ST. THOMAS' COLLEGE (AUTONOMOUS)

THRISSUR, KERALA – 680001

Affiliated to University of Calicut

Nationally reaccredited with 'A' Grade

VERITAS VOS LIBERABIT

CURRICULUM AND SYLLABUS

FOR

POSTGRADUATE PROGRAMME IN STATISTICS

CHOICE BASED CREDIT AND SEMESTER SYSTEM

(w.e.f. 2020 Admission onwards)

ST. THOMAS COLLEGE (AUTONOMOUS), THRISSUR

OUTCOME BASED EDUCATION

POST GRADUATE PROGRAM OUTCOMES

At the end of Post Graduate Program at St. Thomas College (Autonomous), a student would have:

PO1:	Attained profound **Expertise in Discipline**.
PO2:	Acquired **Ability to function in multidisciplinary Domains**.
PO3:	Attained ability to exercise **Research Intelligence** in investigations and Innovations.
PO4:	Learnt Ethical Principles and be committed to **Professional Ethics**.
PO5:	Incorporated **Self-directed and Life-long Learning**.
PO6:	Obtained Ability to maneuver in diverse contexts with **Global Perspective**.
PO7:	Attained **Maturity to respond to one’s calling**.

Course Code	Type	Course title	Credits	Class hours	Ratio Internsl: External
I SEMESTER (Total Credits: 20)					
MST1C01	Core	Analytical Tools for Statistics – I	4	5	01:04
MST1C02	Core	Analytical Tools for Statistics – II	4	5	01:04
MST1C03	Core	Distribution Theory	4	5	01:04
MST1C04	Core	Probability Theory	4	5	01:04
MST1C05	Core	Statistical Computing – 1	4	5	01:04
MST1A01	Audit	Ability Enhancement Course	4 Credits (Not included in CGPA)		
II SEMESTER (Total Credits: 20)					
MST2C06	Core	Design and Analysis of Experiments	4	5	01:04
MST2C07	Core	Estimation Theory	4	5	01:04
MST2C08	Core	Sampling Theory	4	5	01:04
MST2C09	Core	Testing of Statistical Hypotheses	4	5	01:04
MST2C10	Core	Statistical Computing-II	4	5	01:04
MST2A02	Audit	Professional Competency Course	4 Credits (Not included in CGPA)		
III SEMESTER (Total Credits:20)					
MST3C11	Core	Applied Regression Analysis	4	5	01:04
MST3C12	Core	Stochastic Processes	4	5	01:04
MST3E10	Elective I	Statistical Quality Control	4	5	01:04
MST3E05	Elective II	Lifetime Data Analysis	4	5	01:04
MST3C13	Core	Statistical Computing-III	4	5	01:04
IV SEMESTER (Total Credits: 20)					
MST4C14	Core	Multivariate Analysis	4	5	01:04

MST4E02	Elective III	Time Series Analysis	4	5	01:04
MST4C15	Core	Comprehensive Viva-Voce	8(5+3)	10	01:04
MST4C16	Core	Statistical Computing-IV	4	5	01:04
Total			**80**		

Total credits: 80 (Core -60, Elective-12, Project & External Viva-8)

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

Course Code	Course Title	Credits
01	Operations Research-I	4
02	Time Series Analysis	4
03	Operations Research – II	4
04	Queueing Theory	4
05	Lifetime Data Analysis	4
06	Advanced Distribution Theory	4
07	Statistical Decision Theory	4
08	Reliability Modelling	4
09	Actuarial Statistics	4
10	Statistical Quality Control	4
11	Advanced Probability Theory	4
12	Official Statistics	4
13	Biostatistics	4
14	Econometric Models	4
15	Demographic Techniques	4
16	Stochastic Finance	4
17	Longitudinal Data Analysis	4
18	Data Mining Techniques	4

Evaluation and Grading:

Evaluation: The evaluation scheme for each course shall contain two parts; (a) Internal/Continuous Assessment (CA) and (b) External / End Semester Evaluation (ESE). Of the total, 20% weightage shall be given to internal evaluation / continuous assessment and the remaining 80% to external/ESE and the ratio and weightage between Internal and External is **1:4.** Primary evaluation for Internal and External shall be based on 6 letter grades **(A+, A, B, C, D and E)** with numerical values (Grade Points) of **5, 4, 3, 2, 1 & 0** respectively.

The criteria and percentage of weightage assigned to various components for evaluation are as follows:

(A)Theory and Practical:

Internal Evaluation

(a) Theory :			
Sl.No	**Component**	**Percentage**	**Weightage**
1	Examination /Test	40%	2
2	Seminars / Presentation	20%	1
3	Assignment	20%	1
4	Attendance	20%	1
(b) Practical :			
1	Lab Skill	40%	4
2	Records/viva	30%	3
3	Practical Test	30%	3

The students may be addressed Regional/National needs through their projects/assignments/seminars/field works/specific additional topics etc. Field project/Internships/Industrial Visit/Institutional Visits having atleast three days is mandatory. The evaluation for each course except the audit course shall contain two parts

(a) Internal evaluation :20% weightage

(b) External evaluation: 80% weightage

Both the internal and External evaluation shall be carried out using direct grading system as per the general guidelines of university and regulation of St.ThomasCollege (Autonomous).

Internal evaluation must consist of following components

i). 2 Tests (ii) One seminar (iii) One assignment and (iv) Attendance.

The criteria and percentage of weightage assigned to various components for internal evaluation are as follows:

(a) Theory : (Total weightage -5)			
Sl.No	**Component**	**Percentage**	**Weightage**
1	Examination /Test	40%	**2**
2	Seminars / Presentation	20%	**1**

3	Assignment	20%	**1**
4	Attendance	20%	**1**

Grades shall be given for the internal evaluation are based on the grades A+,A,B,C,D&E with grade points 5,4,3,2, 1 &0 respectively. The overall grades shall be as per the Ten Point scale.

Internal Examination

The average of the two examinations/tests can be used to obtain the letter grades as per the following table

Average %/grade range of 2 tests	**Grade**	**Grade point**
90 - 100% ….**(4.5 to 5)**	**A+**	**5**
75 – 89.99%...**(3.75-4.49)**	**A**	**4**
60 – 74.99%...**(3.0 to 3.74)**	**B**	**3**
40 – 59.99%...**(2 to 2.99)**	**C**	**2**
Below 40% **(Below 2.0)**	**D**	**1**
Absent	**E**	**0**

Letter grades of attendance can be derived as per the following table

Range of attendance	**Grading**	**Grade point**
>=90%	**A+**	**5**
85% >=Attendance<90%	**A**	**4**
80% >=Attendance<85%	**B**	**3**
75% >=Attendance<80%	**C**	**2**
50% >=Attendance<75%	**D**	**1**
<50%	**E**	**0**

External Evaluation

The semester-end examinations in theory courses shall be conducted with question papers set by external experts. The question paper pattern is as follows:

(a) Theory:				
Sl. No	**Type of Questions**	**Individual Weightage**	**Total Weightage**	**Number of questions to be answered**
1	Short Answer type questions	2	2 x 4 = 8	4 out of 7
2	Short essay/ problem solving type	3	3 x 4 = 12	4 out of 7
3	Long Essay type questions	5	5 x 2 = 10	2 out of 4
	Total		**30**	**18**

b) Practical : The end semester evaluation in practical course shall be conducted by both internal and external examiners as per the stipulations in the syllabus. The duration shall be **3 hours** and the total weightage should be **30**.

(B) Project work/Dissertation and External Viva-Voce:

Sl. No	Criteria	% of weightage	Weightage External	Weightage Internal
1	Review of literature, formulation of the problem and defining clearly the objective:	10%	4	1
2	Methodology and description of the techniques used	10%	4	1
3	Addressing Local/Regional/National needs by Industrial visit/Institutional visit/field visit and data collection, Analysis, programming/simulation and discussion of results	20%	8	2
4	Presentation of the report, organization, linguistic style, reference etc	20%	8	2
5	Viva-voce Examinations based	40%	16	4

	on project/dissertation			
Total Weightage		100 %	40	10

There shall be a comprehensive Viva Voce examination based on all courses of the programme with **3 credits,** internal and external being in the ratio 1:4. The Viva-Voce shall be conducted by a board of examiners consisting of at least one external expert and internal examiners.

Programme Specific Outcomes (PSO) of M.Sc Statistics

I. PSO1: Understand and apply mathematical fundamentals of statistical techniques for data analysis.
II. PSO2: Understand and implement the techniques involved in probability and statistical distributions in real life situations.
III. PSO3: Understand and implement statistical sampling and inference techniques in real situations.
IV. PSO4: Carry out stochastic modelling of real life problems.
V. PSO5: Explain and apply the techniques of design of experiments, statistical quality control and life time data analysis in real life situations.
VI. PSO5: Implement the statistical techniques using R and Python softwares.

SYLLABI OF CORE COURSES

SEMESTER- I

MST1C01: ANALYTICAL TOOLS FOR STATISTICS – I (4 Credits, 72 Hours)

CO Statement

I. CO1: Understand and apply the functional properties of Multivariable functions and its applications in statistics
II. CO2: Understand and examine the analyticity of a complex function.
III. CO3: Understand and apply theorems on complex integral.
IV. CO4: Examine types of Singularities and residues
V. CO5: Understand Laplace and Fourier transform and associated results.
VI. CO6: Apply Laplace transform to solve differential equations.

Unit-I-Multivariable Functions

Limits and continuity of multivariable functions. Derivatives, directional derivatives and continuity. Total derivative in terms of partial derivatives, Taylor's theorem. Inverse and implicit functions. Optima of multivariable functions. Method of Lagrangian multipliers, Riemann integral of a multivariable function. **(I: A, B, C) (16 Hours)**

Unit-II-Analytic functions and complex integration

Analytical functions, Harmonic functions, Necessary condition for a function to be analytic, Sufficient condition for a function to be analytic, Polar form of Cauchy- Riemann equation, Construction of analytic function. Complex integral, Cauchy's theorem , Cauchy's integral formula and its generalized form. Poisson integral formula, Morera's theorem.Cauchy's inequality, Liouville's theorem, Taylor's theorem, Laurent's theorem. (**II, III: A, B, C) (20 Hours)**

Unit-III- Singularities and calculus of residues

Zeros of a function, singular point, different types of singularities. Residue at a pole, residue at infinity, Cauchy's residue theorem, Jordan's lemma, Integration around a unit circle. Poles on the real axis, Integration involving many valued function. **(IV: A, B, C) (20 Hours)**

Unit-IV- Laplace transform and Fourier Transform

Laplace transform, Inverse Laplace transform. Applications to differential equations, Infinite Fourier transform, Fourier integral theorem. Different forms of Fourier integral formula, Fourier series. (**V, VI : A, B, C) (16 Hours)**

Text Book

1. **Andre's I. Khuri (1993).** Advanced Calculus with applications in statistics. Wiley & sons (Chapter 7)

2. **Pandey, H.D, Goyal, J. K & Gupta K.P (2003).** Complex variables and integral transforms Pragathi Prakashan, Meerut.

3. **Churchill Ruel.V. (1975).** Complex variables and applications .McGraw Hill.

References

1. **Apostol, T.M. (1974).** Mathematical Analysis, Second edition Narosa Publications, New Delhi.

2. **Malik, S.C &Arora.S (2006).** Mathematical Analysis, second edition, New age international

MST1C02: ANALYTICAL TOOLS FOR STATISTICS – II(4 Credits, 72 Hours)

CO Statement

I. CO1: Understand the basics of linear algebra and examine the linear independence of vectors.
II. CO3: Understand and apply operations on matrices and its properties.
III. CO4: Discuss matrices with special structures and their properties.
IV. CO5: Determine the rank and generalized inverse of a matrix.
V. CO5: Understand and execute the decomposition of a matrix.
VI. CO6: To understand the solution of homogeneous equations and their application in real situations, use of g inverse and classification of quadratic forms

Unit-I- Basics of linear algebra

Definition of vector space, sub spaces, linear dependence and independence, basis and dimensions, direct sum and compliment of a subspace, quotient space, Inner product and orthogonality. (**I, II: A, B) (12 Hours)**

Unit-II- Algebra of Matrices

Linear transformations and matrices, mapping, Rank Nullity theorem, operations on matrices, properties of matrix operations, Matrices with special structures-triangular matrix, idempotent matrix, Nilpotent matrix, symmetric, Hermitian and skew Hermitian matrices, unitary matrix. Row and column space of matrix, inverse of a matrix. Rank of product of matrix, rank factorization of a matrix, rank of a sum and projections, Inverse of a partitioned matrix, Rank of real and complex matrix.(**III, IV: A, B**) **(24Hours)**

Unit-III- Eigen values, spectral representation and singular value decomposition

Cayley-Hamilton theorem, minimal polynomial, eigen values, eigen vectors and eigen spaces, spectral representation of a semi simple matrix, algebraic and geometric multiplicities, Jordan canonical form, spectral representation of a real symmetric, concepts of Hermitian and normal matrices, singular value decomposition. (**V: B) (18 Hours)**

Unit- IV- Linear equations generalized inverses and quadratic forms

Homogenous system, general system, generalized inverse, properties of g-inverse, Moore-Penrose inverse, properties, computation of g-inverse, definition of quadratic forms, classification of quadratic forms, rank and signature, positive definite and non-negative definite matrices, extreme of quadratic forms, simultaneous diagonalisation of matrices. (**VI: A,B**) **(18 Hours)**

Text Books

1. **Ramachandra Rao and Bhimashankaran (1992)**..Linear Algebra, Tata McGraw hill 2**.**
Lewis D.W (1995). Matrix theory, Allied publishers, Bangalore.

3.**Walter Rudin (1976).**Principles of Mathematical Analysis, third edition, McGraw –hill International book company New Delhi.

References

1. **Suddhendu Biswas (1997).** A text book of linear algebra, New age international.

2. **Rao C.R (2002).** Linear statistical inference and its applications, Second edition, John Wiley and Sons, New York.

3. Graybill F.A (1983). Matrices with applications in statistics. Wadsworth Publishing Company, Belmont.

MST1C03: DISTRIBUTION THEORY(4 Credits, 72 Hours)

CO Statement

I. CO1: Understand the behavior of various discrete probability distributions and discuss the characterisation properties of it.
II. CO2: Understand the behavior of various continuous probability distributions and discuss the characterisation properties of it.
III. CO3: Illustrate the origin of the distributions based on the family concepts.
IV. CO4: Understand and apply the terminologies of joint, marginal and conditional distributions.
V. CO5: Understand the fundamentals of sampling distribution.
VI. CO6: Explain and derive Chi square, t, F distributions and their properties.

Unit-1: **Discrete distributions:** Random variables, Moments and Moment generating functions, Probability generating functions, Discrete uniform, Binomial, Poisson, Geometric, Negative binomial, Hyper geometric and Multinomial distributions, Power series distributions**. (I: A, B) (16 Hours)**

Unit-2: **Continuous distributions**: Uniform, Normal, Exponential, Weibull, Pareto, Beta, Gamma, Laplace, Cauchy and Log-normal distributions. Pearsonian system of distributions, location and scale families**. (II,III: A, B, C) (20 Hours)**

Unit-3: Functions of random variables: Joint and marginal distributions, Conditional distributions and independence, Bivariate transformations, Covariance and Correlations, Bivariate normal distributions, Hierarchical models and Mixture distributions, Order statistics. (**IV: A, B, E) (20 Hours)**

Unit-4: **Sampling distributions:** Basic concept of random sampling, Sampling from normal distributions, Properties of sample mean and variance. Chi-square distribution and its applications, t-distribution and its applications. F-distribution- properties and applications. Non-central Chi-square, t, and F- distributions**. (V: A, B, E) (16 Hours)**

Text Books

1. **Rohatgi, V.K. (1976).**Introduction to probability theory and mathematical statistics. John Wiley and sons.

2. **Alexnder Mood, Graybill and Bose (1973)** .Introduction to the Theory of Statistics- McGraw Hill

3. **Parimal Mukhopadhyay (2018).** Mathematical Statistics, Book and Allied Publishers,(Ltd.), Calcutta.

References

1. **Johnson ,N.L.,Kotz.S. and Balakrishnan, N.(1995).** Continuous univariate distributions, Vol.I&Vol.II, John Wiley and Sons, New York.

2. **Johnson ,N.L.,Kotz.S. and Kemp.A.W.(1992).**Univariate Discrete distributions, John Wiley and Sons, New York

3. **Kendall, M. and Stuart, A. (1977).** The Advanced Theory of Statistics Vol I: Distribution Theory, 4th Edition

MST1C04: PROBABILITY THEORY (4 Credits, 72 Hours)

CO Statement

I. CO1: Understanding the idea of sets, random variables and its properties
II. CO2: Understand fundamentals of distribution function and properties of expectation.
III. CO3: Explain the properties of characteristic function, independence of random variables and derive the associated results.
IV. CO4: Explain the convergence of random variables and the related results.
V. CO5: State and prove the inequalities and properties related to law of large numbers
VI. CO6: Explain the proof and applications of central limit theorems.

Unit-I: Sets and classes of events – Sequences of sets and their limits – Fields, Sigma fields, Borel field. Random variables, Sigma fields induced by random variables, Vector random variables, limits of sequence of random variables, Probability space, General Probability space, Induced probability space, Concepts of other measures.**(I: A,B) (16 Hours)**

Unit-II: Distribution functions of random variables. Decomposition of distribution functions, Distribution function of vector random variables, Correspondence theorem, Expectation and moments, Properties of expectations, Moments and inequalities, Characteristic functions, Properties, Inversion theorem, Characteristic functions and moments, Bochner's theorem (No proof required), Independence of classes of events; Independence of random variables; Kolmogorov 0-1 law; Borel 0-1 law.**(II: A,B) (20 Hours)**

Unit-III: Convergence of random variables: Convergence in probability, Convergence almost surely, Convergence in distribution, Convergence in r^{th} mean – their inter-relations- examples and counter-examples. Convergence of distribution functions; Weak convergence, Helly-Bray Lemma and Helly – Bray theorem, Levy continuity theorem. **(II,IV: A,B) (16 Hours)**

Unit- IV: Law of Large Numbers – Kolmogorov inequality, Kolmogorov three series theorem; Weak law of large numbers (both IID and Non-IID cases). Strong Law of large numbers (Law of iterated logarithm not included), Central Limit Theorem(CLT),Lindeberg-Levy theorem, Liapounov form of CLT. Lindeberg-Feller CLT (no proof required). Association between Liapounov's condition and Lindeberg conditions; Simple applications of CLT. (**V, VI: A,B,C,D**) **(20 Hours)**

Text books

1**. B.R Bhat (1999).** Modern Probability theory, Wiley Eastern

2. **Laha & Rohatgi (1979).** Probability theory, Wiley New York

3. **Parimal Mukhopadhyay (2018).** Mathematical Statistics, Book and Allied Publishers,(Ltd.), Calcutta.

References

1. **Patrick Billingsley(1995).** Probability and measure, Wiley New York

2. **Galambos (1988).** Advanced probability theory, Marcel Dekker, New York.

ST1C05: STATISTICAL COMPUTING-I (4 Credits, 72 Hours)

Teaching scheme: 5 hours practical per week.

Statistical Computing-I is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the following TWO courses of the first semester.

1. MST1C02: Analytical Tools for Statistics – II

2. MST1C03: Distribution theory

Practical is to be done using R or Python Programming. At least five statistical data oriented/supported problems should be done from each course. Each student shall maintain practical Record and the same shall be submitted for verification at the time of external examination. Students are expected to acquire working knowledge of the statistical packages like EXCEL.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the HoDs of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

SEMESTER II

MST2C06: DESIGN AND ANALYSIS OF EXPERIMENTS(4 Credits, 72 Hours)

<u>CO Statement</u>

I. CO1: Understand the basic principles of experimentation and apply complete block designs.
II. CO2: Discuss analysis of covariance and analysis of experiments with missing observations
III. CO3: Explain the concepts and applications of incomplete block designs
IV. CO4: Understand and apply factorial and fractional factorial designs to take decisions in real scenario.

V. CO5: Understand the concepts of split plot design and strip plot design.

VI. CO6: Understand the fundamentals of Response surface designs, orthogonality and rotatability.

Unit-I: Randomization, Replication and local control, One way and two way classifications with equal and unequal number of observations per cell with and without interaction, Fixed effects and Random effects model. Model adequacy checking, CRD, RBD and Latin Square designs, Analysis of experiments with missing observations, Efficiency, Analysis of co-variance for completely randomized and randomized block designs. **(I: A, B) (20 Hours)**

Unit-II: Incomplete Block Designs: Balanced Incomplete Block designs, Construction of BIB Designs, Analysis with recovery of inter-block information and intra-block information. Partially balanced incomplete block designs, Analysis of partially balanced incomplete block designs with two associate classes, Lattice designs. **(II: A, B) (20 Hours)**

Unit-III: 2^n Factorial experiments. Analysis of 2^n factorial experiments. Total confounding of 2^n designs in 2^n blocks. Partial confounding in2^n blocks. Fractional factorial designs, Resolution of a design, 3^n factorial designs. Concepts of Split plot design and strip plot design. **(III, IV: A,B, C, D) (16 Hours)**

Unit-IV: Response surface designs, Orthogonality, Rotatability blocking and analysis - Method of Steepest accent, Models properties and Analysis. **(V, VI: A, B, C, D) (16 Hours)**

Text Books

1. **Montgomery D C (2001).** Design and Analysis of Experiments, John Wiley.

2. **Das M N and Giri N C (1979).** Design and Analysis of Experiments, second edition, Wiley.

3. **Hinkleman and Kempthrone C** (1994). Design and Analysis of Experiments Volume I, John Wiley.

Reference Books:

1. **Joshi D.D. (1987).** Linear Estimation and Design of Experiments, Wiley Eastern.

2. **Chakrabarti, M.C. (1964).** Design of experiments, ISI, Calcutta.
3. **Experimental Design:** Theory and Applications, Walter T Federer.

MST2C07: ESTIMATION THEORY(4 Credits, 72 Hours)

CO Statement

I. CO1: Understand sufficiency of estimators and related results.
II. CO2: Describe Exponential and Pitman family of distributions.
III. CO3: Understand unbiasedness of estimators and related results.
IV. CO4: Understand consistency of estimators and related results.
V. CO5: Explain and apply methods of estimation.
VI. CO6: Understand the concepts of interval estimation and classify confidence intervals.

Unit-I: Sufficient statistics and minimum variance unbiased estimators

Sufficient statistics, Factorisation theorem for sufficiency, Joint sufficient statistics, Exponential family, Pitman family, Minimal sufficient statistics (MSS). Criteria to find the MSS, Ancillary statistics, Complete statistics, Basu's theorem, Unbiasedness, Best Linear Unbiased estimator(BLUE),Minimum variance unbiased estimator(MVUE),Rao-Blackwell theorem, Lehman- Scheffe theorem, Necessary and sufficient condition for MVUE, Fisher Information, Cramer Rao inequality and its applications. (**I, II, III : A, B**) **(20 Hours)**

Unit-II: Consistent estimator and Consistent asymptotically normal estimators

Consistent estimator, Invariance property of consistent estimator, Method of moments-method of percentiles to determine consistent estimators, Choosing between Consistent estimators. CAN estimators. (**IV: A, B**) **(16 Hours)**

Unit-III: Methods of estimation

Method of moments-method of percentiles-method of maximum likelihood-MLE in exponential family-Cramer family, Cramer Huzurbazar Theorem, Solution of likelihood equations-Bayesian method of estimation-Prior information-Loss functions (squared error absolute error and zero-one loss functions) – Posterior distribution-estimators under the above loss functions.(**V: A, B) (20 Hours)**

Unit-IV: Interval estimation Definition - Shortest expected length confidence interval-large sample confidence intervals-unbiased confidence intervals-examples-Bayesian and Fiducial intervals.(**VI: A, B**) **(16 Hours)**

Text books

1. **Kale,B.K** .(2005)..A first course in parametric inference, Second Edition, Narosa Publishing House, New Delhi.

2. **George Casella and Roger L Berger** (2002). Statistical inference, Second Edition, Duxbury, Australia.

Reference books

1. **Lehmann, E.L(1983).** Theory of point estimation, John Wiley and sons, New York.

2. **Rohatgi, V.K(1976).** An introduction to Probability Theory and Mathematical Statistics, John Wiley and sons, New York.

3. **Rohatgi, V.K (1984).** Statistical Inference, John Wiley and sons, New York.

4. **Rao, C.R (2002).** Linear Statistical Inference and its applications, Second Edition, John Wiley and sons, New York.

MST2C08: SAMPLING THEORY(4 Credits, 72 Hours)

CO Statement

I. CO1: Recollecting and expanding the knowledge about the census and sampling procedures
II. CO2: Understand and apply Simple random sampling, Stratified sampling, Systematic sampling and cluster sampling methods.
III. CO3: Carry out the estimation of population mean, population total and their variances using Simple random sampling, Stratified sampling, Systematic sampling and cluster sampling methods
IV. CO4: Apply and compare Ratio method and Regression method for estimating population total and mean.
V. CO5: Estimate the population total, population mean and their variances using probability proportions to size sampling with and without replacement.
VI. CO6: Understand and apply multi stage and multiphase sampling methods.

Unit-I: Census and Sampling-Basic concepts, probability sampling and non probability sampling, simple random sampling with and without replacement- estimation of population mean and total-estimation of sample size- estimation of proportions. Systematic sampling- linear and circular systematic sampling- estimation of mean and its variance- estimation of mean in populations with linear and periodic trends. (**I, II:A, B, C**) **(16 Hours)**

Unit-II: Stratification and stratified random sampling. Optimum allocations , comparisons of variance under various allocations. Auxiliary variable techniques. Ratio method of estimation-estimation of ratio, mean and total. Bias and relative bias of ratio estimator. Mean square error of ratio estimator. Unbiased ratio type estimator. Regression methods of estimation. Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population. (**III: A, B, C**) **(20 Hours)**

Unit-III: Varying probability sampling-pps sampling with and without replacements. Des- Raj ordered estimators, Murthy's unordered estimator, Horvitz-Thompson estimators, Yates and Grundy forms of variance and its estimators, Zen-Midzuno scheme of sampling, πPS sampling. (**IV:A, B, C**) **(20 Hours)**

Unit-IV: Cluster sampling with equal and unequal clusters. Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling. Multi stage and multiphase sampling. Non-sampling errors. (**V,VI: A, B**) **(16 Hours)**

Text books / References

1. **Cochran W.G (1992):** Sampling Techniques, Wiley Eastern, New York.

2. **D. Singh and F.S. Chowdhary (1986):**Theory and Analysis of Sample Survey Design**,** Wiley Eastern (New Age International), New Delhi.

3. **P.V.Sukhatme**et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

4. **Des Raj (1976):** Sampling Theory. McGraw Hill

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

MST2C09: TESTING OF STATISTICAL HYPOTHESES(4 Credits, 72 Hours)

CO Statement

I. CO1: Recall the fundamentals of testing of hypotheses and understand most powerful tests.
II. CO2: Understand UMP unbiased test for multi parameter case and explain the construction of α-similar tests with Neyman structure.
III. CO3: Understand the concept of locally most powerful tests, Likelihood ratio tests and Bayesian tests.
IV. CO4: Understand and apply single sample non parametric tests.
V. CO5: Understand and apply two sample non parametric tests.
VI. CO6: Understand the fundamentals of sequential probability ratio test, Operating characteristics and Average sample number.

Unit-I: Tests of hypotheses & Most Powerful Tests: Simple versus simple hypothesis testing problem –Error probabilities, p-value and choice of level of significance – Most powerful tests – Neyman Pearson Lemma – Generalized Neyman–Pearson Lemma, One-sided UMP tests, two- sided UMP tests and UMP unbiased tests. (I:**A, B,C,D**) **(16 Hours)**

Unit-II:UMP test for multi-parameter case: UMP unbiased test, α-similar tests and α-similar tests with Neyman structure, construction of α-similar tests with Neyman structure. Principle of invariance in testing of hypotheses, locally most powerful tests – Likelihood ratio tests – Bayesian tests. **(II,III:B,C,D,E) (20 Hours)**

Unit-III: Non-parametric Tests: Single sample tests – testing goodness of fit, Chi-square tests- Kolmogorov– Smirnov test – sign test – Wilcoxon signed rank test. Two sample tests – the chi-square test for homogeneity – Kolmogorov – Smirnov test; the median test – Mann- Whitney-Wilcoxon test - Test for independence – Kendall's tau – Spearman's rank correlation coefficient – robustness. **(IV,V:B,C,D,E) (16 Hours)**

Unit-IV: Sequential Tests: Some fundamental ideas of sequential sampling – Sequential Probability Ratio Test (SPRT) – important properties, termination of SPRT – the fundamental identity of SPRT – Operating Characteristic (OC) function and Average Sample Number (ASN) of SPRT – Developing SPRT for different problems.**(VI:B,C) (20 Hours)**

Text books

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

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

3. **Manojkumar Srivastava and Namita Srivstava(2009).** Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.

Reference books

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

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

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

4. **Lehman, E.L. and Romano, Joseph P.(2005).** Testing Statistical Hypotheses. Third Edition, Springer, New-York.

MST2C10: STATISTICAL COMPUTING-II(4 Credits, 72 Hours)

Teaching scheme: 5 hours practical per week.

Statistical Computing-II is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the following FOUR courses of the second semester.

1.MST2C06: Design and Analysis of Experiments

2.MST2C07: Estimation Theory

3.MST2C08: Sampling Theory

4.MST2C09: Testing of Statistical Hypotheses

Practical is to be done by using R & Python. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the HoDs of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

SEMESTER III

MST3C11: APPLIED REGRESSION ANALYSIS(4 Credits, 72 Hours)

CO Statement

I. CO1: Illustrate the concept of linear regression model.
II. CO2: Estimation and testing the significance of regression parameters and explain properties estimators.
III. CO3: Check the model adequacy of regression models using residual analysis.
IV. CO4: Discuss polynomial, step-wise and non-parametric regression models.
V. CO5: explain logistic and Poisson regression models for binary and count data and estimate their parameters.
VI. CO6: Discuss generalized linear models and estimation of its parameters.

Unit-I: Linear Regression Model, Least squares estimation, Gauss Markov Theorem, Properties of the estimates, Distribution Theory, Maximum likelihood estimation, Estimation with linear restrictions, Generalised least squares; Hypothesis testing - likelihood ratio test, F-test; Confidence intervals. **(I,II: A,B,C,D,E) (16 Hours)**

Unit-II: Residual analysis, Departures from underlying assumptions, Effect of outliers, Collinearity, Non-constant variance and serial correlation, Departures from normality, Diagnostics and remedies. **(III : A, B,C,D,E,F) (20 Hours)**

Unit-III: Polynomial regression in one and several variables, Orthogonal polynomials, Indicator variables, Subset selection of explanatory variables, stepwise regression and Mallows Cp -statistics, Introduction to non-parametric regression. **(IV: A, B,C,D) (16 Hours)**

Unit-IV: Introduction to nonlinear regression, Least squares in the nonlinear case and estimation of parameters, Models for binary response variables, estimation and diagnosis methods for logistic and Poisson regressions. Prediction and residual analysis, Generalized Linear Models – estimation and diagnostics. **(V, VI: B,C,D,E) (20 Hours)**

Text Books

1. **Seber, A.F. and Lee, A.J. (2003).** Linear Regression Analysis, John Wiley, Relevant sections from chapters 3, 4, 5, 6, 7, 9, 10.

2. **Montegomery, D.C., Peck, E.A. and Vining, G.G. (2001).** Introduction to Regression Analysis, Third edition. Wiley.

3. **B. Abraham and Ledotter, J. (1983).** Statistical Methods for Forecasting, John Wiley & Sons.

Reference Books

1. **Searle, S.R. (1971).** Linear models, John Wiley & Sons, Inc.

2. **N. Draper and H. Smith (1986).** Applied Regression Analysis – John Wiley & Sons.

3. **Fox, J. (1984)**. Linear Statistical Models and Related methods, John Wiley,

4. **Christensen, R. (2001).** Advanced Linear Modelling

MST3C12: STOCHASTIC PROCESSES (4 Credits, 72 Hours)<u>**CO Statement**</u>

I. CO1: Recollecting the basic concepts of random variables and conditional probabilities.
II. CO2: Understand the fundamentals of Markov process and classification of states.
III. CO3: Explore inter arrival time and waiting time distributions and their properties.
IV. CO4: Understand generalized Poisson process and their properties.
V. CO5: Understand the concept and applications of renewal process.
VI. CO6: Understand the basic characteristics of queues and the properties of Brownian motion.

Unit-I: Concept of Stochastic processes, examples, Specifications; Markov chains- Chapman Kolmogorov equations – classification of states – limiting probabilities; Gamblers ruin problem and Random Walk – Mean time spent in transient states – Branching processes (discrete time), Hidden Markov chains. (**I, II :A,B,C**) **(16 Hours)**

Unit-II: Exponential distribution – counting process – inter arrival time and waiting time distributions. Properties of Poisson processes – Conditional distribution of arrival times. Generalization of Poisson processes – non-homogenous Poisson process, compound Poisson process, conditional mixed Poisson process. Continuous time Markov Chains – Birth and death processes – transition probability function-limiting probabilities. (**III, IV:A,B,C,D**) **(20Hours)**

Unit-III: Renewal processes-limit theorems and their applications. Renewal reward process. Regenerative processes, Semi-Markov process. The inspection paradox, Insurers ruin problem. (**V:A, B,C, D**) **(16 Hours)**

Unit-IV: Basic characteristics of queues – Markovian models – network of queues. The M/M/I, M/M/C, M/M/1/K, M/M/C/K models, Multi server queues. Brownian motion Process – hitting time – Maximum variable – variations on Brownian motion – Pricing stock options – Gaussian processes – stationary and weakly stationary processes. (V**I: A, B,C**) **(20 Hours)**

Text Books

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

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

References

1. **Karlin, S. and Taylor, H.M. (1975).** A First Course in Stochastic Processes. Second Edition Academic Press. New-York.

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

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

MST3C13: STATISTICAL COMPUTING-III (4 Credits, 72 Hours)

Teaching scheme: 5 hours practical per week.

Statistical Computing-III is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the following THREE courses of the third semester.

1. MST3C11: Applied Regression Analysis

2. MST3E--: Elective -I

3. MST3E--: Elective -II

Practical is to be done by using R & Python. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the H/Ds of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

SEMESTER IV

MST4C14: MULTIVARIATE ANALYSIS (4 Credits, 72 Hours)

CO Statement

I. CO1: Understand the probability functions and their properties of multivariate random variable.

II. CO2: Understand the independence and probability distributions of quadratic and linear forms.

III. CO3: Compute the MLE estimates of the parameters of multivariate normal distribution and determine their sampling distributions.
IV. CO4: Discuss Wishart's distribution and its properties
V. CO5: Describe the testing problems in connection with multivariate normal distribution.
VI. CO6: Illustrate and apply the techniques of Classification, principal component analysis and factor analysis.

Unit-I: Multivariate Normal Distribution – Definition and properties, conditional distribution, marginal distribution. Independence of a linear form and quadratic form, independence of two quadratic forms, distribution of quadratic form of a multivariate vector. Partial and multiple correlation coefficients, partial regression coefficients, Partial regression coefficient. **(I,II : A,B,C) (16 Hours)**

Unit-II: Estimation of mean vector and covariance vector – Maximum likelihood estimation of the mean vector and dispersion matrix. The distribution of sample mean vector, inference concerning the mean vector when the dispersion matrix is known for single and two populations. Distribution of simple, partial and multiple (null-case only) correlation coefficients; canonical correlation. Wishart distribution – properties – generalized variance. **(III, IV : B,C) (20 Hours)**

Unit-III: Testing Problems – Mahalanobis D^2 and Hotelling's T^2 Statistics, Likelihood ratio tests – Testing the equality of mean vector, equality of dispersion matrices, testing the independence of sub vectors, Sphericity test. **(V: A, B, C) (16 Hours)**

Unit-IV: The problem of classification – classification of one of two multivariate normal population when the parameters are known and unknown. Extension of this to several multivariate normal populations. Population principal components – Summarizing sample variation by principal components – Iterative procedure to calculate sample principal components; Factor analysis. **(VI: A, B,C) (20 Hours)**

Text Books

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

2. **Johnson, R.A. and Wichern, D.W. (2001).** Applied multivariate statistical analysis, 3rd Edn., Prentice Hall of India, New Delhi.

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

References

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

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

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

4. **Morrison, D.F. (1976).** Multivariate statistical methods, McGraw Hill, New York.

MST4C15: PROJECT/DISSERTATION AND COMPREHENSIVE VIVA-VOCE (8 Credits) ***[5 credits for Project/Dissertation and 3 credits for Comprehensive Viva-Voce]***

In partial fulfilment of the M.Sc. programme, during the fourth semester each student has to undertake a project work in a selected area of interest under a supervisor in the department. The topic could be a theoretical work or data analysis type. At the end of the fourth semester the student shall prepare a **report/dissertation** which summarizes the project work and submit to the H/D of the parent department positively before the deadline suggested in the Academic calendar. The project/ dissertation is of **5 credits** for which the following evaluation will be followed:

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

1. Review of literature, formulation of the problem and defining clearly the objective: 10%
2. Methodology and description of the techniques used: 10%
3. Addressing Local/Regional/National needs by Industrial visit/Institutional visit/field visit and data collection, Analysis, programming/simulation and discussion of results: 20%
4. Presentation of the report, organization, linguistic style, reference etc.: 20%
5. Viva-voce examinations based on project/dissertation: 40%.

There shall be a comprehensive Viva Voce examination based on all courses of the programme with 3 credits, internal and external being in the ratio 1:4. The Viva-Voce shall be conducted by a board of examiners consisting of at least one external expert and internal examiner.

MST4C16: STATISTICAL COMPUTING-IV **(4 Credits)**

Teaching scheme: 5 hours practical per week.

Statistical Computing-IV is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the following TWO courses of the fourth semester.

1. MST4C14: Multivariate Analysis

2. MST4E--: Elective -III

Practical is to be done by using R & Python. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the H/Ds of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

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SYLLABI OF ELECTIVE COURSES

E01: Operations Research-I (4 Credits, 72 Hours)

CO Statement:

I. CO1: Discuss the concept of Operations Research.
II. CO2: Understand and apply linear programming problem to solve real life problems.
III. CO3: Understand and apply the transportation and assignment problems to solve real life problems.
IV. CO4: Discuss sensitivity analysis and parametric programming.
V. CO5: Understand integer programming problems.
VI. CO6: Explain game theory and apply it in real life problems.

Unit-I: Operations Research.-definition and scope, Linear programming, simplex method, artificial basis techniques, two phase simplex method, Big-M method, duality concepts, duality theorems, dual simplex methods. **(I, II: A, B, C) (24 Hours)**

Unit-II: Transportation and assignment problems, sensitivity analysis, parametric programming. + Sequencing and Scheduling problems-2 machine n-Job and 3- machine n-Job Problems. (III: A, B) **(24 Hours)**

Unit-III: Integer programming: Cutting plane methods, branch and bound technique, application of zero – one programming. (**V: A, B**) **(12 Hours)**

Unit-IV: Game theory: two person zero sum games, minimax theorem, game problem as a linear programming problem. Co-operative and competition games. (VI: A, B, C) **(12 Hours)**

Text Book

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

References

1. **Hadley, G. (1964).** Linear Programming, Oxford & IBH Publishing Co, New Delhi.

2. **Taha. H.A. (1982).** Operation Research, An Instruction, Macmillan.

3. **Hiller FS. And Lieberman, G.J. (1995).** Introduction to Operations Research, McGraw Hill

4. **Kanti Swamp, Gupta, P.K and Manmohan.(1999).** Operations Research, Sultan Chand & Sons.

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E02: Time Series Analysis (4 Credits, 72 Hours)

CO Statement

I. CO1: Discuss the fundamentals and components of time series.
II. CO2: Describe applications and methods of smoothing.
III. CO3: Discuss time series models and determine suitable models.
IV. CO4: Estimate the parameters of ARMA models and apply these models for forecasting.
V. CO5: Apply time series models using statistical packages.
VI. CO6: Explain spectral analysis of weakly stationary process describe non-linear time Series models.

Unit-I: Motivation, Time series as a discrete parameter stochastic process, Auto – Covariance, Auto-Correlation and spectral density and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, Holt – Winter smoothing, forecasting based on smoothing, Adaptive smoothing. **(I, II: A, B, C) (24 Hours)**

Unit-II: Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR / MA periods. (III: A, B) **(12 Hours)**

Unit-III: Estimation of ARMA models: Yule – Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory, Residual analysis and diagnostic checking. Forecasting using ARIMA models, Use of computer packages like SPSS. (**V: A, B**) **(24 Hours)**

Unit-IV: Spectral analysis of weakly stationary process. Herglotzic Theorem. Periodogram and correlogram analysis. Introduction to non-linear time Series: ARCH and GARCH models. (VI: A, B, C) **(12 Hours)**

Text Books

1. **Box G.E.P and Jenkins G.M. (1970).** Time Series Analysis, Forecasting and Control. Holden-Day

2. **Brockwell P.J. and Davis R.A. (1987).** Time Series: Theory and Methods, Springer – Verlag.

3. **Abraham B and Ledolter J.C. (1983).** Statistical Methods for Forecasting, Wiley

References

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, Charles Griffin

4. **K.Tanaka (1996).** Time Series Analysis – Wiley Series.

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E03: Operations Research-II (4 Credits, 72 Hours)

CO Statement:

I. CO1: Discuss the Non linear programming problems and methods to solve the problems.
II. CO2: Understand and solve quadratic programming problem.
III. CO3: Explain Dynamic and Geometric programming.
IV. CO4: Discuss inventory management, deterministic and probability models.
V. CO5: Understand Replacement models.
VI. CO6: Understand simulation modeling and random number generation

Unit-I. Non-linear programming, Lagrangian function, saddle point, Kuhn-Tucker Theorem, Kuhn-Tucker conditions, Quadratic programming, Wolfe's algorithm for solving quadratic programming problem. **(16 Hours)**

Unit-II. Dynamic and Geometric programming: A minimum path problem, single additive constraint, additively separable return; single multiplicative constraint, additively separable return; single additive constraint, multiplicatively separable return, computational economy in DP. Concept and examples of Geometric programming. **(20 Hours)**

Unit-III. Inventory management; Deterministic models, the classical economic order quantity, nonzero lead time, the EOQ with shortages allowed, the production lot-size model. Probabilistic models.the newsboy problem, a lot size. reorder point model. **(20Hours)**

Unit-IV. Replacement models; capital equipment that deteriorates with time, Items that fail completely, mortality theorem, staffing problems, block and age replacement policies. Simulation modeling: Monte Carlo simulation, sampling from probability distributions. Inverse method, convolution method, acceptance-rejection methods, generation of random numbers, Mechanics of discrete simulation. **(16 Hours)**

Text Books

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

2. **M.Sasieni, A.Yaspan and L.Friendman(1959).** Operations Research; Methods and Problems, Wiley, New York.

3. **Hamdy A. Taha (1997).** Operations Research – An Introduction, Prentice-Hall Inc., New Jersey.

4. **Ravindran, Philips and Solberg (1987).** Operations Research- Principles and Practice, John Wiley & Sons, New York.

References

1. **Sharma, J.K. (2003).** Operations Research, Theory & Applications, Macmillan India Ltd.

2. **Manmohan, Kantiswaroop and Gupta(1999).** Operation Research, Sultan Chand & Sons New Delhi.

E04: Queueing Theory (4 Credits, 72 Hours)

CO Statement

I. CO1: Understanding basic concepts of queueing theory
II. CO2: Analyze behaviours of queueing models
III. CO3: Study on queueing networks
IV. CO4: Apply queueing models
V. CO5: Evaluate performance measures
VI. CO6: Create significance and applications of queueing theory

Unit-I. Introduction to queueing theory, Characteristics of queueing processes, Measures of effectiveness, Markovian queueing models, steady state solutions of the M/M/I model, waiting time distributions, Little's formula, queues with unlimited service, finite source queues. **(16 Hours)**

Unit-II. Transient behavior of M/M/1 queues, transient behavior of M/M/∞. Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models. Bulk input $M^{[X]}$ /M/1 model, Bulk service $M/M^{[Y]}$ /1 model, Erlangian models, M/Ek/1 and Ek/M/1. A brief discussion of priority queues. **(20 Hours)**

Unit-III. Queueing networks-series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non Jackson networks. **(16 Hours)**

Unit-IV. Models with general arrival pattern, The M/G/1 queueing model, The Pollaczek-khintchine formula, Departure point steady state systems size probabilities, ergodic theory, Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities. **(20 Hours)**

References

1. **Gross, D. and Harris, C.M.(1985).** Fundamentals of Queuing Theory, 2nd Edition, John Wiley and Sons, new York.

2. **Kleinrock L (1975).** Queuing Systems, Vol. I &Vol 2, Joohn Wiley and Sons, New York.

3. **Ross, S.M. (2007).** Introduction to Probability Models. 9th Edition, Academic Press, New York.

4. **Bose, S.K. (2002).** An Introduction to Queuing Systems, Kluwer Academic/Plenum Publishers, New York.

E05: Lifetime Data Analysis (4 Credits, 72 Hours)

Course objectives

I. CO1: Discuss life time distributions and important parametric models.
II. CO2: Explain censoring and estimation of parameters using censored data.
III. CO3: Understand and estimate the survival probabilities using product – limit and Nelson-Aalen methods.
IV. CO4: Describe inference under exponential model and discuss the comparison of distributions.
V. CO5: Explain important hazard models and apply Rank test, Log-rank test and Generalized Wilcox on test
VI. CO6: Discuss multivariate lifetime models and data

Unit-I: Lifetime distributions-continuous and discrete models-important parametric models: Exponential Weibull, Log-normal, Log-logistic, Gamma, Inverse Gaussian distributions, Log location scale models and mixture models. Censoring and statistical methods. **(I,II : A,B,C) (16 Hours)**

Unit-II: The product-limit estimator and its properties. The Nelson-Aalen estimator, 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. **(III: A, B,C) (20 Hours)**

Unit-III: Inference under exponential model – large sample theory, type-2 censored test plans, comparison of two distributions; inference procedures for Gamma distribution; models with threshold parameters, inference for log-location scale distribution: likelihood based methods: Exact methods under type-2 censoring; application to Weibull and extreme value distributions, comparison of distributions. **(IV: A, B,C) (16 Hours)**

Unit-IV: Log-location scale (Accelerated Failure time) model, Proportional hazard models, Methods for continuous multiplicative hazard models, Semi-parametric maximum likelihood-estimation of continuous observations, Incomplete data; Rank test for comparing Distributions, Log-rank test, Generalized Wilcox on test. A brief discussion on multivariate lifetime models and data. **(V,VI: A, B,C) (20 Hours)**

Text Books

1. **Lawless, J.F.(2003).** Statistical Methods for Lifetime (Second Edition), John Wiley & Sons Inc., New Jersey.

2. **Kalbfiesche, J.D. and Prentice, R.L. (1980).** The statistical Analysis of Failure Time Data, John Wiley & Sons Inc. New Jersey.

References

1. **Miller, R.G.(1981).** Survival Analysis, John Wiley & Sons Inc.

2. **Bain, L.G.(1978).** Statistical Analysis of Reliability and Life testing Models, Marcel Decker.

3. **Nelson, W. (1982).** Applied Life Data Analysis.

4. **Cox, D.R and Oakes, D.(1984).** Analysis of Survival Data. Chapman and Hall.

5. **Lee, Elisa, T. (1992).** Statistical Methods for Survival Data Analysis, John Wiley & Sons.

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E06: Advanced Distribution Theory (4 Credits, 72 Hours)

CO Statement

I. CO1: Discuss stopped sum distributions.
II. CO2: Describe the bivariate discrete distributions and its properties.
III. CO3: Explain bivariate continuous models and distributions with specified conditionals.
IV. CO4: Discuss bivariate Pareto family and multivariate Liouville distributions.
V. CO5: Understand record values and its properties.
VI. CO6:Illustrate the moments relationships and characterizations of record values from exponential, Weibull and logistic models.

Unit-I: Stopped sum distributions: Poisson stopped sum, Neyman type A, Poission-binomial, Poisson-negative binomial, Legrangian Poisson distributions, Distributions of order Poisson, negative binomial, Logarithmic series, Binomial. **(20 Hours)**

Unit-II: Bivariate discrete distributions: bivariate power series distributions, bivariate Poisson, negative binomial and logarithmic series distributions, properties of these distributions, bivariate hypergeometric distribution and its properties. **(20 Hours)**

Unit-III: Bivariate continuous models, bivariate Pearson system, Farlie Morgenstern distribution; distributions with specified conditionals, bivariate Pareto of I, II, III and IV kind, multivariate Liouville distributions. **(16 Hours)**

Unit-IV: Record values - definition, properties, distribution of nth record, record values from exponential, Weibull and logistic; Moments relationships, characterizations. **(16 Hours)**

Reference Books

1. **Johnson, N.L., Kotz, S. and Kemp, A.W. (1992).** Univariate discrete distributions, second edition, Wiley.

2. **Kocherlakota, S. and Kocharlakota, K. (1992).** Bivariate Discrete Distributions, Marcel-Dekker.

3. **Johnson, N.L., Kotz, S. and Balakrishnan, N. (1997).** Discrete multivariate distributions, second edition, Wiley.

4. **Kotz, S. ,Balakrishnan, N. and Johnson, N.L. (2000).** Continuous multivariate distributions, Volume I, John Wiley and Sons.

5. **Arnold, B.C., Balakrishnan, N. and Nagaraja, H.N. (1998).** Records, John Wiley and Sons.

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E07: Statistical Decision Theory (4 Credits, 72 Hours)

<u>**CO Statement**</u>

I. CO1. Understand the statistical decision problems and Interpret the decision rules and loss randomized decision rules.
II. CO2. Interpret the utility and classify the loss functions, standard loss functions and vector valued loss functions
III. CO3. Discuss the effort of prior information in the decision rules and Compare the informative and non-informative priors
IV. CO4. Describe posterior distribution, Bayesian inference
V. CO5. Understand the Bayesian robustness Admissibility of Bayes Rule.

Unit-I: Statistical decision Problem – Decision rule and loss-randomized decision rule. Decision Principle – sufficient statistic and convexity. Utility and loss-loss functions- standard loss functions- vector valued loss functions. **(16 Hours)**

Unit-II: Prior information-subjective determination of prior density-Non-informative priors-maximum entropy priors, the marginal distribution to determine the prior-the ML-II approach to prior selection. Conjugate priors. **(20 Hours)**

Unit-III: The posterior distribution-Bayesian inference-Bayesian decision theory-empirical Bayes analysis – Hierarchical Bayes analysis-Bayesian robustness Admissibility of Bayes rules. **(20 Hours)**

Unit-IV: Game theory – basic concepts – general techniques for solving games Games with finite state of nature-the supporting and separating hyper plane theorems. The minimax theorem. Statistical games. **(16 Hours)**

Text Book

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

References

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

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

3. **Giovanni Parmigiani, Luroles, Y.T. Inouve and Hedibert F. Lopes (2009).** Decision Theory-Principles and Approaches, John Wiley.

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E08: Reliability Modelling (4 Credits, 72 Hours)

<u>**CO Statement**</u>

I. CO1: Understand basic concepts of structural reliability
II. CO2: Analyze system reliability
III. CO3: Study on ageing properties of a system
IV. CO4: Apply reliability theory to shock models and stress-strength models
V. CO5: Study on maintenance and replacement models
VI. CO6: Create significance and applications of reliability theory

Unit-I: 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. **(16 Hours)**

Unit-II: 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 of coherent systems, convolutions and mixtures. **(20 Hours)**

Unit-III: Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. **(20 Hours)**

Unit-IV: Maintenance and replacement policies; availability of repairable systems; modelling 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. **(16 Hours)**

Text Books / References

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

2. **Bain L.J. and Engelhardt (1991).** Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

3. **Aven, T. and Jensen,U. (1999).** Stochastic Models in Reliability, Springer-Verlag, New York, Inc.

4. **Lawless, J.F. (2003).** Statistical Models and Methods for Lifetime (Second Edition), John Wiley & Sons Inc., New Jersey.

5. **Nelson, W (1982).** Applied Life Data analysis; John Wiley.

6. **Zacks, S. (1992).** Introduction to Reliability Analysis: Probability Models and Statistics Methods. New York: Springer-Verlag.

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E09: Actuarial Statistics (4 Credits, 72 Hours)

I. CO1: Understand and apply the elements of interest.
II. CO2: Discuss regular pattern of cash flows and related topics.
III. CO3: Illustrate and apply individual and collective risk models for a short period.
IV. CO4: Discuss survival distributions and derive survival functions.
V. CO5: Explain and apply life insurance models.
VI. CO6: Discuss and apply annuity models.

Unit I: Elements of the Theory of Interest -Compound interest - Nominal rate - Discount and annuities -Accumulated value - Effective and nominal discount rates. Cash flows - An analogy with currencies - Discount functions - Calculating the discount function - Interest and discount rates - Constant interest - Values and actuarial equivalence – Regular pattern cash flows -Balances and reserves -Time shifting and the splitting identity - Change of discount function - Internal rates of return - Forward prices and term structure – Economics of Insurance – Utility – Insurance and Utility **(16 Hours)**

Unit II: An Individual Risk Model for a Short Period: The distribution of individual payment – The aggregate payment (convolutions) – Premiums and solvency – Some general premium principles. A Collective Risk Model for a Short Period: The distribution of aggregate claim (Single homogeneous and several homogeneous groups) – Premiums and solvency. **(20 Hours)**

Unit III: Survival Distributions - Survival functions and force of mortality - The time-until-death for a person of a given age - Curtate-future-lifetime- Survivorship groups- Life tables and interpolation- Analytical laws of mortality - A Multiple Decrement Model - Multiple Life Models **(16 Hours)**

Unit IV: Life Insurance Models: The present value of a future payment- The present value of payments for a portfolio of many policies – Whole life insurance - Deferred whole life insurance - Term insurance – Endowments - Varying Benefits - Multiple Decrement and Multiple Life Models. Annuity Models: Continuous and discrete annuities - Level Annuities (certain and random annuities)- whole life annuities – Temporary annuities - Deferred annuities - Certain and life annuities - Varying Payments – annuities with m-thly payments - Multiple Decrement and Multiple Life Models – Premiums and reserves. **(20 Hours)**

Text books:

1. Actuarial Models – The mathematics of insurance (2nd Edn), Vladimir I Rotar, CRC Press
2. Fundamentals of Actuarial Mathematics, **S David Promislow,** John Wiley
3. Actuarial Mathematics, **N L Bowers, HU Gerber, JC Hickman, D A Jones, C A Nesbitt**, Society of Actuaries.

E10: Statistical Quality Control (4 Credits, 72 Hours)

CO Statement

I. CO1: Understand the concepts quality, quality assurance and acceptance sampling.

II. CO2: Explain and compare the methods of acceptance sampling for attributes.

III. CO3: Explain acceptance sampling by variables and continuous sampling plans.

IV. CO4: Describe and apply the control chart for attributes.

V. CO5: Explain and implement control chart for variables.

VI. CO6: Understand process capability analysis and Explain CUSUM and EWMA control charts.

Unit-I: Quality and quality assurance, methods of quality assurance, Introduction to TQM. Acceptance sampling for attributes, Single sampling, Double sampling. Multiple sampling and Sequential sampling plans. Measuring the performance of these sampling plans **(16 Hours)**

Unit-II: Acceptance sampling by variables, sampling plans for single specification limit with known and unknown and unknown variance, Sampling plans with double specification limits., comparison of sampling plans by variables and attributes, Continuous sampling plans I, II &III. **(20 Hours)**

Unit-III: Control charts, Basic ideas, Designing of control charts for the number of non- conformities.

Mean charts. Median charts. Extreme value charts, R-charts, and S-charts ARI, Economic design of

control charts. **(16 Hours)**

Unit-IV: Basic concepts of process monitoring and control; process capability and process optimization.

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.
(20 Hours)

Text Books

1. **Montgomory, R.C. (1985).** Introduction to Statistical Quality Control. 4th edition.Wiley, New-York.

2. **Mittage, H.J. and Rinne, H. (1993).**Statistical Methods for Quality Assurance. Chapman and Hall.Chapters13 and 14.

3. **Oakland, J.S. and Follorwel, R.F. (1990).** Statistical Process Control.East-West Press.Chapters 13 and 14.

4. **Schilling, E.G. (1982).** Acceptance Sampling in Quality Control. Marcel Dekker. 5. Duncan, A.J. (1986). Quality Control and Industrial Statistics.

References

1. **Gerant, E.L. and Leaven Worth, R.S. (1980).** Statistical Quality Control.Mc-Graw Hill

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

3. **Ott, E.R. (1975).** Process Quality Control; McGraw Hill. 4. Wetherill, G.B. and Brown, D.W ( ).: Statistical Process Control: Theory and Practice.

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E11: Advanced Probability Theory (4 Credits, 72 Hours)

<u>CO Statement</u>

I. CO1: Introduce the basic concepts of Probability, Mathematical expectation and Lebesgue - Stieltjes integrals

II. CO2: Study on Weak and Complete convergence of random variables.

III. CO3: Illustrate the Infinitely divisible distributions then connect it with Stable distribution then discuss its convergence.

IV. CO4: Describe the basic theorems based on Decomposition of normal distribution

V. CO5: Discuss the relevance's of Conditional expectations in Martingales and Random-Nikodyn theorem

Unit-I: Review of Elementary Probability theory, Basic properties of expectations, Sequences of integrals, Lebesgue - Stieltjes integrals, Weak convergence - Theorems. **(16 Hours)**

Unit-II: Complete convergence: Kolmogorov's three-series and two series theorems, Decomposition of normal distribution, Levy metric, Zolotarev and Lindeberg-Feller Theorems; Berry-Esseen Theorem. **(20 Hours)**

Unit-III: More on Infinitely divisible distributions, Convergence under UAN, Convergence to special distributions, Cauchy functional equation, Stable distributions. **(16 Hours)**

Unit-IV: Conditional expectations (general case), Random-Nikodyn theorem, Martingales, Doob's decomposition, LP -spaces Martingales, Martingale limit theorems, Exchangeability, Definite's theorem. **(20 Hours)**

Text Books

1. **Galambos J (1988).** Advanced Probability Theory, Marcel Dekker, New York

References

1. **Ash R. B (2000).** Probability and Measure Theory, Second edition. Academic Press.

2. **Billingsley P (1985).** Probability and Measure, Second edition, John Wiley and Sons, NewYork.

3. **Laha R.G. and Rohatgi, V.K. (1979).** Probability Theory, John Wiley and Sons, NewYork

E12: Official Statistics (4 Credits, 72 Hours)

<u>**CO Statement**</u>

I. CO1: Understand Indian and International Statistical systems, its role, functions and activities

II. CO2: Discuss the scope and contents of population census of India.

III. CO3: Understand the population growth in developed and developing countries and evaluate the performance of family welfare programmes

IV. CO 3: Identify Statistics related to industries, foreign trade, balance of payment, cost of living inflation, educational and social statistics

V. CO4 : Understand economic development and national income estimation using product approach, income approach and expenditure approach

VI. CO5: Discuss the measures of inequality in income and measures of incidence and intensity.

Unit I: Introduction to Indian and International Statistical systems. Role, function and activities of Central and State Statistical organizations. Organization of large-scale sample surveys. Role of National Sample Survey Organization. General and special data dissemination systems. Scope and Contents of population census of India. **(16 Hours)**

Unit II: Population growth in developed and developing countries, Evaluation of performance of family welfare programmes, projections of labour force and man power. Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics. **(20 Hours)**

Unit III: Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach, income approach and expenditure approach. **(16 Hours)**

Unit IV: Measuring inequality in incomes: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Senetc. **(20 Hours)**

Suggested Readings:

1. Basic Statistics Relating to Indian Economy (CSO) 1990
2. Guide to Official Statistics (CSO) 1999
3. Statistical System in India (CSO) 1995
4. Principles and Accommodation of National Population Census, UNEDCO.
5. **Panse, V.G:** Estimation of Crop Yields (FAO)
6. Family Welfare Year Book. Annual Publication of D/O Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
8. **CSO (1989)a:** National Accounts Statistics- Sources and Methods.
9. **Keyfitz, N (1977):** Applied Mathematical Demography- Springer Verlag.
10. **Sen, A(1977):** Poverty and Inequality.
11. **UNESCO:** Principles for Vital Statistics Systems, Series M-12.
12. **CSO (1989)b:** Statistical System in India
13. **Chubey, P.K (1995):** Poverty Measurement, New Age International.

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E13: Biostatistics (4 Credits, 72 Hours)

<u>CO Statement</u>

I. CO1: Discuss types of Biological data and Principles of Biostatistical design of medical studies.

II. CO2: Understand the concepts of survival time functions of important parametric models and comparing two survival distributions using L.R test and Cox’s F-test.
III. CO3: Explain censoring and estimation of parameters using censored data.
IV. CO4: Understand and estimate the non-parametric methods for estimating survival function and variance of the estimator using actuarial and Kaplan –Meier methods.
V. CO5: Describe competing risk theory and estimate the probabilities of death by ML method.
VI. CO6: Discuss the Basic biological concepts in genetics and clinical trials.

Unit-I: Biostatistics-Example on statistical problems in Biomedical Research-Types of Biological data-Principles of Biostatistical design of medical studies- Functions of survival time, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, distribution having bath-tub shape hazard function. Parametric methods for comparing two survival distributions (L.R test and Cox’s F-test). **(16 Hours)**

Unit-II: Type I, Type 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. Acturial and Kaplan –Meier methods. **(20 Hours)**

Unit-III: Categorical data analysis (logistic regression) - 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 ML method. Stochastic epidemic models: Simple and general epidemic models. **(16 Hours)**

Unit-IV: Basic biological concepts in genetics, Mendel’s law, Hardy- Weinberg equilibrium, random mating, natural selection, mutation, genetic drift, detection and estimation of linkage in heredity. Planning and design of clinical trials, Phase I, II, and III trials. Sample size determination in fixed sample designs. Planning of sequential, randomized clinical trials, designs for comparative trials; randomization techniques and associated distribution theory and permutation tests (basic ideas only); ethics behind randomized studies involving human subjects; randomized dose-response studies(concept only). **(20 Hours)**

Text Books / 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.** and **Grant, G.R. (2001).** Statistical methods in Bioinformatics: An Introduction, Springer.

5. **Friedman, L.M., Furburg, C.** and**DeMets, D.L. (1998).** Fundamentals of Clinical Trials, Springer Verlag.

6. **Gross, A. J.** and **Clark V.A. (1975).** Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.

7. **Lee, Elisa, T. (1992).** Statistical Methods for Survival Data Analysis, John Wiley & Sons.

8. **Li, C.C. (1976).** First Course of Population Genetics, Boxwood Press.

9. **Daniel, W.W.(2006).** Biostatistics: A Foundation for Analysis in the Health sciences, John Wiley & sons. Inc.

10. **Fisher, L.D.** and **Belle, G.V. (1993).** Biostatistics: A Methodology for the Health Science, John Wiley & Sons Inc.

11. **Lawless, J.F.(2003).** Statistical Methods for Lifetime (Second Edition), John Wiley & Sons.

12. **Chow, Shein-Chung and Chang, Mark (2006).** Adaptive Design Methods in Clinical Trials. Chapman & Hall/CRC Biostatistics Series.

13. **Chang, Mark (2007).** Adaptive Design Theory and Implementation Using SAS and R. Chapman & Hall/CRC Biostatistics Series.

14. **Cox, D.R. and Snell, E.J. (1989).** Analysis of Binary Data, Second Edition. Chapman & Hall / CRC Press.

15. **Hu, Feifang and Rosenberger, William (2006).** The Theory of Response-Adaptive Randomization in Clinical Trials. John Wiley.

16. **Rosenberger, William and Lachin, John (2002).** Randomization in Clinical Trials: Theory and Practice. John Wiley.

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E14: Econometric Models (4 Credits, 72 Hours)

CO Statement

I. CO1: Understand basic concepts of Economics.
II. CO2: Discuss the optimization problems with more than one choice variable in Economics.
III. CO3: Explain the optimization problems with equality constraints and discuss Domar growth model, Solow growth model and Cobweb model.
IV. CO4: Explain the meaning and methodology of econometrics and understand the concept of regression and autocorrelation.
V. CO5: Discuss the dynamic econometric models
VI. CO6: Discuss the inconsistency of OLS estimators and understand the basic concepts of stochastic process

Unit-I: Basic economic concepts: Demand, revenue, average revenue, marginal revenue, elasticity of demand, cost function, average cost, marginal cost. Equilibrium analysis: Partial market equilibrium- linear and nonlinear model, general market equilibrium, equilibrium in national income analysis. Leontief input output models. Optimization problems in economics, Optimization problems with more than one choice variable: multi product firm, price discrimination. **(16 Hours)**

Unit-II: Optimization problems with equality constraints: utility maximization and consumer demand, homogeneous functions, Cobb-Duglas production function, least cost combination of inputs, elasticity of substitution, CES production function. Dynamic analysis: Domar growth model, Solow growth model, Cobweb model. **(16 Hours)**

Unit-III: Meaning and methodology of econometrics, regression function, multiple regression model, assumptions, OLS and ML estimation, hypothesis testing, confidence interval and prediction. Multicollinearity, Heteroscedasticity, Autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them. Dynamic econometric models: Auto regressive and distributed lag- models, estimation of distributed lag- models, Koyck approach to distributed lag-models, adaptive expectation model, stock adjustment or partial adjustment model, estimation of auto regressive models, method of instrumental variables, detecting autocorrelation in auto regressive models: Durbin- h test, polynomial distributed lag model. **(20 Hours)**

Unit-IV: Simultaneous equation models: examples, inconsistency of OLS estimators, identification problem, rules for identification, method of indirect least squares, method of two stage least squares . Time series econometrics: Some basic concepts, stochastic processes, unit root stochastic processes, trend stationary and difference stationary stochastic processes, integrated stochastic processes, tests of stationarity, unit root test, transforming non-stationary time series, cointegration. Approaches to economic forecasting, AR, MA, ARMA and ARIMA modeling of time series data, the Box- Jenkins methodology. **(20 Hours)**

Text Books

1.**Alpha C Chiang (1984).** Fundamental Methods of Mathematical Economics(Third edition), McGraw –Hill, New York.

2.**Damodar N Gujarati (2007).** Basic Econometrics(Fourth Edition), McGraw-Hill, New York.

References

1.**Johnston, J (1984).** Econometric Methods(Third edition), McGraw–Hill, New York.

2.**Koutsoyiannis,A (1973).** Theory of Econometrics, Harper & Row, New York.

3.**Maddala,G.S. (2001).** Introduction to Econometrics(Third edition), John Wiley & Sons, New York.

4.**Taro Yamane (1968).** Mathematics for Economists an elementary survey(second edition), Prentice-Hall, India.

E15: Demographic Techniques (4 Credits, 72 Hours)

CO Statement

I. CO1: Understand the sources of demographic Statistics and explain basic demographic measures.

II. CO2: Understand life tables and construct a lifetable.

III. CO3: Explain the measures of fertility.

IV. CO4: Understand the point estimates and population projections based on mortality, fertility and migration basis.

V. CO5: Discuss the ageing of the population

VI. CO6: Estimate the demographic measures from incomplete data

Unit-I: Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Specific rates, Labour force participation rates, Density of population, Probability of dying. **(20 Hours)**

Unit-II: Life tables: Construction of a life table, Graphs of lx, qx, dx, Functions Lx, Tx and Ex. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity. **(20 Hours)**

Unit-III: Fertility: Measures of Fertility, Reproductivity formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable populations, Calculation of the age distribution of a stable population, Model Stable Populations. **(16 Hours)**

Unit-IV: Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections, Ageing of the population, Estimation of demographic measures from incomplete data. **(16 Hours)**

Text book

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

References

1. **Keyfitz, N. (1977)**. Applied Mathematical Demography A Wiley-Interscience Publication

2. **Keyfilz, N. (1968).** Introduction to the Mathematic of Population Ready, Mass: Addition-Wesley.

3. **Keyfilz, N. and Caswell, H. (2005).** Applied Mathematical Demography, Third edition, Springer.

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E16: Stochastic Finance (4 Credits, 72 Hours)

CO Statement

I. CO1. Understand the basic concepts of financial markets and market lines.
II. CO2. Learn the usage of Statistical models in modeling Financial data.
III. CO3. Interpret and apply the black Scholes theorem and its properties.
IV. CO4. Describe the pricing of European and American options by monte-Carlo and finite difference methods.
V. CO5. Discuss on the modelling security market and price process models
VI. CO6. Learn the special features of the financial time series and their models and its estimation.

Unit-I: Basic concepts of financial markets. Forward contracts, futures contracts, options-call and put options, European option and American options. Hedgers, speculators, arbitrageurs. Interest rates, compounding, present value analysis, risk free interest rates. Returns, gross returns and log returns. Portfolio theory – trading off expected return and risk, one risky asset and one risk free asset. Two risky assets, estimated expected return. Optimal mix of portfolio CAPM, capital market line, betas and security market line. **(20 Hours)**

Unit-II: Options, pricing via arbitrage, law of one price. Risk neutral valuation. Binomial model- single and multiperiod binomial model, martingale measure. Modelling returns: lognormal model, random walk model, geometric Brownian motion process. Ito lemma (without proof). Arbitrage theorem. The Black-Scholes formula. Properties of the Black-Scholes option cost, the delta hedging arbitrage strategy. Some derivatives, their interpretations and applications. **(20 Hours)**

Unit-III: Volatility and estimating the volatility parameter. Implied volatility. Pricing American options. Pricing of a European option using Monte-Carlo and pricing an American option using finite difference methods. Call options on dividend-paying securities. Pricing American put options, Modeling the prices by adding jumps to geometric Brownian motion. Valuing investments by expected utility. Modeling security market: Self-financing portfolio and no arbitrage, price process models, division rule, product rule**(16 Hours)**

Unit-IV: Financial Time Series – Special features of financial series, Linear time series models: AR(1), AR(p), ARMA(p,q) processes, the first and second order moments, estimation and forecasting methods. Models for Conditional heteroscedasticity: ARCH(1), ARCH(p), GARCH(p,q) models and their estimation. Comparison of ARMA and GARCH processes. **(16 Hours)**

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References

1. **Sheldon M. Ross (2003).** “An elementary introduction to Mathematical Finance”,
2. **David Ruppert (2004).** “Statistics and Finance an Introduction” – Springer International Eddition.
3. **Masaaki Kijima (2003).** “Stochastic process with applications to finance”, Chapman Hall.
4. **Ruey S. Tsay (2005).** “Analysis of Time Series III ed”, John Wiley & Sons
5. **John C. Hull (2008).** “Options, Futures and other derivatives”, Pearson Education India.
6. **Christian Gourieroux and Joann Jasiak (2005).** “Financial Econometrics”, New Age International (P) Ltd.
7. **Cuthbertson K and Nitzsche D (2001).** “Financial Engineering - Derivatives and Risk Management”, John Wiley & Sons Ltd.

E17: Longitudinal Data Analysis (4 Credits, 72 Hours)

<u>CO Statement</u>

I. CO1: Study the basic concepts of Linear Model in longitudinal data analysis
II. CO2: Analyze numerical methods two solve the problems in Linear Model
III. CO3: Study on Study on basic concepts of Generalized Linear Model
IV. CO4: Illustrate and study on missing data mechanism in longitudinal data analysis
V. CO5: Study on Multivariate and Time-dependent covariates in longitudinal data analysis

Unit-I: General Linear Model for Longitudinal Data.ML and REML estimation, EM algorithm: General linear mixed-effects model, Inference for ; the random effects, BLUPs, Empirical Bayes , Bayes, Shrinkage Model building and diagnostic, Relaxing parametric assumptions: generalized additive mixed model. **(20 Hours)**

Unit-2. Generalized Linear Model for Longitudinal Data: Marginal models, for binary, ordinal, and count data: Random effects models for binary ordinal and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses. **(16 Hours)**

Unit-3. Dropouts and missing data: Classification missing data mechanism; Intermittent missing Values and dropouts; Weighted estimating equations; Modelling the dropout process (Selection and pattern mixture models). **(20Hours)**

Unit-4. Time-dependent covariates and special topics: Dangers of time-dependent covariates: Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies. **(16 Hours)**

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Text books

1.**Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003).** Analysis of Longitudinal Data, Edn 2. Oxford University press, New York. Analysis, John Wiley & Sons, New York.

References

1.**Crowder, M.J. and Hand, D.J. (1990).** Analysis of Repeated Measures. Chapman and Hall/CRC Press, London .

2. **Davidian,M. and Giltinan, D.M. (1995**). Nonlinear Models for Repeated Measurement Data. Chapman and Hall/CRC Press, London.

3.**Hand,D and Crowder, M. (1996).** Practical Longitudinal Data Analysis. Chapman and Hall/CRC Press, New York. Lindsey, J.K. (1993) Models for Repeated Measurements. Oxford University Press, New York.

4.**Little, R.J.A, and Rubin, O.B. (2002).** Statistical Analysis with Missing Data, 2nd edition, Wiley, New York.

5.**McCullagh,P. and Nelder.J.A (1989).** Generalized Linear Models. 2nd edition, Chapman and Hall/CRC Press, London.

6.**Weiss, R.E. (2005).** Modeling Longitudinal Data. Springer, New York.

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E18: Data Mining Techniques (4 Credits, 72 Hours)

I. CO1: Understand and apply classification techniques and concept of decision trees.
II. CO2: Discuss clustering techniques in statistical and data mining viewpoints.
III. CO3: Explain and apply unsupervised and unsupervised learning and data reduction techniques.
IV. CO4: Explain and apply artificial neural networks and extensions of regression models.
V. CO5: Discuss data warehousing and online analytical data processing.
VI. CO6: Explain and apply the techniques of association rules and prediction.

Unit-1: Review of classification methods from multivariate analysis; classification and decision trees.

Clustering methods from both statistical and data mining viewpoints; vector quantization. **(20 Hours)**

Unit-2: Unsupervised learning from univariate and multivariate data; Dimension reduction and feature selection. Supervised learning from moderate to high dimensional input spaces; **(20 Hours)**

Unit-3: Artificial neural networks and extensions of regression models, regression trees. Introduction to databases, including simple relational databases. **(16 Hours)**

Unit-4: Data warehouses and introduction to online analytical data processing. Association rules and prediction; data attributes, applications to electronic commerce. **(16 Hours)**

Text books / References

1.**Berson, A. and Smith, S.J. (1997).** Data Warehousing, Data Mining, and OLAP. (McGraw-Hill.)

2.**Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984).** Classification and Regression Trees. (Wadsworth and Brooks/Cole).

3.**Han, J. and Kamber.M. (2000).** Data Mining; Concepts and Techniques.(Morgan Kaufmann)

4.**Mitchell, T.M. (1997).** Machine Learning. (Mc Graw-Hill)

5.**Ripley, B.D. (1996).** Pattern Recognition and Neural Networks. (Cambridge University Press).

MODEL QUESTION PAPER

I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

Course Code & Course Name

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .
2. .
3. .
4. .
5. .
6. .
7. .

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .
9. .
10. .
11. .
12. .

13. .

14. .

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .

16. .

17. .

18. .

(5x2=10 weightages)

M. Sc. Statistics Programme under CBCSS

Audit courses:

In addition to the core and elective courses of the programme there will be two Audit Courses (Ability Enhancement Course & Professional Competency Course) with 4 credits each. These have to be done one each in the first two semesters. These courses are mandatory for all programmes but their credits will not be counted for evaluating the overall SGPA & CGPA. The Department/College shall conduct examination for these courses and have to intimate /upload the results of the same to the University on the stipulated date during the Third Semester. Students have to obtain only minimum pass requirements in the Audit Courses. The details of Audit courses are given below.

MST1A01: Ability Enhancement Course (AEC) 4 Credits

The objective of this course is to enhance the ability and skill of students in the core and elective areas of statistics, through hands on experience, internship, industrial visits, case study, community linkage, book/research paper review, scientific word processing etc.

The faculty members in the department collectively or a particular faculty member shall be in charge of this course for students of the semester, which shall be decided by the Department council. The following are the requirements in this course:-

1. Short term internships at research institutions/R&D centre/Industry.
2. Seminar presentation on a topic in statistics or related fields that is not normally covered in the in the syllabi of the programme.
3. Case study and analysis on any relevant issues in the nearby society
4. Publication of articles in statistical magazines/journals
5. Interaction with Statistical Organizations/ Industries/ Research Institutions.
6. Any community linking programme relevant to the area of study

7. Book/paper review and summary.

8. English communication skills and technical writing with LATEX.

9. Survey methodology and Data collection- sampling frames and coverage error, non-response.

10. Developing a questionnaire, collect survey data pertaining to a research problem (such as gender discrimination in private vs government sector, unemployment rates, removal of subsidy, impact on service class). Formats and presentation of reports.

After conducting the AEC, the evaluation/examination should be done either common for all students of the semester or individually depending upon the AEC conducted. Evaluation/examination on AEC must contain the following components: MCQ type written examination, Report on study/investigation, Presentation, Viva voce etc. as decided by the Department council. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the AEC should be determined.

MST2A02: Professional Competency Course (PCC) 4 Credits

The objective of this course is to get professional competency and exposure in the core areas of statistics. It particularly aims to improve the skill level of students, especially for using software useful in their respective field of study, both related to the core and elective subject area. Also it is a platform for the student community to undertake socially committed statistical investigations and thereby developing a method of learning process by doing through the involvement with society.

The faculty members in the department collectively or a particular faculty member shall be in charge of this course for students of the semester, which shall be decided by the Department council. The following are the requirements in this course:-

1. Working knowledge on different statistical software/utilities like SPSS (or GNU PSPP), R, Python. (Introduction of the software- Use of the software as a calculator, as a graphing (plotting) utility, for matrix operations and for problems on probability distributions)

2. Use of Internet and other technologies - Internet and www, applications, internet protocols.

3. E-commerce and financial statistics- Electronic fund transfer, payment portal, e-commerce security.

4. Mobile commerce, Bluetooth and Wi-Fi

5. Introduction to Data Science and Big-data issues.
6. Trend Analysis (elementary time series analysis) and Index numbers
7. Official Statistics: An outline of present official statistical systems in India, Methods of collection of official statistics, their reliability and limitations, Role of MoSPI, CSO, NSSO and NSC.

8. Monte Carlo methods: Brief look at some popular approaches- simulating a coin toss, a die roll and a card shuffle.

9. CDF inversion method- simulation of standard distributions

10. Monte Carlo Integration- Basic ideas of importance sampling.

After conducting the PCC, the evaluation/examination should be done either common for all students of the semester or individually depending upon the PCC conducted. Evaluation/examination on PCC must contain the following components: MCQ type written examination, Report on study/investigation, Presentation, Viva voce etc. as decided by the Department council. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the PCC should be determined.

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MODEL QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST1C01: ANALYTICAL TOOLS FOR STATISTICS – I

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Define the terms pole and essential singularities giving one example each.
2. Define the inverse Laplace transform of a function.
3. What do you mean by removable singularity?
4. State Cauchy's integral formula.
5. Obtain the Laplace transform of *tSinh2t*
6. Define Riemann integral of a multivariable function.
7. Define a periodic function. Give an example.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Explain the Total derivative.
9. State and prove inverse function theorem.
10. Find the Laplace transform of f(t)=cost.
11. Varify C-R equations: $f(z)=z^3+z+1$
12. f(z) = u+iv is an analytic function with u=2x(1-y) . Determine the function completely.
13. Solve the initial value problem using Laplace transformation $y'' - 2y + 3 = t$, y'(0)=1, y(0)=1
14. Obtain the Fourier transform of $f(x) = 1/(1-x)$

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. State and Prove Taylor's theorem.
16. Derive the necessary and sufficient conditions for differentiability.
17. State and prove Cauchy's integral theorem.
18. Find Laplace transforms of following functions

(a) $t^2 Sin\theta t$

(b) te^{-32t}

(c) $te^t - Sinht$

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST1C01: ANALYTICAL TOOLS FOR STATISTICS – I

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 3

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST1C02: ANALYTICAL TOOLS FOR STATISTICS – II

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. If A and B are symmetric matrices, show that AB+BA is symmetric matrix?
2. Define Idempotent and Hermitian matrices.
3. Show that the vectors (1, 2, 3) and (2,-2,0) form a linearly independent set.
4. Do the vectors a_1=(3,0,2), a_2=(7,0,9), a_3=(4,1,2) form a basis for R^3?
5. If A is any subset of a vector space V, prove that A is a subspace of V iff A =SP(A).
6. Define dimension of a vector space.
7. When do you say a quadratic form $X'AX$ to be positive definite and positive semi-definite.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Let V be a finite dimensional vector space. Show that all bases of V have same number of elements.
9. Let S be a subspace of a finite dimensional vector space. Then prove that every generating set C of S contains a basis of S.
10. If A is an m*m Idempotent matrix, then show that (a) I_m - A is also idempotent. (b) Each eigen value of A is 0 or 1.
11. Using Cayley –Hamilton theorem obtain the inverse of the matrix $\begin{bmatrix} 6 & -2 & 0 \\ -2 & 3 & 0 \\ 0 & 0 & 2 \end{bmatrix}$.
12. Prove that the geometric multiplicity of a characteristic root cannot exceed algebraic multiplicity of the same.
13. Classify the following quadratic form as positive definite, positive semi-definite and indefinite $2x^2$+ $2y^2$ + $3z^2$ - 4yz- 4zx+ 2xy.
14. For a portioned matrix show that $\begin{vmatrix} A & C \\ B & C \end{vmatrix}$ =$|A||D - BA^{-1}C|$ where A ,D are square matrices and A is non- singular.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. (a) Let $X_1, X_{2\,,}\ldots X_n$ be the characteristic vectors corresponding to distinct characteristic roots of a matrix. Prove that $X_1's$ are linearly independent.
    b) For a real symmetric matrix show that characteristic vectors corresponding to distinct characteristic roots are orthogonal.
16. State and prove Cayley –Hamilton theorem
17. What do you mean by matrix mapping. Write a short note on change of basis in matrix mapping.
18. (a) Define the rank of a matrix. Prove that the rank of the product of two matrices cannot exceed the rank of either matrix. (b) Reduce the following matrix to its normal form and hence find its rank $\begin{bmatrix} 1 & 1 & 2 \\ 1 & 2 & 3 \\ 0 & -1 & -1 \end{bmatrix}$.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST1C02: ANALYTICAL TOOLS FOR STATISTICS – II

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1

2. .Module 2

3. .Module 2

4. .Module 3

5. .Module 3

6. .Module 4

7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 2

10. .Module 2

11. .Module 3

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST1C03: DISTRIBUTION THEORY

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. For any integer valued random variable X with probability distribution $P(X = k) = p_k, k = 0,1,2 \dots$ and $P(X > k) = q_k$. If $P(s)$ and $Q(s)$ are generating functions associated with $\{p_k\}$ and $\{q_k\}$, show that $Q(s) = (1-s)^{-1}(1-P(s))$.
2. Obtain the moment generating function of the modified power series distribution.
3. Write down the p.m.f. of the trinomial distribution. Also obtain (a) the marginal distributions; and (b) the expression for correlation coefficient.
4. Identify a discrete distribution for which mean is equal to variance. State the reproductive property for this distribution.
5. $X_1, X_2, \dots, X_n$ are independent geometric random variables, identically distributed with parameter p. Obtain the distribution of $X_{(1)} = \min(X_1, X_2, \dots, X_n)$.
6. If X follow the uniform distribution, $U(0, 1)$, obtain the distribution of $Y = -\log X$.
7. State the lack of memory property of the exponential distribution and interpret the same in life time studies.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. is an absolutely continuous random variable with distribution function $F(x)$. Obtain the distribution of (a) $Y = F(x)$ and (b) $Z = 1 - F(x)$. Discuss an application of this result from the modelling point of view.

9. Let X and Y be independent random variables following the negative binomial distributions, $NB(r_1, p)$ and $NB(r_2, p)$ respectively. Show that the conditional probability mass function of X given $X + Y = t$ is hypergeometric.

10. Define the hypergeometric distribution. Show that under conditions the hypergeometric distribution tends to the binomial distribution.
11. State and prove Chebyshev's inequality. If X be distributed with p.d.f
$$f(x) = \begin{cases} 1, & 0 < x < 1 \\ 0, & otherwise, \end{cases}$$
prove that $P\left[\left|X - \frac{1}{2}\right| < \sqrt{\frac{1}{12}}\right] \geq 0.75.$
12. Define mixture distributions. Obtain the expression for the mean and variance of the mixture distribution in terms of the mean and variance of the component distributions. Also discuss a practical situation where mixture models are appropriate.
13. Show that if $E(X^2) < \infty$, then prove that $V(X) = V\big(E(X|Y)\big) + E\big(V(X|Y)\big)$.
14. If (X, Y) is a random vector following the bivariate exponential distribution with $P(X > x, Y > y) = \exp(\lambda x + \mu y + \theta xy), x, y > 0, \lambda, \mu > 0, 0 < \theta < 1$. Find the marginal distribution of X and Y.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. Write down the differential equation satisfied by Pearson system of distributions. What is the basis for classification of members of the family into various types? Deduce the normal distribution as a member of the family. Explain whether the uniform distribution belong to the family.
16. Find the joint pdf of the range w and midpoint m in random samples of size n from $U(-\frac{1}{2}, \frac{1}{2})$. Hence or otherwise find the pdf of m and its variance.
17. In sampling from a normal population, show that the sample mean $\overline{X}$ and the sample variance S^2 are independently distributed. Hence or otherwise obtain the distribution of $\overline{X}$ and S^2.
18. Define the non-central F statistic and derive its distribution. Obtain the expression for mean and variance. Also describe the applications of the distribution.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST1C03: DISTRIBUTION THEORY

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2

12. .Module 3

13. .Module 3

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST1C04: PROBABILITY THEORY

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Define empirical distribution function.
2. Define weak convergence of distribution functions.
3. Explain Bernoulli weal law of large numbers.

4. Find the characteristic distribution of exponential distribution.
5. Find the characteristic distribution of exponential distribution
6. Define Martingale and sub-Martingale
7. If $\{X_n\}$ is a Martingale then show that $g\{X_n\}$is a sub-Martingale where g is any convex function.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Define a Random Variable.
9. Explain different definitions of probabilities and state their properties.
10. State and prove Jordan decomposition theorem.
11. Show that convergence in probability implies convergence in law.
12. State and prove Lindeberg-Lévy central limit theorem.
13. Prove that the conditional expectation possesses linearity property
14. Show that Radon-Nikodym derivative is unique up to sets of P- measure zero.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. State and prove Borel 0-1 Law
16. Derive Kolmogorov strong law of large numbers for a sequence of i.i.d random variables.
17. Derive the inversion formula for characteristic functions.
18. State and prove Doob decomposition

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST1C04: PROBABILITY THEORY

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

<u>Answer any four (3 weightages each)</u>

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2
12. .Module 3
13. .Module 4
14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

II SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST2C06: DESIGN AND ANALYSIS OF EXPERIMENTS

PART A

Answer any four (2 weightages each)

1. Write the linear model for two-way ANOVA with their assumptions and write the basic principles of Design of experiments.
2. What is a Graeco- Latin Square design?.
3. Mention the situation in which analysis of covariance is used.
4. Write any four parametric relationship for BIBD.
5. Distinguish between complete and incomplete block designing
6. Explain Yates procedure for finding sum of squares in a 3^2 factorial experiment.
7. Explain Method of Steepest accent.

(2 x 4=8 weightages)

PART B

<u>Answer any four (3 weightages each)</u>

8. Explain residual analysis of one-way ANOVA.
9. If a single observation is missing in Graeco Latin Square Design, estimate the missing value.
10. Define a BIBD and suggest a method for its construction. Then discuss the analysis if a BIBD with recovery of inter- block information.
11. Write a short note on Lattice designs.State and prove Fisher's inequality.
12. A 2^3-factorial experiment is conducted in RBD with block size 8, having confounded the interaction effect ABC and replicated four times. Outline the analysis of this design.
13. Describe in detail the analysis of a split plot design.
14. Explain the terms Orthogonality and Rotatability blockingand its analysis

(3x 4=12 weightages)

PART C

<u>Answer any two (5 weightages each)</u>

15. A) Explain the working procedure of two-way ANOVA, stating the necessary assumptions.
    B) Write a short note on Analysis of co-variance for completely randomized design.
16. A)Estimate the treatment effects for the Balanced Incomplete Block Design model using least squares method.
    B) Explain analysis of partially balanced incomplete block designs with two associate classes
17. A) Describing a 3^2-factorial experiment, explain how the Yate's technique is used to calculate the sum of squares in the analysis. Obtain the ANOVA table and carry out its analysis.
    B) Explain Fractional factorial designs and Resolution of a design
18. A) Write the analysis of a Response surface designs
    B) Explain the automatic confounding in 2^n factorial experiments having m factors are confounded.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

II SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Nov 2019

Branch: Statistics

MST2C06: DESIGN AND ANALYSIS OF EXPERIMENTS

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

<u>Answer any two (5 weightages each)</u>

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

II SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST2C07 : Estimation Theory

Time: 3 Hours **Maximum Weightage: 30**

PART A

<u>Answer any four (2 weightages each)</u>

1. Find the MLE of θ based on random sample of size n drawn from a population with pdf as f(x, θ) $= \begin{cases} \theta e^{-\theta x}, 0 < x < \infty, \theta > 0 \\ 0, \ o.w. \end{cases}$
2. Define BLUE.
3. Let $X_1, X_2, \ldots, X_n$ are i.i.d. U(0, θ). $\theta > 1$.
   Define $Y_i = \begin{cases} 1, if\ X_i > 1 \\ o, O.W \end{cases}$
   Find the estimate of θ by the method of moments.
4. Explain Fisher's information.
5. A random sample of size n is taken from Poisson (λ).Obtain the Sufficient statistic for λ
6. Explain the method of Percentile.
7. Let $X_1, X_2, \ldots, X_n$ are i.i.d. random variables with common PMF
8. P($X_i = k$) = 1/N, k= 1,2,…N, i= 1,2,…n. Obtain sufficient statistic for N.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

9. If (X_1, X_2) is a random sample from a distribution with density function f(x)=$\theta x^{\theta-1}, 0 \leq x \leq 1, \theta > 0$. Find Fisher's information onθ contained in the sample.
10. Find CRLB for the variance of an unbiased estimator of θ in sampling from N(θ, 1).
11. Let X_1, X_2 be i.i.d. Poisson (λ) random variables and consider the statistic T= $X_1 + 2X_2$. Show that T is not sufficient for λ.
12. Let $X_1, X_2, \ldots, X_n$ are i.i.d. B(1,p) random variables . Show that T= $\sum_{i=1}^{n} X_i$ is complete and sufficient.
13. Show by an example that the exclusion of even one member from the family destroys completeness.
14. Let $X_1, X_2, \ldots, X_n$ be a random sample from U(0, θ). Find the shortest length CI for θ at level 1-∝ , based on sufficient statistic for θ

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. a) Let $X_1, X_2, \ldots, X_n$ be a random sample from Poisson (λ). Find the UMVUE of (i) λ (ii)$e^{-\lambda}$ (iii) λ^2 (iv) $\lambda^2 + 2\lambda$
16. Let X$\sim B(n, p) where\ p \sim U(0,1)$. Find the baye's estimator and Baye's risk under squared error loss function.
17. a) State and prove Basu's theorem.

b) Let $X_1, X_2, \dots, X_n$ be a random sample from N(μ, σ^2). Show that the sample mean $\bar{x}$ and sample variance S^2 are independent.

18. a) State and prove Factorization theorem.

b) Let $X_1, X_2, \dots, X_n$ is a random sample from a population with p.d.f

$$f(x, \theta) = 1/\theta e^{-x/\theta}, x > 0, \theta > 0.$$

Find CRLB for the variance of the unbiased estimate of θ.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

II SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST2C07 : Estimation Theory

Time: 3 Hours **Maximum Weightage: 30**

PART A

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 1
3. .Module 2
4. .Module 2
5. .Module 3
6. .Module 3
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

MODEL QUESTION PAPER

III SEMESTER M.Sc. DEGREE EXAMINATION

STATISTICS

MST2C08: SAMPLING THEORY

Time 3 hours **Maximum Weightage: 30**

Part A

Answer any four (2 weightages each)

1. Sample mean is an unbiased estimator of the population mean in SRSWR. Prove
2. What is sampling error.(b) Explain unrestricted random sampling.
3. (a)Explain about Random number table.(b)Explain Narain's scheme of sample selection
4. What are the principles of Sampling. Explain
5. (a)What you mean by General selection procedure in PPS sampling?(b)Prove that in ratio estimation B($\hat{R}$) =-Cov($\hat{R}$, $\overline{x}$)/$\overline{X}$
6. (a)Explain Stratifiedsampling.(b)Explain Systematic sampling.
7. (a)Describe Lahiri's method of selection under PPS Sampling.(b)What are the principles of stratification.

(2x4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Cluster sampling will be efficient only when the variation between clusters is as small as possible; Prove.

9(a)Explain Durbin's Π PS sampling.(b)What are the advantages of stratified sampling?

10. Show that in SRSWOR Sample mean $\overline{y}$ is the BLUE of $\bar{Y}$

11.Explain Neyman allocation.

12.Write about sampling frame. Explain various defects associated with it.

13.Prove that in SRS the bias of regression estimator $\overline{y_{lr}}$is approximately – Cov ($\overline{x}$, b).

14. Estimate the sample size for the estimation of population mean in SRS.

(3x4=12 weightages)

Part C

Answer any two (5 weightages each)

15.(a).(a) Derive Yates-Grundy form of estimated variance of Hurvitz-Thomson estimator of population mean upon a PPS sample without replacement.

(b)For an SRSWOR with population size *N* and sample size *n*, show that the probability of a specified unit being selected at any given draw is 1/N.

16.(a) Explain Periodic and Linear trends in Systematic Sampling.

(b) Prove that in PPS sampling without replacement, Desraj ordered estimator is unbiased for population total. Derive its sampling variance.

17.(a)Prove that$V(ran)\geq V(pro)\geq V(opt)$(b) Explain Hartly-Ross estimator also obtain an unbiased estimator for population total

18.(a)Carry out a comparison between the mean per unit and ratio estimator with regression estimator. (b)(a) Obtain the mean and its variance in equal cluster sampling

(c) Explain Lahiri's total method of drawing a PPS sampling.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

III SEMESTER M.Sc. DEGREE EXAMINATION

STATISTICS

MST2C08: SAMPLING THEORY

Time 3 hours **Maximum Weightage: 30**

Part A

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 1
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4

7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2
12. .Module 3
13. .Module 4
14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1
16. .Module 2
17. .Module 3
18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

SECOND SEMESTER M.Sc. DEGREE EXAMINATIONS(CBCSS)

(Regular / Supplementary / Improvement**)**

Statistics

MST2C09 : Testing of Statistical Hypotheses

Time: 3 Hours Max. Weightage: 30

Part A.

Answer any four (2 weightages each)

(4 x 2=8 Weightage)

1. Define MP and UMP tests.
2. What is p- value ? How is it used in statistical test procedures ?
3. Define likelihood ratio test. Explain its properties.
4. Explain locally most powerful tests and ∝- similar test.
5. How do you test independence using Kendall's tau?
6. Explain Run test and sign test.
7. Define OC function and ASNof SPRT. State its properties.

Part B.

Answer any four (3 weightages each)

(4 x 3=12 weightage)

8. Based on a sample of size n drawn from a distribution with density:
$$f(x,\theta) = \begin{cases} e^{-(x-\theta)}, & x > 0 \\ 0 \quad , & otherwise \end{cases}$$
Find the most powerful test of $H_0: \theta = \theta_0 \ vs \ H_1: \theta = \theta_1$.
9. Define consistency of a test. Show that likelihood ratio test is consistent.
10. Let $X \sim U(0, \theta)$. Derive UMP test of size α for testing $H_0: \theta = \theta_0 \ vs \ H_1: \theta \neq \theta_0$.
11. Define monotone likelihood ratio property. Examine whether the density:
$$f(x,\theta) = \frac{1}{2} e^{-|x-\theta|}, -\infty < x < \infty$$
Satisfies monotone likelihood ratio property.
12. Distinguish between Chi- square goodness of fit and Kolmogorov- Smirnov test. Describe their merits and demerits.
13. Show that the Kolmogorov test statistic is distribution free if the distribution function of the population is continuous.

14. Define A.S.N function. Let $X \sim b(1, p)$. Find the A.S.N of the SPRT $H_0: p = p_0 \ vs \ H_1: p = p_1$.

Part C.

Answer any two (5 weightages each)

(2 x 5 = 10 weightage)

15. a. State and prove Neymann-Pearson fundamental Lemma
    b. Find the MP test $X \sim N(\theta, 1) H_0;\ \theta = \theta_0 \ vs \ H_1: \theta = \theta_1 (> \theta_0)$

16. Derive a UMPU for testing $H_0: \mu \in [\mu_1, \mu_2]$ against $H_1: \mu \notin [\mu_1, \mu_2]$ using a random sample of size n from $N(\mu, 1)$.

17. a. Write about signed rank test and Wilcoxon signed rank test
    b. Explain Mann- Whitney test for equality of median.

18. a. For SPRT with stopping bound s A and B, Show that $A \leq \frac{1-\beta}{\alpha}$and $\geq \frac{\beta}{1-\alpha}$, where (α, β) is the strength.
    b. Show that SPRT terminates with probability one.

GENERAL PATTERN OF QUESTION PAPER

SECOND SEMESTER M.Sc. DEGREE EXAMINATIONS(CBCSS)

(Regular / Supplementary / Improvement**)**

Statistics

MST2C09 : Testing of Statistical Hypotheses

Time: 3 Hours Max. Weightage: 30

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3

5. .Module 3

6. .Module 4

7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

III SEMESTER M.Sc. DEGREE EXAMINATION

STATISTICS

MST3C12: STOCHASTIC PROCESSES

Time 3 hours **Maximum Weightage: 30**

Part A

Answer any four (2 weightages each)

8. Prove that Markov chain is completely determined by the one-step TPM and the initial distribution.
9. Show that state *i* is recurrent if $\sum_{n=1}^{\infty} p_{ii}^{(n)} = \infty$ and is transient if $\sum_{n=1}^{\infty} p_{ii}^{(n)} < \infty$.
10. *What is Inspection Paradox? Explain it in the context of a renewal process.*
11. Bring out the relation between Poisson process and Binomial distribution.
12. Derive the Chapman – Kolmogorov equation.
13. Explain Stationary distribution with the help of an example.
14. Derive Poisson process. **(2x4=8 weightages)**

PART B

Answer any four (3 weightages each)

15. (a)Define recurrent and transient states.(b)State and prove the memory less property of exponential distribution.(c) Show that inter arrival times are exponentially distributed.
16. (a) Define renewal reward process.(b)Show that the number of renewals by time $t \geq n$ if and only if the n^{th} renewal occurs on or before time t.(c)Distinguish between open and closed systems.
17. (a)Differentiate between weakly stationary process and strongly stationary process.(b)Explain Markov chain as graph with the help of an example.(c)Explain Brownian motion process
18. (a)Explain Stopping Time (b)Explain Arbitrage theorem(c)Define renewal density.
19. (a)Define linear death process.(b)Derive the steady state probabilities of M/M/1 model.
20. (a)Show that the renewal function $m(t) = \sum_{n=1}^{\infty} F_n(t), \forall t,$ where $F_n(t) = P(S_n \leq t), n \geq 1, \forall\, t$.(b)Write down the steady state equations of Erlang's Loss system.
21. Let {X_n, n = 1, 2, …} be a four step Markov chain with one step TPM $\begin{bmatrix} 0.5 & 0 & 0.5 & 0 \\ 0 & 0.5 & 0 & 0.5 \\ 0.5 & 0 & 0.5 & 0 \\ 0 & 0.5 & 0 & 0.5 \end{bmatrix}$. Find the periodicities of the states.(b)If {N(t)} is a Poisson process, the derive the auto-correlation between N(t) and N($t+s$), t,s >0.

(3x4=12 weightages)

Part C

Answer any two (5 weightages each)

15.(a) Derive Pollock-Kinchins formulae. (b) Show that the renewal function satisfies renewal equation.

16.(a) State and prove central limit theorem on renewal process.(b) Define Stochastic processes and its various states with the help of examples.

18.(a). Establish the relation between probability generating functions of off spring random variable and n^{th} generation size in Galton –Watson branching Process. Derive its mean also.(b) Derive the distribution of first hitting time of a Brownian motion process

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

III SEMESTER M.Sc. DEGREE EXAMINATION

STATISTICS

MST3C12: STOCHASTIC PROCESSES

Time 3 hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3E05& Lifetime Data Analysis

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Define hazard rate. Show that the hazard rate determines the distribution uniquely.
2. Write a short note on discrete mixture models.
3. Define Nelson Aalen estimate and write down an expression for its standard error.
4. Explain progressive type II censoring.
5. Obtain an exact confidence interval for the parameter when the lifetimes follow exponential distribution.
6. Describe Wald type confidence procedures for location-scale distributions.
7. Describe generalized Wilcoxon test procedure.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Obtain the survival function and hazard function of log-logistic distribution and examine its monotone behaviors.
9. What is mean residual life function? Obtain its relationship with hazard rate. Also show that the mean residual life function uniquely determines the distribution.
10. Define Kaplan Meier estimate. Show that it can be derived as a non-parametric MLE of the survival function.
11. Explain the standard life table methods.
12. Explain how regression models can be used for comparing or testing the equality of two distributions.
13. Derive the Cox likelihood as a marginal likelihood.
14. Explain the procedures for comparing two Weibull distributions.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. Describe the general formulation of right censoring and also derive the likelihood function.
16. For the data on remission times (in days) given below obtain Kaplan-Meier estimator of survival function S(t) at t=1, 10, 29 and 60.
    1, 1, 2, 4, 4, 6, 6, 6, 7, 8, 9, 9, 10, 12, 13, 14, 18, 19, 24*, 26, 29, 31*, 42, 45*, 50*, 57, 60, 71*, 83*, 91.
    (Here * denote the censored observations).
17. Describe likelihood based methods for log-location scale distributions under censored samples.
18. Explain the linear rank tests for comparing different distributions.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3E05& Lifetime Data Analysis

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2
12. .Module 3
13. .Module 4
14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1
16. .Module 2
17. .Module 3
18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

III SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3E10 – STATISTICAL QUALITY CONTROL

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Discuss various dimensions of quality and total quality management.
2. Explain multiple sampling plan and explain its advantages and disadvantages.
3. Explain the construction of OC curve for single sampling plan.
4. Distinguish between defects and defectives. Discuss suitable control chart for number of defects and number of defectives.
5. Explain (i) extreme value charts and (ii) Economic design of control charts
6. The molecular weight of a particular polymer should fall between 2100 and 2350. Fifty samples of this material were analyzed with the results and s = 60. Assume that molecular weight is normally distributed. Check whether the process is centered at the midpoint of the specification limits.
7. Write notes on orthogonal arrays and robust quality.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Discuss curtailment and its advantages? Derive average sample number of double sampling with and without curtailment.
9. Discuss rectifying inspection. Derive the AOQ and ATI of a single sampling plan for attributes under rectifying inspection.
10. Derive the probability of acceptance for variable sampling plans with a single specification limit when lots are normally distributed with known variance.
11. Explain Continuous sampling plan? Compare CSP- I and CSP - II plans.
12. The number of nonconforming switches in samples of size 150 are given below. Construct a fraction nonconforming control chart for these data. Does the process appear to be in control?

Sample	No. of non- conforming	Sample	No. of non- conforming

number	switches	number	switches
1	6	11	7
2	4	12	13
3	4	13	0
4	1	14	9
5	3	15	5
6	7	16	1
7	8	17	4
8	10	18	5
9	5	19	7
10	2	20	12

13. Explain exponentially weighted moving average control chart. Write its advantages.
14. Explain process capability analysis. Discuss various methods for process capability analysis.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. Discuss the construction of sampling plan for variables when AQL and LTPD along with the consumer's and producer's risk are given.
16. (a) Explain the significance of acceptance sampling. Write down the advantages and disadvantages of acceptance sampling. (b) Compare Single sampling plan and double sampling plan for attributes.
17. (a) Construct control chart of mean and range for the following data and comment on the state of control. (b) Derive ARL of mean chart.

Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Sample values	42	46	66	36	57	77	87	45	45	66	87	66
	64	53	81	87	99	89	56	78	78	55	57	120
	44	75	34	60	46	56	39	34	98	48	77	33
	75	89	4	79	77	48	121	98	39	88	55	55
	86	44	75	66	44	40	56	65	65	64	97	66

(A_2 = 0.577, D_3 =0, D_4 = 2.115)

18. Explain CUSUM control charts. Distinguish between tabular CUSUM and V mask procedures.

GENERAL PATTERN OF QUESTION PAPER

III SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3E10 – STATISTICAL QUALITY CONTROL

Time: 3 Hours **Maximum Weightage: 30**

Part A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

III SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3C11 – APPLIED REGRESSION ANALYSIS

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Discuss simple linear regression model and least square estimation of its parameters.
2. State and prove Gauss – Markov theorem.
3. Discuss non – parametric regression models.
4. What are outliers? What will happen to the regression models if the data contain outliers?
5. Explain various link functions.
6. Consider the multiple linear regression model $y= \beta_0 + \beta_1 x_1 + \ldots + \beta_1 x_{n} + \varepsilon$ where $\varepsilon \sim N(0, \sigma^2)$. Prove that residual mean square is an unbiased estimator of σ^2.
7. Explain multicollinearity and serial correlation in regression model.

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. Describe the maximum likelihood method for the estimation of parameters of multiple linear regression and write the properties of estimates.
9. Explain the construction of confidence intervals in regression models.
10. Discuss the impacts of violationof normality assumption in regression models. What are the remedies to overcome this violation?
11. Compare multiple regression and stepwise regression.
12. Discuss the role of orthogonal polynomials in polynomial regression.
13. Discuss Generalized Linear Models.
14. Distinguish between linear and non-linear regression models.

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. Discuss various scaled residuals. Explain the model adequacy checking using residuals.
16. Distinguish between multiple linear and logistic regression models? Estimate the parameters of logistic regression model.
17. Explain polynomial regression in one and several variables.

18. Explain logistic regression model and Poisson regression model.

GENERAL PATTERN OF QUESTION PAPER

III SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3C11 – APPLIED REGRESSION ANALYSIS

Time: 3 Hours **Maximum Weightage: 30**

19.

PART A

Answer any four (2 weightages each)

1. .Module 1
2. .Module 2
3. .Module 2
4. .Module 3
5. .Module 3
6. .Module 4
7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1
9. .Module 1
10. .Module 2
11. .Module 2
12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

MODEL QUESTION PAPER

I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3C12&MULTIVARIATE ANALYSIS

Time: 3 Hours **Maximum Weightage: 30**

PART A

Answer any four (2 weightages each)

1. Define Singular multivariate normal distribution.

2. Define Wishart distribution.

3. Define Multiple correlation and Partial correlation coefficients.

4. Let X ~N$p(\mu;\ \Sigma)$. Write down the characteristic function of X.

5. Define generalized variance.

6. Describe sphericity test.

7. What do you mean by factor analysis?

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8.Derive the null distributions of the sample correlation coefficient and sample partial correlation coefficient.

9. If $X = (X_1,\ X_2)$is a random vector following the bivariate normal distribution

$N(\mu_1, \mu_2, \sigma_1, \sigma_2, \rho)$. Show that if $\rho = 0$, then X and Y are independent. Is the converse true?

10. Let V~ Wp(Σ,n),then find the distribution of AVA’, Where A is a square matrix of order p.

11.Let X=($X^{(1)}$, $X^{(2)}$) ~ Np(μ, Σ), find the conditional distribution of $X^{(1)}$on $X^{(2)}$. Show that the regression of $X^{(1)}$on $X^{(2)}$is linear.

12.Obtain the MLE’s of ϑ and Σ in Np(ϑ,Σ).

13. Derive the likelihood ratio test to test the equality of mean vectors of two multivariate normal distributions, when the dispersion matrices are equal and known.

14. Define canonical correlation. How would you estimate the canonical correlation and canonical variables?

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. State and prove Cochran's theorem on quadratic forms.

16. If $X \sim N_p(0; \Sigma)$, show that the quadratic form $X'AX$ follows Chi-square distribution with r d.f.iff$A\Sigma$ is idempotent of rank r.

17. (a) Derive the likelihood ratio test for testing the equality of dispersion matrices of two multivariate normal distributions. (b) Derive the distribution of Hotelling'sT^2 statistic.

18. (a) What are principal components? Discuss its properties. (b) Suppose that in a classification problem that two underlying population are normal distribution with unknown parameters μ_1, $\mu_2$and Σ (the common dispersion matrix). Obtain the classification region such that the probabilities of two misclassification are equal, given large samples from both the populations.

(5x2=10 weightages)

GENERAL PATTERN OF QUESTION PAPER

I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (CBCSS) Month & Year

Branch: Statistics

MST3C12&MULTIVARIATE ANALYSIS

Time: 3 Hours **Maximum Weightage: 30**

Answer any four (2 weightages each)

1. .Module 1

2. .Module 2

3. .Module 2

4. .Module 3

5. .Module 3

6. .Module 4

7. .Module 4

(2 x 4=8 weightages)

PART B

Answer any four (3 weightages each)

8. .Module 1

9. .Module 1

10. .Module 2

11. .Module 2

12. .Module 3

13. .Module 4

14. .Module 4

(3x 4=12 weightages)

PART C

Answer any two (5 weightages each)

15. .Module 1

16. .Module 2

17. .Module 3

18. .Module 4

(5x2=10 weightages)

Blue Print for Question Paper Setting / Scrutiny (QP-A)						
PG Programme : STATISTICS						
Course and course code: **MST1C01: ANALYTICAL TOOLS FOR STATISTICS – I**						
Total Mark: 30 Weightage						
Question Paper			**Syllabus**			
Sections or Parts	Weightage	Question Numbers	**UNIT 1**	**UNIT 2**	**UNIT 3**	**UNIT 4**
			25 Hrs	**25 Hrs**	**20 Hrs**	**20 Hrs**
			8 Weightage	**8 Weightage**	**7 Weightage**	**7 Weightage**
Expected Weightage >>>>						
I	**2**	**1**	**2**			
		2		**2**		
		3		**2**		
		4			**2**	
		5			**2**	
		6				**2**
		7				**2**
II	**3**	**8**	**3**			
		9	**3**			
		10		**3**		
		11		**3**		
		12			**3**	
		13			**3**	
		14				3
III	**5**	**15**	5			
		16		5		
		17			5	
		18				5
Actual Weightage >> >>			8	8	7	7