FAROOK COLLEGE (AUTONOMOUS)

KOZHIKODE, KERALA-673 632

SYLLABUS

M. Sc. STATISTICS

CHOICE BASED CREDIT SEMESTER SYSTEM-PG-2019
(FCCBCSS PG – 2019)

2019 ADMISSION ONWARDS

CERTIFICATE

I hereby certify that the documents attached are the bona fide copies of the syllabus of M.Sc. Statistics Programme to be effective from the academic year 2019-20 onwards.

Date: PRINCIPAL

Place: Farook College

CONTENTS

M. Sc. Statistics Programme under
Choice Based Credit Semester System
FCCBCSS PG-2019
Programme Structure & Syllabi
(With effect from the academic year 2019-2020 onwards)

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

Course Code	Type	Course Title	Credits	Class hours	Ratio Internal: External
I SEMESTER (Total Credits: 20)					
MST1C01	Core	Analytical Tools for Statistics – I	4	5	1:4
MST1C02	Core	Analytical Tools for Statistics – II	4	5	1:4
MST1C03	Core	Distribution Theory	4	5	1:4
MST1C04	Core	Probability Theory	4	5	1:4
MST1C05	Core	Statistical Computing – 1	4	5	1:4
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	1:4
MST2C07	Core	Estimation Theory	4	5	1:4
MST2C08	Core	Sampling Theory	4	5	1:4
MST2C09	Core	Testing of Statistical Hypotheses	4	5	1:4
MST2C10	Core	Statistical Computing-II	4	5	1:4
MST2A02	Audit	Professional Competency Course	4 Credits (Not included in CGPA)		
III SEMESTER (Total Credits:20)					
MST3C11	Core	Applied Regression Analysis	4	5	1:4
MST3C12	Core	Stochastic Processes	4	5	1:4
MST3E---	Elective	Elective-I	4	5	1:4
MST3E---	Elective	Elective-II	4	5	1:4
MST3C13	Core	Statistical Computing-III	4	5	1:4
IV SEMESTER (Total Credits: 20)					
MST4C14	Core	Multivariate Analysis	4	5	1:4
MST4E---	Elective	Elective-III	4	5	1:4
MST4P01	Core	Project/Dissertation and Comprehensive Viva-Voce	8(5+3)	10	1:4
MST4C15	Core	Statistical Computing-IV	4	5	1:4
		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

External Evaluation

a) The semester-end examinations in theory courses shall be conducted with question papers set by external experts. The duration shall be **3 hours** and the total weightage should be **30**.

The question paper pattern is as follows:

b) 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**

c) **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:

Project work				
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	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 on project/dissertation	40%	16	4
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.

Grading: Direct Grading System based on a 10 – Point scale is used to evaluate the performance (External and Internal Examination of students)

For all courses (Theory & Practical)/Semester/Overall Programme, Letter grades and **GPA/SGPA/CGPA** are given on the following way:

a) First Stage Evaluation for both Internal and External done by the Teachers concerned in the following Scale:

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

The Grade Range for both Internal & External shall be:

Letter Grade	Grade Range	Range of Percentage (%)	Merit / Indicator
O	4.25 – 5.00	85.00 – 100.00	Outstanding
A+	3.75 – 4.24	75.00 – 84.99	Excellent
A	3.25 – 3.74	65.00 – 74.99	Very Good
B+	2.75 – 3.24	55.00 – 64.99	Good
B	2.50 – 2.74	50.00 – 54.99	Above Average
C	2.25 – 2.49	45.00 – 49.99	Average
P	2.00 -2.24	40.00 – 44.99	Pass
F	< 2.00	Below 40	Fail
I	0	-	Incomplete
Ab	0	-	Absent

No separate minimum is required for internal evaluation for a pass, but a minimum **P** Grade is required for a pass in the external evaluation. However, a minimum **P grade** is required for pass in a course.

SYLLABI OF CORE COURSES

SEMESTER- I

MST1C01: ANALYTICAL TOOLS FOR STATISTICS – I (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 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. 20 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 (Credits: 4, Hours per week: 5)

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. 15 hours

Unit-II- Algebra of Matrices

Linear transformations and matrices, 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. 25 hours

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. 25 hours

Unit- IV- Linear equations generalized inverses and quadratic forms

Homogenous system, general system, Rank Nullity Theorem (statement only), 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. 25 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 (Credits: 4, Hours per week: 5)

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. 20 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. 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, Multivariate distributions, Inequalities and Identities. Order statistics. 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. 30 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 (Credits: 4, Hours per week: 5)

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. 20 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.

25 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. 25 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. 20 hours

Text book

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.

MST1C05: STATISTICAL COMPUTING-I (Credits: 4, Hours per week: 5)

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 the centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed by the College 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 (Credits: 4, Hours per week: 5)

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 co-variance for completely randomized and randomized block designs. Analysis of experiments with missing observations. 25 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. 25 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 20 hours

Unit-IV: Response surface designs, Orthogonality, Rotatability blocking and analysis - Method of Steepest accent, Models properties and Analysis. 20 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.

MST2C07: ESTIMATION THEORY (Credits: 4, Hours per week: 5)

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.

30 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. 20 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. 25 hours

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

15 hours

Text books

1. **Kale,B.K** .(2005)..A first course in parametric inference, Second Edition, NarosaPublishing 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, JohnWiley and sons, New York.

MST2C08: SAMPLING THEORY (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 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. 20 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 (Credits: 4, Hours per week: 5)

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. 25 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.

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.

25 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. 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 (Credits: 4, Hours per week: 5)

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 or 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 the centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed by the College 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 (Credits: 4, Hours per week: 5)

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.

25 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.

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. 25 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. 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 (Credits: 4, Hours per week: 5)

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. 20 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. 25 hours

Unit-III: Renewal processes-limit theorems and their applications. Renewal reward process. Regenerative processes, Semi-Markov process. The inspection paradox, Insurers ruin problem. 20 hours

Unit-IV: Basic characteristics of queues – Markovian models – network of queues. The M/G/I system. The G/M/I model, Multi server queues. Brownian motion Process – hitting time – Maximum variable – variations on Brownian motion – Pricing stock options – Gaussian processes – stationary and weakly stationary processes. 25 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 (Credits: 4, Hours per week: 5)

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 or 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 the centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed by the College 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 (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 20 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. 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.

MST4P01: PROJECT/DISSERTATION AND COMPREHENSIVE VIVA-VOCE (Credits: 8) ***[5 credits for Project/Dissertation and 3 credits for Comprehensive Viva-Voce]*** **(Hours per week : 10)**

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 College, 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. 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.

MST4C15: STATISTICAL COMPUTING-IV (Credits: 4, Hours per week: 5)

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 or 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 the centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed by the College 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 (Credits: 4, Hours per week: 5)

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. 30 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. 25 hours

Unit-III: Integer programming: Cutting plane methods, branch and bound technique, application of zero – one programming. 20 hours

Unit-IV: Game theory: two person zero sum games, minimax theorem, game problem as a linear programming problem. Co-operative and competition games. 15 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 (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 25 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. 15 hours

Text Books

1. **Box G.E.P and Jenkins G.M. (1970).** Time Series Analysis, Forecasting and Control. Holden-Day
2. **BrockwellP.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 (Credits: 4, Hours per week: 5)

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. 20 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. 25 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. 20 hours

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. 25 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.

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E04: QUEUEING THEORY (Credits: 4, Hours per week: 5)

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. 20 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/E_k/1 and E_k/M/1. A brief discussion of priority queues. 25 hours

Unit-III. Queueing networks-series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non Jackson networks. 20 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/E_k/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities. 25 hours

References

1. **Gross, D. and Harris, C.M.(1985).** Fundamentals of Queueing Theory, 2nd Edition, John Wiley and Sons, new York.
2. **Kleinrock L (1975).** Queueing Systems, Vol. I &Vol 2, Joohn Wiley and Sons, New York.
3. **Ross, S.M. (2007).** Introduction to Probability Models. 9th Edition, Academic Press, New York.
4. **Bose, S.K. (2002).** An Introduction to Queueing Systems, Kluwer Academic/Plenum Publishers, New York.

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E05: LIFETIME DATA ANALYSIS (Credits: 4, Hours per week: 5)

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. 20 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. 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. 25 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. 25 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 (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 20 hours

Unit-IV: Record values - definition, properties, distribution of nth record, record values from exponential, Weibull and logistic; Moments relationships, characterizations. 20 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 (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 20 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 (Credits: 4, Hours per week: 5)

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. 20 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. 25 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. 25 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. 20 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 (Credits: 4, Hours per week: 5)

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.

25 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.

20 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. 25 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 (Credits: 4, Hours per week: 5)

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. 20 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. 25 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. 25 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 (Credits: 4, Hours per week: 5)

Unit-I: Review of Elementary Probability theory, Basic properties of expectations, Sequences of integrals, Lebesgue-Stieltjes integrals, Weak convergence - Theorems. 25 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. 25 hours

Unit-III: More on Infinitely divisible distributions, Convergence under UAN, Convergence to special distributions, Cauchy functional equation, Stable distributions. 20 hours

Unit-IV: Conditional expectations (general case), Random-Nikodyn theorem, Martingales, Doob's decomposition, L_P -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.

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E12: OFFICIAL STATISTICS (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 20 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 (Credits: 4, Hours per week: 5)

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). 25 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. 25 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. 20 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 OrientedApproach, 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.: AnIntroduction, Springer.
5. **Friedman, L.M., Furburg, C.** and**DeMets, D.L. (1998).** Fundamentals of Clinical Trials,SpringerVerlag.
6. **Gross, A. J.** and **Clark V.A. (1975).** Survival Distribution; Reliability Applications inBiomedical 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, JohnWiley &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 inClinical Trials. Chapman & Hall/CRC Biostatistics Series.

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

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

15. **Hu, Feifang and Rosenberger, William (2006).** The Theory of Response-AdaptiveRandomization 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 (Credits: 4, Hours per week: 5)

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. 20 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. 20 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. 25 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. 25 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, NewYork.

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(secondedition), Prentice-Hall, India.

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E15: DEMOGRAPHIC TECHNIQUES (Credits: 4, Hours per week: 5)

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. 25 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. 25 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. 20 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 (Credits: 4, Hours per week: 5)

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. 25 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. 25 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 20 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. 20 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 Lt

E17: LONGITUDINAL DATA ANALYSIS (Credits: 4, Hours per week: 5)

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. 25 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. 25 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). 20 hours

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. 20 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, 2nd Edn. Oxford University press, New York.

2.**Fitzmaurice, G.M., Laird, N.M and Ware, J.H.(2004).**Applied Longitudinal 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 (Credits: 4, Hours per week: 5)

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. 25 hours

Unit-3: Artificial neural networks and extensions of regression models, regression trees. Introduction to databases, including simple relational databases. 20 hours

Unit-4: Data warehouses and introduction to online analytical data processing. Association rules and prediction; data attributes, applications to electronic commerce. 25 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. (MorganKaufmann.)
4. **Mitchell, T.M. (1997).** Machine Learning. (McGraw-Hill.)
5. **Ripley, B.D. (1996).** Pattern Recognition and Neural Networks. (CambridgeUniversity Press).

MODEL QUESTION PAPER
I/II/III/IV SEMESTER M. Sc. DEGREE EXAMINATION (FCCBCSS) 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 FCCBCSS - 2019

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.

SEMESTER I

MST1A01: Ability Enhancement Course (AEC) (Credits :4)

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.

SEMESTER II

MST2A02: Professional Competency Course (PCC) (Credits:4)

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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