed by the University. The external viva-voce shall cover all the courses under gone in the two year programme and carries 20 marks for external viva voce.

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Syllabi of Elective Courses

GROUP I

01: Operations Research (4 Credits)

Unit 1. Linear programming problem, simplex method, Big M method, two phase simplex method, duality and degeneracy, revised simplex method, Integer Programming Problem (IPP)- need for IPP, Gomory's cutting plain method method for solving pure IPP.

Unit 2. Non linear programming problem, constrained maxima and minima, Khun-Tucker conditions, quadratic programming problem, the Wolfe's and Beal's methods of solving a quadratic problem. Dynamic programming problem, the recursive method of solution.

Unit 3. Characteristics of inventory systems, deterministic and stochastic inventory models, lead time concepts, EOQ solution, Stochastic inventory models, solution of single period models. (s, S) policies.

Unit 4. Game theory, solution of a game, graphical, dominance and LPP methods. Replacement models, network analysis, CPM and PERT, Monte Carlo Simulation and its applications to inventory and queueing systems.

Books for Study

1. Kanti Swarup, Gupta and Manmohan.(1985). Operations Research, Sultan Chyand & Sons.
2. Rao, S. S.( ). Optimization Theory and Applications, New Age Publishers
3. Taha, H. A.(1992). Operations Research, 5th edition, Mac Millan.

Books for Reference

1. Fabrycky, W. J, Ghare, P. M. and Torgerson, P. E.( ). Applied Operations Research
2. Gross and Harris.(1998). Fundamentals of Queueing Theory, 3rd edition.
3. Hardley, G & Whitin, T. M.( ). Analysis of Inventory Systems, Taruporewala & Sons.
4. Phillips, Ravindran and Solberg.(2007). Operations Research Principles and Practice, Wiley India Pvt. Ltd.

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02: Queuing Theory (4 Credits)

Unit 1. 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 2. Transient behavior of M/M/1 queues, transient behaviour 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 $M^{[y]}/M/1$ model, Erlangian models, $M/E_k/1$ and $E_k/M/1$. A brief discussion of priority queues.

Unit 3. Queueing networks-series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks.

Unit 4. 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 $M/E_k/1$ and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities.

References

1. Bose, S. K.(2002). An Introduction to Queueing Systems, Kluwer Academic/Plenum Publishers, New York.
2. Gross, D. and Harris, C. M.(1985). Fundamentals of Queueing Theory, 2nd Edition, John Wiley and Sons, New York.
3. Kleinrock, L.(1976). Queueing Systems, Vol. 1 & 2, Wiley-Interscience.
4. Ross, S. M.(2007). Introduction to Probability Models, 9th Edition, Academic Press, New York.

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03: 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 or these classes under formation coherent systems, convolution 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 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. Aven, T. and Jensen, U. (1999). Stochastic Models in Reliability, Springer, Verlag, New York, Inc.
2. Bain, L. J. and Engelhardt.(1991). Stochastic Models in Reliability, Springer- Verlag, New York, Inc.
3. Barlow, R. E. and Proschan, F.(1985). Statistical Theory of Reliability and Life Testing.
4. Lawless, J. F.(2003). Statistical Methods for Lifetime (2^{nd} Edition), John Wiley & Sons, Inc., New Jersey.
5. Nelson, W.(1982). Introduction to Reliability Analysis: Probability Models and Statistics Methods, New York, Springer- Verlag.

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GROUP II

04: Econometrics (4 Credits)

Unit 1. The theory of production, variable proportions, returns to scale, producer's equilibrium, homogeneous production functions, Euler's theorem, Cobb-Douglus production function, elasticity of substitution, C.E.S production function.

Unit 2. Simple and multiple linear regression models, assumptions, least square estimation, properties of estimators, confidence intervals and tests of significance. The adjusted coefficient of determination. Regression and analysis of variance. Distributed lag models and

estimation of parameters, Almon and Koyck lag models, non linear regression models, forecasting power of an econometric model.

Unit 3. Econometric problems, autocorrelation, sources and tests for autocorrelation, Durbin-Watson test, estimation of parameters, multi collinearity, sources, tests and estimation, hetroscedasticity, sources, tests and estimation, idea of Ridge regression and properties, application of principal components, errors in variables.

Unit 4. Simultaneous equation models, structural, reduced form and recursive models, the problem of identification, rank and order conditions, identifying restrictions, estimation of simultaneous equations, indirect least squares, instrumental variable technique, two stage least squares, limited information and full information maximum likelihood methods.

Bookd for Study

1. Gujarathi, D. and Sangeetha, S.(2007). Basic Econometrics, Mc Graw Hill
2. Johnston, J.(2009) Econometric Methods, 4th edition, Mc Graw Hill
2. Judge, G. J, Grifiths, W. E & et al.(1985). Theory and Practice of Econometrics, 2nd edition, John Wiley.

Books for Reference

1. Edward Dowling.(2000). Introduction to Mathematical Economics, Shaums Outline Series.
2. Koutsoyiannis.(2000). Theory of Econometrics, Palgrave.
3. Maddala, G. S.(1979). Econometrics, Tata Mc Graw Hill
4. Salvatore Dominic.(1981). Statistics and Econometrics, Shaums Outline Series

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05: Statistical Quality Assurance (4 Credits)

Unit 1. 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 2. Acceptance sampling by variables, sampling plans for single specification limit with known and unknown variance, sampling plans with double specification limits, comparison of sampling plans by variables and attributes, continuous sampling plans I, II, III.

Unit 3. 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. ARI, Economic design of control charts.

Unit 4. 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.

Books for Study.

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

Books for Reference

1. Chin-Knei Chao.(1987). Quality Programming, John Wiley.
2. 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.

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06- Statistical Decision Theory (4 Credits)

Unit 1: 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 2: Prior information- subjective determination of prior density-non- informative priors- maximum entropy priors-the marginal distribution to determine the prior- the ML-II aproach to prior selection. Conjugate priors.

Unit 3 :The posterior distribution-Bayesian inference – Bayesian decision theory- empirical Bayes analysis- hierarchical Bayes analysis- Bayesian robustness. Admissibility of Bayes rules.

Unit 4: Game theory- basic concepts- general techniques for solving games with finite state of nature- the supporting and separating hyperplane theorem. The minimax theorem. Statistical games.

Books for Study

1. Berger, O. J(1985): Statistical decision theory and Bayesian analysis, second edition, Springer- Verlag

Books for Reference

1. Fergusosn T. S(1967). Mathematical Statistics; A decision theoretic approach, Academic Press, New York
2. Lehmann, E. (1983). Theory of Point Estimation, John Wiley, New York.

GROUP III

07: Bio-Statistics (4 Credits)

Unit 1. Functions of survival time, survival distributions and their applications viz. exponential, gamma, weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, chi-square test for uncensored observations). Parametric methods for comparing two survival distributions viz. L.R. test, Cox's F-test.

Unit 2. Type I, Tyep II and progressive or random censoring with biological examples, estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan-Meier methods.

Unit 3. Competing risk theory, indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model. Conditional death density functions.

Unit 4. Basic biological concepts in genetics, Mendel's law, Hardy-Weinberg equilibrium, random mating, distribution of allele frequency(dominant/co-dominant cases), Approach to equilibrium for X-linked genes, natural selection, mutation, genetic drift, equilibrium when both natural selection and mutation are operative, detection and estimation of linkage in heredity.

References

1. Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Cox, D. R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
3. Elandt, R. C. and Johnson(1975). Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
4. Ewens, W. J.(1979). Mathematics of Population Genetics, Springer Verlag.
5. Ewens, W. J. and Grant, G. R.(2001). Statistical Methods in Bio informatics: An Introduction, Springer.
6. Friedman, L. M., Furburg, C. and DeMets, D. L.(1998). Fundamentals of Clinical Trials, Springer Verlag.
7. Gross, A. J. and Clark, V. A.(1975). Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
8. Lee, Elisa, T.(1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
9. Li, C. C.(1976). First Course of Population Genetics, Boxwood Press.
10. Miller, R. G.(1981). Survival Analysis, John Wiley & Sons.

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08: Demography (4 Credits)

Unit 1. Definitions and concepts used in Demography- Interface between Statistics and Demography- Sources of Demographic data: Census,Vital Registration System,Sample surveys. Population Composition and Structure- Age, Sex, Religion, Education, Income, Dependency etc., Population pyramid. Concepts of Fertility, Nuptiality, Mortality, Morbidity, Migration and Urbanisation. Determinants and consequences of population change, population distribution.

Unit 2. Measurement of mortality and morbidity, Force of mortality. Measurement of fertility- TFR, GRR, NRR. Standardisation of rates- Concept of life tables- Various types of life tables- Multiple decrement and multi-state life tables- Working life table- mortality models- model life tables- U.N., Coale&Demeny, Leaderman's system, Brass' Logit system, U.N. tables for developing countries- Stable population models -
database and application- Uses of life table approach in Demography- Birth Interval Analysis.

Unit 3. Structure of population- Lotka's stable population theory: concepts, assumptions and properties. Stationery and quasi-stable population, population momentum, population waves. Population estimation and projection. Population growth- exponential, logistic- different methods of population estimation and projection- Mathematical and component methods.

Unit 4. Stochastic models for population changes- Pure birth and death process- birth, death, migration models- Markov chain- Renewal process

Books for study

1. Henry, S. Shryock and Jacob, S. Siegel (1976). Methods and Materials of Demography, Academic Press, New York.
2. Ramkumar, R. and Gopal, Y. S. (1996). Technical Demography, Wiley Eastern Limited.
3. Srinivasan, K.(1998). Basic Demographic Techniques and Applications; Sage Publications, New Delhi.

Books for Reference

1. Asha, A. Bhende and Tara Kanitkar- Population Studies (5th revised edition), Himalaya Publishing House, New Delhi.
2. Krishnan Namboodiri and C. M. Suchindran (1987). Life table techniques and their applications, Academic Press, London.
3. Saxena, P. C. and Talwar, P. P. (1987). Recent Advances in the Techniques for Demographic Analysis, Himalaya Publishing House.
4. UNDP (2003). Human Development Report.

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09: Lifetime Data Analysis (4 Credits)

Unit 1. 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. Censuring and statistical methods.

Unit 2. The product-limit estimate and its properties. The Nelson-Aalen estimate, interval estimation of survival probabilities, asymptotic properties of estimators, descriptive and diagnostic plots, estimation of hazard function, methods for truncated and interval censored data, life tables.

Unit 3. 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 distribution, likelihood based methods, exact methods under type-2 censoring application to Weibul and extreme value distributions, comparison of distributions.

Unit 4. 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, Generalised Wilcoxon test. A brief discussion on multivariate lifetime models and data.

Books for Study

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

Books for Reference

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

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10: Actuarial Statistics(4 Credits)

Unit 1. Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of 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 benefits through multiple life functions evaluation for special mortality laws.

Unit 2. 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 3. 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, difwrred 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 4. Net Premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semicontinuous 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 differential equations for reserves, commutation functions. Some practical considerations: Premiums that include expenses- general expenses, types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

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 et. al. (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. Relevant Publications of the Actuarial Education Co., 31, Bath Street, Abingdom, Oxfordshire, OX143FF (U.K.).
8. Rolski, T. et. al. (1998). Stochastic Processes for Insurance and Finance, Wiley.
9. Spurgeon, E. T. (1972). Life Contingencies, Cambridge University Press.

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11 - Statistics using SAS (4 Credits)

Unit 1: Basic Concepts in Data Analysis – variables, values, quantitative variables versus classification variables, observational units, scale of measurements, basic approach for research, descriptive versus inferential statistical analysis, hypothesis testing

Introduction to SAS programs – What is SAS?, three types of SAS files; Data input – Inputting questionnaire data versus other types of data, inputting data using the DATALINES statement, inputting a correlation or covariance matrix..

Working with Variables and Observations in SAS study – Manipulating, subsetting, concatenating and merging data.

Unit 2: Simple Descriptive Data Analysis – Introduction, PROC MEANS, creating frequency table with PROC FREQ, PROC PRINT, PROC UNIVARIATE, Test for normality, Stem-and-Leaf plot, skewness.

Analysis of Bivariate Data – Significance tests versus measures of association, levels of measurement, Appropriate statistics, scattergrams with PROC GPLOT, Pearson correlation with PROC CORR, options used with PROC CORR, Spearman correlations with PROC CORR, Chi-square test of independence, Two way classification table, tabular versus raw data, assumptions underlying Pearson correlation coefficient, Spearman correlation coefficient and chi square test of independence

Unit 3 : t-tests – two types of t-test, independent samples t test, independent variable and dependent variable, writing the SAS program, interpreting and summarizing the results. The paired samples t test, paired versus independent samples, problems with the paired samples approach, difference score variable, interpreting and summarizing the results, assumptions underlying the t tests.

Unit 4: One Way ANOVA with One between Subjects Factor – Basics of one way ANOVA, between subjects design, multiple comparison procedures, statistical significance versus the magnitude of the treatment effect, writing the SAS program, interpreting and summarizing the results.

Factorial ANOVA with Two Between Subject Factors – Introduction, Factorial Design Matrix, significant main effects and significant interaction effects, writing the SAS program, interpreting and summarizing the results.

Books for Study

1. Norm O'Rourke, Larry Hatcher and Edward J.Stepanski(2005): Using SAS for Univariate and Multivariate Statistics, SAS Institute Inc. and WIley

Books for Reference

1. Der, G. and Everitt, B.S.(2006). A Handbook of Statistical Analysis Using SAS, CRC Press.

Dr. T. M. Surendranath,
Chairman, B.O.S.(PG) in Statistics.

PATTERN OF QUESTIONS

Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/she shall also submit a detailed scheme of evaluation along with the question paper.

Question papers for the ESE of Theory Courses shall have three parts: Part A, Part B and Part C. There shall be 8 questions(without omitting any unit of the concerned syllabus) of 2 marks each in Part-A, 8 questions (without omitting any unit of the concerned syllabus)of 4 marks each in Part -B and 8 questions(without omitting any unit of the concerned syllabus) of 7 marks each in part C. The students shall answer all 8 questions from Part A, any 4 questions from Part B and 4 questions from Part C. Maximum mark is 60

MODEL QUESTION PAPER

FIRST SEMESTER M.Sc DEGREE EXAMINATION (CBSS)

Branch: Statistics

STA1C01: Course 1.1 - Probability Theory I

Time: 3 Hours Maximum Marks. 60

Part A

(Answer ALL questions, each question carries 2 marks). (8X2 = 16)

1. Distinguish between a field and a sigma field.
2. Define set function and give an example of an additive set function.
3. Define a measurable function and show that if {fn} is a sequence of measurable functions, then lim sup{fn} and lim inf {fn} are also measurable.
4. Define the distribution function of univariate and bivariate random variables.
5. Define Lebesgue integral of a non-negative measurable function.
6. Define expectation of an arbitrary real random variable.
7. State Fubini's theorem and explain its use in probability theory.
8. Explain the terms 'Product space' and 'Product measure'

Part B

(Answer any FOUR questions. each question carries 4 marks) (4X4= 16 marks)

9. Define partition of a set. If $\{A_1, A_2, A_3\}$ is a partition of Ω, then obtain the minimal sigma field generated by this partition.

10. Define probability measure and show that

$$P(A_1 \cap A_2 \cap ..... \cap A_n) \geq \sum_1^n P(A_i) - (n-1)$$

11. Show that inverse mapping preserves all set operations.
12. Show that a random variable induces a probability space.
13. If f and g are Lebesgue integrable show that f + g is also Lebesgue integrable.
14. Explain measure theoretic approach to mathematical expectation and state its properties
15. Define conditional probability measure and show that it obeys the axioms of a probability measure
16. State Fubinis thereon. Explain its importance

Part C

(Answer any FOUR questions. each question carries 7 marks) (4X7= 28 marks)

17. (i) Explain how the limit of an arbitrary sequence of sets is defined and examine the given sequence of sets for convergence. If convergent, derive the limit.

$$A_n = \left(-1 - 1/n, 1 - \frac{1}{2n} \right)$$

(ii) Define a measure. If μ is a finite measure with $\mu(\Omega) = M < \infty$ then show that $\frac{\mu}{M}$ is a probability measure.

18. (i) Define Borel field on R. Show that it is the sigma field generated by the class of intervals of the form (a,b) (a< b), a,b ϵ R.
(ii) Establish the continuity property of probability measure.

19. (i) If $\{X_n\}$ is a sequence of randm variables, then define lim Xn. When will you say that Xn $\rightarrow$ X uniformly.

(ii) Let Y: R $\rightarrow$ R and Y be defined as

$$Y(w) = \begin{cases} 0, \text{ if } w < 5 \\ 1, \text{ if } w \geq 5 \end{cases}$$

Find the sigma field induced by Y.

20. (i) State and prove the Jordan decomposition theorem on distribution functions.
(ii) Let X be a random variable with distribution function

$$F(x) = \begin{cases} 0, x < 0 \\ 1/2, x = 0 \\ 1/2 + x/2, 0 < x < 1 \\ 1, x \geq 1 \end{cases}$$

Decompose F

21. (i) State and prove the Monotone convergence theorem. Let $\{U_n\}$ be a sequence of non-negative measurable functions. Then show that

$$\int \sum_{n=1}^{\infty} U_n = \sum_{n=1}^{\infty} \int U_n$$

22. Let f be a Borel measurable function. When do you say that f is integrable? If $\int f d\mu$ exists and c ϵ R , show that $\int cf d\mu$ exists and is equal to c $\int f d\mu$.

(ii)For a non-negative random variable X with finite expectation, prove that

$$E(X) = \int_0^{\infty} [1 - F(x)] dx$$

where F(x) is the distribution function of X.

23. Define absolute continuity of a measure with respect to another measure and State Radon-Nikodym Theorem. Also explain Radon- Nikodym derivative and prove that it is unique upto sets of p-measure zero.

24. State and prove Lebesgue decomposition theorem.

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MODEL QUESTION PAPER
FIRST SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics
STA1C02: Course 1.2- Mathematical Methods for Statistics I

Time: 3 Hours Maximum Marks. 60

Part A
(Answer ALL questions, each question carries 2 marks). (8X2 = 16)

1. Define closed set. Give an example.
2. What is the kind of discontinuity of the function f(x) = (sin2x)/x ; x $\neq$ 0; = 0; if x = 0 at the origin?
3. Using Lagrange's mean value theorem prove that if f′(x) = 0 for all x ε [a, b], then f(x) is a constant on [a, b].
4. A function f is defined on R by f(x) = x; 0 ≤ x < 1; = 1 ; x ≥ 1. Examine whether the derivative of f(x) at x = 1 exists.
5. Define Beta and Gamma integrals.
6. Give an example of a bounded function which is not Riemann integrable.
7. Define analytic function. Find the domain in which the function f(z) = 1/(z-3) is analytic.
8. Find the poles of the function $f(z) = 1/[(z-1)(z+2)^2]$

Part B
(Answer any FOUR questions. each question carries 4 marks) (4X4= 16 marks)

9. Establish Cauchy's principle of convergewnce of sequence of real numbers.
10. State D'Alembert's Ratio Test. Test the convergence of the infinite series
$\sum_{n=1}^{\alpha} \frac{n^2-1}{n^2+1} x^n$, for x > 0
11. State and prove Rolle's theorem of differential calculus.
12. Define extreme values. Show that the function $f(x, y) = (y-x)^4 + (x-2)^4$ has a minimum at (2, 2)
13. Define Riemann Stieltje's integral. Let f(x) = α(x) = 0 for a ≤ x < c
f(x) = α(x) = 1for c < x ≤ b, f© = 0, and α(x) = 1. Prove or disprove $\int_a^b f(x)d\alpha(x) = 0$
14. Define Laplace transform and give an example. State its properties
15. Show that the function $U = e^{-x}(xsiny – ycosy)$ is harmonic and find its conjugate.
16. State and establish Cauchy Riemann equations satisfied by an analytic function

Part C
(Answer any FOUR questions. each question carries 7 marks) (4X7= 28 marks)

17 Define limit point of a set. Give an example. Also state and prove Bolzano- Weierstrass theorem
18. Define monotonic sequence. Establish the necessary and sufficient condition for the convergence of a monotonic sequence.

19. Explain Lagranges method of multipliers. Find the maximum value of 8xyz subject to the conditions $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1$, x > 0, y > 0, and z > 0

20.(i) Show that a function derivable at a point is necessarily continuous at that point. Is the converse true? Give an example.

(ii) Show that $\frac{x}{1+x} < \log(1+x) < x$ $\forall$ x > 0

21. State and prove a necessary and sufficient condition for Riemann-Stieltje's integrability.

22. (i) State and prove fundamental theorem of integral calculus.
(ii) Show that every continuous function is integrable.

23. State and prove Cauchy's Residue theorem. Using contour integration, evaluate $\int_0^{2\pi}\frac{\sin 3\theta}{5-3\cos\theta}d\theta$

24. (i) Define singularity. Explain different types of singularity of a complex function.
(ii) State and prove Cauchy's fundamental theorem on complex integration.

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MODEL QUESTION PAPER
FIRST SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics
STA1C03: Course 1.3- Mathematical Methods for Statistics II

Time: 3 Hours Maximum Marks. 60

Part A
(Answer ALL questions, each question carries 2 marks). (8X2 = 16)

1. Explain dimension of a vector space
2. Explain idempotent matrix.
3. Distinguish between ordinary inverse and generalized inverse.
4. Define index and signature of the quadratic form
4. Describe bisection method.
6. Distinguish between direct and indirect method of solving the system of linear equations.
7. Define metric space. Give an example
8. Explain compactness.

Part B
(Answer any FOUR questions. each question carries 4 marks) (4X4= 16 marks)

9. Explain vector space and sub space. Give an example for each.
10. Describe the method of finding inverse of a square matrix with an example
11. Explain classification of quadratic forms with an example.
12. Prove that generalized inverse always exist and is not unique
13. Explain spectral decomposition. Give an application of spectral decomposition.
14. Explain Newton Raphson method.
15. Define differential equations. Define degree and order of differential equations and explain linear homogeneous differential equations.
16. Let (X, d) be a metric space. Show that a subset of X is closed if and only if its complement is open.

Part C
(Answer any FOUR questions. each question carries 7 marks) (4X7= 28 marks)

17. Explain linear dependence and independence. Prove that linear dependence and independence in a system of vectors is not changed by scalar multiplication of the vectors by non-zero scalar.

18. Explain basis and orthogonal basis. Also explain the Gram Schmidt orthogonalisation process.

19. Explain diagonalisation of a quadratic form. Prove that if A is a real symmetric matrix, then $P'AP = \Lambda$, where P is an orthogonal matrix and Λ is a diagonal matrix.

20. Explain M-P g-inverse and write its properties. Show that M-P g-inverse is unique

21. Explain system of linear algebraic equations and test of consistency. Also describe Gauss-Seidel method of solving system of linear algebraic equations.

22. Explain iteration method and establish its acceleration of convergence.

23 (i) Show that every closed subset of a compact metric space is compact
(ii) Define connected set. State its properties

24. Show that continuous mapping of a compact metric space is uniformly continuous.

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MODEL QUESTION PAPER
FIRST SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics
STA1C04: Course 1.4-Distribution Theory

Time: 3 Hours Maximum Marks. 60

Part A
(Answer ALL questions, each question carries 2 marks). (8X2 = 16)

1. Define pgf and obtain the pgf of Negative Binomial distribution
2. Define generalized power series distribution and obtain its mgf.
3. Define log normal distribution and obtain its mean
4. A truncated Poisson distribution is given by the mass function, $P(X = x) = e^{-\lambda}\lambda^x/\{(1 - e^{-\lambda}).x!\}$, x = 1, 2, 3, …, find the mean of the distribution.
5. State Fisher- Cochran theorem.
6. Define non central t distribution.
7. Define (i) r^{th} order statistic and (ii) standard error.
8. Derive the standard error of the sample mean

Part B
(Answer any FOUR questions. each question carries 4 marks) (4X4= 16 marks)

9. Let X_1, X_2, X_3, …, X_{k-1} have a multinomian distribution. Find the mgf of the distribution and hence obtain the marginal distribution of X_1

10. If X and Y are independent binomial variates with parameters (n_1, p) and (n_2, p) respectively, show that the conditional distribution of X given X + Y = n is hyper geometric.
11. Describe the method of orthogonal polynomials for fitting an n^{th} degree polynomial
12. Define compound Poisson distribution and obtain its probability mass function
13. Let X_1, X_2, X_3, …, X_n be independent normal variates having same variance and let Q be a quadratic function in these variates. Obtain the characteristic function of Q.
14. Establish the relationship between Chi-square, t and F distributions
15. Derive the asymptotic distribution of sample range.
16 Derive the standard error of the sample correlation coefficient.

Part C
(Answer any FOUR questions. each question carries 7 marks) (4X7= 28 marks)

17. (i) Define hyper geometric distribution. Find the factorial moments of hyper geometric distribution and hence or otherwise derive the mean and variance of distribution

18. Derive the recurrence relation of cumulants of power series distribution. Show that binomial distribution and negative binomial distribution are special cases of power series distributions

19. (i)Define Standard Weibul distribution and obtain its rth raw moment.
(ii) If X_i, i = 1,2,3,…,n are i.i.d.r.v's having Weibul distribution with three parameters, show that the variable $Y = \min(X_1, X_2, \ldots, X_n)$, also has Weibul distribution and identify the parameters.
20. Let X_1, X_2, X_3 denote a random sample of size 3 drawn from the exponential distribution with unit mean, show that $Y_1 = X_1/(X_1 + X_2)$,

$Y_2 = (X_1 + X_2)/(X_1 + X_2 + X_3)$ and $Y_3 = X_1 + X_2 + X_3$ are mutually independent.

21. Define non non central F variate, derive its pdf and obtain the mean. Also deduce the pdf of central F distribution from the pdf of the non central F distribution.

22. State and prove a necessary and sufficient condition for independence of two quadratic forms in n independent normal variates.
23. (i) Define order statistics. Derive the distribution of r^{th} order statistic based on a random sample of size n from a population.
    (ii) Derive the distribution of largest sample in case of uniform $(0, \theta)$ population.
24. (i)Derive the asymptotic distribution of sample median
    (ii) Derive the standard error of sample variance

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MODEL QUESTION PAPER
FIRST SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics
STA1C05: Course 1.5- Sampling Theory

Time: 3 Hours Maximum Marks. 60

Part A
(Answer ALL questions, each question carries 2 marks). (8X2 = 16)

1. What do you mean by non-sampling errors? Describe various sources of non-sampling errors.
2. Distinguish between probability sampling and judgment sampling.
3. Describe a practical situation where stratified random sampling is more appropriate than simple random sampling.
4. Illustrate the method of selecting a cluster sample through an example.
5. Explain sampling with varying probabilities.
6. Explain Lahiri's method of PPS with replacement.
7. Describe characteristics of the Ratio method of estimation.
8. Explain linear regression estimation.

Part B
(Answer any FOUR questions. each question carries 4 marks) (4X4= 16 marks)

9. Show that sample mean is an unbiased estimator of population mean in SRSWOR and find its variance.
10. Describe the method of estimating the sample size in SRSWOR.
11. In stratified random sampling derive an unbiased estimator of population mean. Also find its variance.
12. What is cluster sampling? Describe how you estimate population mean under cluster sampling with equal clusters.
13. Determine an unbiased estimator and find its variance under sampling with varying probabilities with replacement.
14. Explain Midzuno scheme of sampling
15. Show that Ratio estimate $\hat{}$ is unbiased if the correlation coefficient is zero
16. Explain unbiased types of ratio estimator
17.

Part C
(Answer any FOUR questions. each question carries 7 marks) (4X7= 28 marks)

18. Discuss the principal steps involved in the planning and execution of large scale sample surveys.
19. Explain the procedure of selecting a systematic sample and describe its advantages over SRS.
20. Compare the efficiencies of SRS, Proportional and Neyman optimum allocation
21. Explain the advantages of Cluster Sampling. Give the different estimators of population mean under the unequal cluster sampling WOR. Determine the bias of the estimator and find the variance of the estimator.

22. Explain the ordered estimates. Determine unbiased estimator and give the expression for its variance.
23. Explain an unordered estimate. Determine an expression for variance under Yates and Grundy estimate.

24. Determine the Ratio estimators in stratified sampling and find its bias and variance.

25. Determine the bias for regression estimator and find the approximate variance of the estimator.

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MODEL QUESTION PAPER

SECOND SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: STATISTICS

STA2C06: Probability Theory II

Time: 3 Hours Maximum marks: 60

Part A
Answer all questions, each question carries 2 marks (8X2= 16 Marks)

1. State Cr-inequality.
2. Define characteristic function and state its important properties
3. What do you mean by almost sure convergence?
4. State Slutsky's theorem and indicate its importance in Statistical inference
5. When do you say that sequence of random variables obey strong law of large State numbers?
6. State Glivenko –Cantelli Theorem
7. What is central limit problem? Explain?.
8. What are infinitely divisible distributions?

Part B
(Answer any 4 questions. Each question carries 4 marks) (4X4 = 16 Marks)

9. Establish Holder's inequality and hence deduce $|r| \leq 1$, where r is the correlation coefficient

OR

10. State and prove Borel-Cantelli Lemma
11. What do you mean by convergence in probability? Illustrate through an example.

OR

12. State and prove Helly-Bray theorem
13. Explain Kolmogorov's three series Theorem

OR

14.Describe Kolmogrov strong laws of large numbers

15. State Lindberg-Feller form of Central Limit theorem and show that Liapounov's condition implies Lindberg's condition .

OR

16. Let $X_1, X_2, \ldots X_n$ be a sequence of iid standardized variates with 4^{th} order moment exists. Find the limiting distribution of $\sqrt{n}(X_1X_2 + X_3X_4 + \ldots + X_{2n-1}X_{2n}) / (X_1^2 + X_2^2 + \ldots + X_{2n}^2)$

Part C
(Answer any 4 questions. Each question carries 7 marks).(4X7= 28 Marks)

17 (i) State and prove the basic inequality and hence deduce the Markov's inequality.

(ii) Establish Jensen's inequality.

OR

18 State and prove the inversion theorem for characteristic functions.

19. (i) Define convergence in probability and convergence in rth mean.

(ii) Show that $X_n \to 0$ in probability , if and only if $E\left(\frac{|X_n|}{1+|X_n|}\right) \to 0$ as $n \to \infty$

OR

20. (i)Define convergence in distribution.

(ii) State and prove the continuity theorem for characteristic functions

21 Establish Khintchin's WLLN for the iid case

OR

22 (i) Show that the WLLN holds for a sequence of independent random variables $\{X_k\}$ if $\sum_1^n \sigma_k^2 / n^2 \to 0$.

(ii)State the law of iterated logarithms

23 State and prove Liapounov's form of Central limit theorem

OR

24. (i) Define Martingale and give an example.
(ii) Establish Lindberg_levy form of Central limit theorem

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MODEL QUESTION PAPER

SECOND SEMESTER M. Sc DEGREE EXAMINATION (CBSS)

Branch: Statistics

STA2C07: Stochastic Processes

Time: 3 Hours Maximum Marks. 60

Part A

Answer all questions, each question carries 2 marks) (8X2 = 16 marks)

1. Define (i) Markov process and (ii) martingale.
2. Give an example of a covariance stationary process
3. What do you mean by order of a Markov chain?
4. Distinguish between reducible and irreducible Markov chains.
5. Define compound Poisson process.
6. State the properties of Poisson process
7. Define renewal process with an example.
8. Find the probability of extinction corresponding to the offspring distribution $p_0=$ $p_1=0.25$ and $p_2=0.5$.

Part B

Answer any 4 questions. Each question carries 4 marks (4X4 = 16 marks)

9. Stating conditions, establish that Weiner process is a Markov process with independent increments. Is it a Gaussian process?

OR

10. Explain moving average process
11. Derive Chapman- Kolmogrov equations.

OR

12. Describe Gamblers ruin problem. Find the probability of ultimate ruin of the gambler.
13. Define Yule Furry Process. Derive its probability distribution.

OR

14. Establish the relation between Poisson process and binomial distribution

15. State and prove Elementary renewal theorem.

OR

16. Establish the properties of generating functions of a branching process.

Part C
Answer any 4 questions. Each question carries 7marks (4X7 = 28 marks)

17. (i) Classify the stochastic process in terms of nature of its state space and indexing set. Give example for each type.

(ii) Let X_n denote the product of sequence of n i.i.d random variables each with mean one. Examine whether the process $\{ X_n, n\geq 1\}$ fs a martingale or not.

OR

18. (i)Distinguish between strictly stationary and covariance stationary Processes. Describe evolutionary process with an example.
(ii) Show that every stochastic process with independent increments is a Markov process.

19. (i) Define recurrent and transient states. Show that a state i is recurrent iff $\sum P_{ii}^{(n)} = \infty$
(ii) Prove that all states in an equivalent class are either recurrent or transient.

OR

20. Define (i) stationary distribution and (ii) class property and periodicity of a Markov chain. Prove that ergodicity is a necessary and sufficient condition for the existence of stationary distribution in case of an irreducible aperiodic Markov chain.

21. A) (i) Define birth and death process and derive its equations.
(ii) Write short notes on Birth- Immigration process

OR

22. Show that the intervals between successive occurrences of n event are exponential distribution if and only if the number of occurrences of the event in the interval follows a Poisson process.
(ii) Write short notes on time dependent Poisson process.

23. Define Galton- Watson branching process and probability of extinction in a branching process. Obtain the probability of extinction in a branching process when (i) mean number of offsprings is less than or equal to one and (ii) the mean is greater than one.

OR

24. (i) Define renewal function and establish its integral equation.
(ii) Obtain the distribution of total number of progeny in a branching process

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MODEL QUESTION PAPER

SECOND SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics

STA2C08: Statistical Inference- I

Time: 3 Hours Maximum Marks: 60

Part A
(Answer all questions, each question questions 2 marks (8X2 = 16 marks)

1. Define sufficient and complete statistics.
2. Find an unbiased estimator of $e^{-\lambda}$
3. Find the maximum likelihood estimator of θ based on a random sample of size n from Uniform $(0, \theta)$.
4. Define minimum chi square estimator.
5. State Cramer- Rao inequality under regularity conditions.
6. Distinguish between UMVUE and MVBE estimators.
7. Define (i) Confidence set and (ii) Unbiased confidence set.
8. Define pivotal quantity.

Part B
(Answer any 4questions. each question carries 4 marks).(4X4 = 16 marks)

9. State and prove the sufficient conditions for consistency. Is it a necessary condition?

OR

10. Show that the n^{th} order statistic based on a random sample of size n from the population,
$P(X = k) = 1/N,\ k = 1, 2, \ldots, N,$
where N is a positive integer, is a complete sufficient statistic.

11. Estimate the parameters α and β by the method of moments in a Beta (α, β) distribution based on a random sample.

OR

12. A random sample of size n is drawn from the following population,
$f(x, \theta_1, \theta_2) = \theta_1$, if x = 1
$= (1 - \theta_1)/(\theta_2 - 1)$, if x = 2,3,…, θ_2 ;
=0, otherwise,
where $\theta_1 \varepsilon [0,1]$ and $\theta_2 = 2, 3, \ldots$ are unknown parameters. Find the maximum likelihood estimators of θ_1 and θ_2
13. Find the UMVUE of θ based on a random sample from exponential distribution with mean $1/\theta$.

OR

14. Explain CAN and BAN estimators with examples

15. Describe the pivotal quantity method of constructing shortest confidence interval.

OR

16. Explain the procedure of constructing Fiducial interval

Part C

(Answer any 4questions. each question carries 7marks).(4X7= 28marks)

17. (i)State and prove factorization theorem on sufficiency.
(ii)Let $X_1, X_2, \ldots, X_n$ be a random sample from the distribution,
$f(x, \theta) = \exp\{-(x-\theta)\}$; $x > \theta$
$= 0$; otherwise; $-\infty < \theta < \infty$.
Show that $Y_1 = \text{Min}(X_1, X_2, \ldots, X_n)$ is a consistent estimator of θ.

OR

18. (i)Define exponential family of probability distributions. Show that binomial distribution belongs to the exponential family. Give an example of a distribution which does not belong to the exponential family.
(ii)Define consistent estimator. If t_n is a consistent estimator of θ, and φ is any continuous function of θ, show that $\varphi(t_n)$ is a consistent estimator of $\varphi(\theta)$.

19. Explain the method of maximum likelihood. Stating regularity conditions, prove that a consistent solution of the likelihood equation is asymptotically normal.

OR

20. (i) Describe the method of successive approximation to maximum likelihood estimators.
(ii) Write short notes on the method of modified chi square and method of least squares.

21. (i) State and prove Rao-Blackwell theorem.
(ii) Let $X_1, X_2, \ldots, X_n$ be i.i.d. Poisson(λ). Find the UMVUE of λ

OR

22. (i) Establish Battacharya inequality.
(ii) Describe the conditions for equality sign in Cramer- Rao inequality.

23. (i). Find $100(1-\alpha)\%$ shortest confidence interval for the parameter θ of Uniform $(0, \theta)$ based on a random sample.
(ii) Describe a general method of finding pivotal statistic in confidence interval estimation..

OR

24. (i) Obtain $100(1-\alpha)\%$ confidence interval for the parameter θ of exponential distribution, $f(x, \theta) = \theta e^{-\theta x}$; $x \geq 0$, $\theta > 0$; $= 0$, otherwise
(ii) Find UMAU confidence interval of level $1-\alpha$ for the variance of normal population based on a random sample

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MODEL QUESTION PAPER

SECOND SEMESTER M.Sc DEGREE EXAMINATION (CBSS)
Branch: Statistics
STA2C09: Design & Analysis of Experiments

Time: 3 Hours Maximum Marks. 60

Part A

(Answer all questions, each question questions 2 marks (8X2 = 16 marks)

1. Describe the technique of ANOVA
2. Describe Graeco Latin Square design.
3. Distinguish between total and partial confounding.
4. Explain the concept of fractional replication in factorial experiment.
5. Describe PBIBD.
6. Describe split plot design.
7. Define connectedness of a design.
8. Define auxiliary variable and explain its use in design of experiment.

Part B

(Answer any 4 questions. Each question carries 4 marks).(4X4= 16 marks)

9. Explain the principles of experimentation.

OR

10. Describe the efficiency of CRD comparing to RBD.
11. Define factorial experiment. Explain how will you find the main effects and interaction effects in a 2^n experiment.

OR

12. Explain the concept of fractional replication with its importance
13. Establish Fisher's inequality.

OR

14. Explain missing plot analysis in BIBD.
15. Describe the optimality criteria.

OR

16. Describe the estimation of residual effects in ANCOVA

Part C

(Answer any 4 questions. Each question carries 7marks).(4X7= 28 marks)

17. Distinguish between Latin square and Graeco-Latin square designs and briefly explain the analysis of a Graeco-Latin square design.

OR

18. State and prove Gauss-Markov's theorem.
19. Describe the layout of a 2^3 experiment where all the interactions are partially confounded. In such case indicate the degrees of freedom and sum of squares for all the components of the treatment sum of squares. Also prepare the ANOVA table in this case.

OR

20. Describe a 3^2 factorial experiment. Explain Yates procedure of analysis of a 3^2 factorial experiment.
21. What is a BIBD? Explain the intra block analysis of a BIBD.

OR

22. Briefly explain the analysis of a strip plot design.
23. Briefly explain the analysis of covariance in a RBD.

OR

24. Explain the mixed plot technique. How will you conduct the analysis when two observations corresponding to same treatment in different blocks are mixed together?

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