INSTITUTE OF SCIENCE, NAGPUR.

(An Autonomous Institute of Government of Maharashtra)

DEPARTMENT OF STATISTICS

Syllabus

Master of Science (M.Sc.) Semester Pattern

STATISTICS

(STA/ PG/2021/01)

(To be Implemented from 2021-2022)

M.Sc. (Semester Pattern) Syllabus

Semester wise Name of Papers

Subject - Statistics

Semester	Paper	Name of the Paper	Paper Code
I	I	ELEMENTS OF MATHEMATICAL	**MSFS11**
	II	DISTRIBUTION THEORY	**MSFS12**
	III	ESTIMATION THEORY	**MSFS13**
	IV	SAMPLING THEORY	**MSFS14**
	Laboratory Coursework Practical (if applicable	PRACTICAL – I	**MSFS15**
		PRACTICAL – II	**MSFS16**
		SEMINAR	**MSFS17**
II	I	PROBABILITY THEORY	**MSFS21**
	II	ELEMENTARY STOCHASTIC	**MSFS22**
	III	TESTING OF HYPOTHESIS	**MSFS23**
	IV	LINEAR MODELS AND DESIGNS	**MSFS24**
	Laboratory Coursework Practical (if applicable)	PRACTICAL – I	**MSFS25**
		PRACTICAL – II	**MSFS26**
		SEMINAR	**MSFS27**
III	I	DECISION THEORY AND NON PARAMETRIC	**MSSS31**
	II	LINEAR AND NONLINEAR MODELING	**MSSS32**

	III	CORE ELECTIVE I	**MSSS33**
		A - Industrial Process and Quality Control	*MSSS33A*
		B - Survival Analysis	*MSSS33B*
		C - Demography	*MSSS33C*
		D - Time Series Analysis	*MSSS33D*
	IV	CORE ELECTIVE II	**MSSS34**
		A - Mathematical Programming	*MSSS34A*
		B - Data Mining	*MSSS34B*
		C - Bioassay	*MSSS34C*
	Laboratory Coursework Practical (if applicable)	PRACTICAL – I	**MSSS35**
		PRACTICAL – II	**MSSS36**
		SEMINAR	**MSSS37**
IV	I	MULTIVARIATE ANALYSIS	**MSSS41**
	II	COMPUTATIONAL STATISTICS	**MSSS42**
	III	CORE ELECTIVE III	**MSSS43**
		A - Industrial Statistics	*MSSS43A*
		B - Reliability Theory	*MSSS43B*
		C - Statistical Genetics	*MSSS43C*
		D - Stochastic Models in Finance	*MSSS43D*

	IV	CORE ELECTIVE IV	**MSSS44**
		A - Operations Research	*MSSS44A*
		B - Actuarial Statistics	*MSSS44B*
		C - Statistical Ecology	*MSSS44C*
	Laboratory Coursework Practical (if applicable)	PRACTICAL – I	**MSSS45**
		PROJECT	**MSSS46**
		SEMINAR	**MSSS47**

Ex. MSSS32 : M -M.Sc, S-Statistics , S-Second Year, S3- Semester-3, 2- Subject Paper-2

Marking Scheme of Syllabus

Faculty of Science M.Sc. Semester-I to IV (Statistics)

Semester	Paper	Total Periods / Week	Marks		Total Marks	Credits
			Theory / Practical	Internal		
I to IV	I	04	80	20	100	4
	II	04	80	20	100	4
	III	04	80	20	100	4
	IV	04	80	20	100	4
	Laboratory Course (Practical) If Applicable	Practical – I	60	40	100	4
		Practical – II / Project	60	40	100	4
		Seminar	25		25	1
Total					625	25

Explanatory Terms

1 Core compulsory: Main theory papers in the concerned subjects

2 Core Elective I and II: These papers will be specialization in the concerned subject

3. Project/ Review writing: Project / Review writing is in semester IV

4. Seminar: The Seminar in Semester shall be presented by the candidates in his/her parent department only.

General Rules and Regulations regarding pattern of question paper

A] Pattern of Question Papers

1. There will be four units in each paper.
2. Question paper will consist of five questions.
3. Four questions will be on four units with internal choice (one question on each unit)
4. Fifth question will be compulsory with questions from each of the four units having equal weight age and there will be no internal choice.
5. Maximum marks of each paper will be 80.
6. Each paper will be of three hours duration
7. Projects shall be evaluated by both Internal and External examiners.
8. Practical / laboratory examination of 100 marks. Distribution of marks shall be 20 internal and 80 external.
9 Minimum passing marks in each head (theory, practical & project) will be 40%.

B] Duration of practical examination will be of four – five hours
Distribution of marks of practical examination of 100 marks will be as follows:

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Practical performance	Viva Voce	Practical Record	Total
60	20	20	100

C] Project Work:
Project work will carry **100 marks** and distribution of these 100 marks will be as follows.
For written project work: **40 Marks**- Evaluated jointly by External and Internal Examiner
Presentation: **20 Marks**- Evaluated jointly by External and Internal Examiner
Internal Assessment: **20 Marks**- Evaluated by Internal Examiner
Viva Voce: **20 Marks**- Evaluated by External Examiner

SUBJECT: STATISTICS

M.Sc. – I SEMESTER - I

MSFS11: PAPER I - ELEMENTS OF MATHEMATICAL ANALYSIS

OBJECTIVES:

Learning Statistics requires a strong mathematical background. This course is designed to include the mathematical concepts that are useful in learning basic concepts in statistics. The course includes topics like matrix algebra, measure theory etc.

OUTCOMES:

At the end of the course , students become well versed with,

1. Students get knowledge of the mathematical concepts that are used as tool to understand the basic concepts in statistics.
2. Students learn matrix algebra which is a tool for understanding the branch of statistics called Multivariate Analysis, Linear modelling and many others.
3. Students learn measure theory which helps them in understanding the concept of probability as a measure.
4. Students learn measurable functions which helps them in understanding the concept of random variables as measurable functions. These two are very basic and important concepts in statistics.

Unit-I **(15 Hrs)**

(A) Real valued functions. Riemann and Riemann Stieltijes integral, Integration by Parts, mean value theorem. Elements of complex integration, Analytic function, definition of line integral, Cauchy integration formula, Residue theorem.

Unit-II **(15 Hrs)**

(B) Matrix algebra: characteristic roots of real matrices, right and left characteristic vectors. Independence of characteristic vectors their multiplicities. Generalized inverse, Definiteness of a real quadratic form Reduction to quadratic form.

Unit-III **(15 Hrs)**

(C) Sets : Classes of sets, Sequences of sets, lim sup and liminf of sequences of sets, field, □-field, □field generated by a class, Borel□- field. Set functions, additive set functions & their properties. Measure, Measure spaces, Measurable function, simple function, Integral of measure function w.r.t. measure.

Unit-IV **(15 Hrs)**

(D) Sequences of measurable functions, convergence a.e. and in measure. Monotone convergence theorem, Fatous lemma, Dominated convergence theorem and their application**.**

SUBJECT: STATISTICS

M.Sc. – I SEMESTER - I

MSFS12: PAPER II - DISTRIBUTION THEORY

OBJECTIVES:

The entire analysis in statistics is based on probability distribution of the random variable under consideration. The course includes a study of some basic standard discrete and continuous distributions along with their properties. Besides, important concepts like truncated and mixture distributions are also introduced. The concept and distributional properties of order statistic is also introduced in this course

OUTCOMES:

At the end of the course , students become well versed with,

1. Students will get knowledge of some basic standard discrete and continuous distributions along with their properties.
2. Students also learn the applications of the random variables studied in real life situations. Students develop the ability to test whether the given random variable follows any of the standard distributions based on which further analysis can be done.
3. Students will get knowledge about some sampling distributions with their applications and some useful inequalities.
4. Students learn the concept of truncation and mixture distributions and also an important concept of order statistics. These concepts are useful in many areas like Actuarial Science, Telecommunication and in non-parametric density estimation.

Unit-I **(15 Hrs)**

(A) Brief review of basic distribution theory, joint, marginal and conditional pmfs and pdfs, conditional expectation. Some discrete distributions - Binomial, Poisson, negative binomial, geometric, uniform, multinomial and hyper geometric distribution. Comparison between binomial and hyper geometric distributions.

Unit-II **(15 Hrs)**

(B) Continuous distributions- Normal, bivariate normal, exponential uniform. Functions of random variables and their distributions. Joint distribution of sample and induced sampling distribution of a statistic. Beta, Gamma, Cauchy, Log-normal, Weibull, Laplace distributions. Chi-square distribution and its properties

Unit-III **(15 Hrs)**

(C) t and F distributions and their properties and applications. Markov, Holder, Jensen, Liaponov inequalities. Approximating distributions of sample.

Unit-IV **(15 Hrs)**

(D) Compound, truncated and mixture distributions. Distributions of quadratic forms under normality and related distribution theory. Order statistics, their distribution and their properties, joint and marginal distribution of order statistics. Extreme values and their asymptotic distributions. (statement only) with applications.

SUBJECT: STATISTICS

M.Sc. – I SEMESTER - I

MSFS13: PAPER III - ESTIMATION THEORY

OBJECTIVES:

Estimation theory is an important part of statistical Inference. The objective of this course is to train the students in obtaining point and interval estimate of the parameter based on given data.

OUTCOMES:

At the end of the course, students become well versed with,

1. The basic problem of estimation, various methods of estimation and properties that are to be satisfied by a good point estimator.
2. Students get knowledge of sufficiency based on the concept of information and CR inequality is used in getting MVUE.
3. Methods to improve an unbiased estimator to MVUE.
4. Construction of confidence interval of the parameters of various distributions.

Unit-I **(15 Hrs)**

(A) Problem of Point estimation, unbiased estimator, minimum variance unbiased estimator (MVUE), consistent estimator's likelihood function Methods of estimation: Maximum likelihood, Minimum chi square, method of moments. Method of scoring, Properties of maximum likelihood estimator.

Unit-II **(15 Hrs)**

(B) Fisher information and information matrix, Cramer Rao inequality Sufficiency Principle, Factorization theorem, minimal sufficiency, construction of minimal sufficient statistic, minimal sufficient statistic for exponential family.

Unit-III **(15 Hrs)**

(C) Rao-Blackwell theorem, completeness, bounded completeness, Lehman-Scheffe theorem and their use. Pitman's family, Minimal sufficiency in Pitman family

Unit-IV **(15 Hrs)**

(D) Interval estimation: Confidence level , construction of confidence intervals using Pivots. Uniparametric case multi-parametric case (up to 2 parameters)

SUBJECT: STATISTICS

M.Sc. – I SEMESTER - I

MSFS14: PAPER IV - SAMPLING THEORY

OBJECTIVES:

Statisticians draw conclusion on the basis of samples. The conclusions are close to reality only when they are based on a sample which is a proper representative on the population. This course is designed to train the students to obtain an appropriate sample in any given situation.

OUTCOMES:

At the end of the course, students become well versed with,

1. Students will get knowledge about various methods of sampling like SRSWOR, SRSWR, Stratified random sampling, Cluster sampling, systematic sampling etc.
2. Students will get knowledge about the efficiency of one method of sampling with respect to the other so that in any given situation, they will be able to apply an appropriate method of sampling.
3. They also learn about ratio method of estimation and regression method of estimation when the data on the associated variable is also available along with a study variable.
4. Students also get knowledge about Warner's model of randomized response technique and two stage sampling.

Unit-I **(15 Hrs)**

(A) Basic methods of sample selection: - Simple random sampling with replacement, Simple random sampling without replacement & Sampling with replacement. Unequal probability sampling: PPS WR/WOR (including Lahiri's scheme) and related estimators of finite population mean (Hansen – Horvitz and Des-Raj estimators for general sample size and Murthy's estimators for a sample of size two.) Horvitz Thompson's estimator

Unit-II **(15 Hrs)**

(B) Stratified random sampling: Estimation of population mean, total and variance, Allocation problem and estimation problem, Construction of strata and number of strata, Systematic sampling and comparison with SRS and stratified random sampling.

Unit-III **(15 Hrs)**

(C) Use of supplementary information for estimation: - Ratio and Regression method of estimation based on SRSWOR. Unbiased ratio estimate. Cluster sampling, equal and unequal sizes, Two stage sampling with equal number of second stage units.

Unit-IV **(15 Hrs)**

(D) Double sampling for estimating strata sizes in ratio and regression method of estimation. Randomized response technique (Warners model, Related and Unrelated questionnaire methods.)

MSFS15: PRACTICAL COURSE I

List of Practicals

1). Fitting of truncated Binomial distribution

2). Fitting of truncated Poisson distribution

3). Drawing a random sample from a bivariate normal distribution

4). Estimation of μ and σ using random sample

5). Estimation using Minimum chi-square method

6). Problems on method of Maximum likelihood

7). Problems on Method of Moments

8). Problems on UMVUE

9). Problems on Confidence Intervals for mean and difference of means

10). Problems on Confidence Intervals for proportions and sample size

11). Confidence Intervals for variance and ratio of variances

MSFS16: PRACTICAL COURSE II

List of Practicals

1). Simple Random Sampling
2). Simple Random Sampling with varying Probability with Replacement
3). Ratio and Regression estimate of population mean and standard error in case of SRS
4). Des-Raj and Horvitz-Thompson estimator
5). Hartley Ross estimator
6). Cluster sampling with unequal cluster sizes
7). Problems on Two Stage sampling
8). Estimation of population mean and variances using Double sampling

MSFS17: SEMINAR

Topics will be selected by students

SUBJECT: STATISTICS

M.Sc.– I SEMESTER - II

MSFS21: PAPER I - PROBABILITY THEORY

OBJECTIVES:

A majority of topics in Statistics depend upon a strong foundation of Probability theory. It also serves as base for applied probability theory. Another basic concept is that of a random variable, its distribution and associated properties. Sequences of random variables is also a part of this course so that asymptotic or long run behaviour of the sequence can be studied.

OUTCOMES:

At the end of the course, students become well versed with,

1. Students learn the concept of probability as a measure and its various properties. Besides this, they learn the concept of random variable, its types, probability distribution, cumulative distribution function, and its various properties.
2. Types of convergences for sequences of random variables and their inter-relationships. Weak and strong law of large numbers based on the above types of convergence
3. Concept and importance of Central Limit Theorem which helps in understanding the limiting behaviour and the concept of characteristic function and its properties.
4. This course gives a strong base for advanced theoretical as well as advanced applied probability.

Unit-I **(15 Hrs)**

(A) Probability measure on a sigma field Probability space, Properties of Probability measure, Continuity, mixture of Probability Measures Axiomatic definition of Probability. Independence of two events and more than two events Mutual independence sequence of independent events, independent classes of events, Borel-Cantelli lemma, Random variables, Expectation of random variables, Linear Properties of expectations.

Unit-II **(15 Hrs)**

(B) Distribution function and its properties. Convergence of a sequence of rvs, convergence a.s, convergence in probability convergence in distribution, convergence in rthmean their interrelations, Yule-Slutsky results

Unit-III **(15 Hrs)**

(C) Weak and Strong law of large numbers; Chebyshev Weak Law of large numbers Khinchins weak law of large numbers, Kolmogorov strong law of large numbers (statement only). Kolmogorov inequality.

Unit-IV **(15 Hrs)**

(D) Characteristic function, simple properties Inversion theorem and uniqueness Property, Continuity theorem. Central limit theorem – De-Moivre Laplace, Lindeberg Levy, Lindeberg-Feller (Sufficiency only)

SUBJECT: STATISTICS

M.Sc.– I SEMESTER - II

MSFS22: PAPER II - ELEMENTARY STOCHASTIC PROCESSES

OBJECTIVES:

Almost all processes that we come across in real life are stochastic in nature. The course includes some basic standard stochastic processes which help in understanding the real life situations. Many processes are observed to be Markovian in nature. Study of such processes is also included in this course.

OUTCOMES:

At the end of the course, students become well versed with,

1. The definition of stochastic processes and its classification. Markov chain and its applications in different areas, Classification of states and various results associated with Markov Chain.
2. Random walk model, birth processes, death processes and their applications in life sciences. They also learn birth and death processes and its direct application in queuing theory.
3. Poisson processes, Wiener processes, etc. They also learn about their applications in physical sciences.
4. Renewal theory in discrete and continuous time and branching processes.

Unit-I **(15 Hrs)**

(A) Definition of Stochastic Process, Classification of Stochastic processes according to state space and time domain. Examples of various Stochastic Processes. Definition of Markov Chain, Examples of Markov Chain Formulation of Markov Chain models, initial distribution, Stationary transition Probability Matrix, Chapman-Kolmogorov equation, calculation of n-step transition probabilities. Classification of states, closed and irreducible classes, transient, recurrent, and null states, Periodic States, Criteria for the various types of states, Ergodic theorem.

Unit-II **(15 Hrs)**

(B) Algebraic treatment for finite Markov chains.Random walk and Gambler's Ruin problem Absorbing and reflecting barriers. First Passage Probability.Expected duration of game.Random walk in 2 and 3 dimensions.

Unit-III **(15 Hrs)**

(C) Discrete state space continuous time Markov Chain, Poisson Process, Pure birth process, pure death process, Birth and death process. Continuous state space continuous time Markov chain :Kolmogrov's equation Wiener process as a limit of random walk model, properties of Wiener process. Covariance stationary processes.

Unit-IV **(15 Hrs)**

(D) Renewal Theory: Renewal process in discrete time, Renewal process in continuous time, Renewal equation, Elementary renewal theorem and its applications. Poisson process as a renewal process, study of residual life time processes, current life time and total life time. Branching process: Galton-Watson branching process for the size of nth generation, the relation between the generating function, probability of ultimate extinction, distribution of population size.

SUBJECT: STATISTICS

M.Sc.– I SEMESTER - II

MSFS23: PAPER III - TESTING OF HYPOTHESIS

OBJECTIVES:

There are some standard statistical methods useful in testing various types of hypotheses. These methods are widely used in almost all disciplines. Sometimes we need to construct a test procedure if the situation is not as required in the standard methods. The course includes basic lemma useful in construction of the test. The test procedure also changes according to the nature of null hypothesis, alternative hypothesis, the distribution of a random variable under consideration etc. The course helps in constructing most powerful or uniformly most powerful tests for different types of hypotheses for any given distribution. Some situations require sequential test procedure.

OUTCOMES:

At the end of the course, students become well versed with,

1. A good understanding of the concept of hypotheses helps the students to differentiate between types of hypotheses like, null and alternative, simple and composite, one sided and two sided etc.
2. They learn about the two types of errors committed while constructing any test and the probabilities associated with them.
3. They also learn basic Neyman-Pearson lemma used in construction of most powerful test for testing simple null hypothesis against simple alternative hypothesis. Besides this, they learn about its extension in construction of uniformly most powerful Test.
4. The students become well versed in the construction of unbiased test where UMP test does not exist . They also learn about similar test, test with Neyman structure and sequestial test procedure SPRT.

Unit-I **(15 Hrs)**

(A) Test of hypothesis, concept of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test in the class of size □ tests. N.P lemma, MP test for simple against simple alternative hypothesis.

Unit-II **(15 Hrs)**

(B) UMP tests for simple null hypothesis against one sided alternative and for one sided null against one sided alternative in one parameter exponential family. Extension of the above results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property.Non existence of UMP test for simple null against two-sided alternatives in one parameter exponential family.

Unit-III **(15 Hrs)**

(C) Likelihood ratio test. Asymptotic distribution of LRT statistics (without proof). Wald test, Rao's score test, Pearson's chi-square test for goodness of fit. Bartlett's test for homogeneity of variances. (without proof).

Unit-IV **(15 Hrs)**

(D) Sequential testing. Sequential probability ratio test. Relation among parameters Application of SPRT to Binomial, Poisson, Normal Distribution. Generalized Neyman Pearson lemma (Statement only), unbiased test, UMPUT and their existence in case of exponential family similar tests and tests with Neyman structure.

SUBJECT: STATISTICS

M.Sc.– I SEMESTER - II

MSFS24: PAPER IV - LINEAR MODELS AND DESIGNS

OBJECTIVES:

Design of Experiments is a systematic method to determine the relationship between factors affecting a process and its output. It is useful in understanding cause and effect relationships. This is useful in managing inputs that will be reflected as variations in outputs. It is used in areas like agriculture, Psychology, medicine, engineering, biochemistry etc.

OUTCOMES:

At the end of the course, students become well versed with,

1. They learn basic design like CRD, RBD, LSD, techniques of estimating missing values (if any) in the data.
2. Use of BIBD and its various types such as RBIBD, ARBIBD, SBIBD and Youden square design,
3. They learn use of factorial experiments as per the requirement of the situation where the effects of treatments are studied at two levels and their interactions.
4. Use of confounding in factorial experiments to maintain homogeneity of the block. Concept of double confounding.

Unit-I **(15 Hrs)**

(A) Gauss- Markov theorem, Analysis of variance, elementary concepts (one and 2 way classified data) Review of elementary design (CRD, RBD, LSD) Missing plot technique in RBD and LSD with one and two missing values (only estimation of missing values)

Unit-II **(15 Hrs)**

(B) BIBD : Elementary parametric relations, Analysis. Definitions and parametric relations of SBIBD, RBIBD ARBIBD, PBIBD. Youden square design - Definition and analysis.

Unit-III **(15 Hrs)**

(C) Analysis of covariance of one way and two way classified data., split plot design: construction and analysis. General factorial experiments, factorial effects, best estimates and testing the significance of factorial effects, study of 23 and 24 factorial experiments in RBD.

Unit-IV **(15 Hrs)**

(D) Confounding in factorial experiments, complete and partial confounding. Simultaneous confounding, double confounding concept of generalized interaction.

MSFS25: PRACTICAL COURSE I

List of Practicals

1). Problems on Markov chain
2). Classification of states
3). Markov chain with absorbing barriers
4). Problems on Poisson process
5). Problems on classification of states
6). Determination of n step probability
7). Tracing of sample path
8). Problems on size and power of test
9). Problems on most powerful test
10). Construction of uniformly most powerful test

MSFS26: PRACTICAL COURSE II

List of Practicals

1). Analysis of missing data in RBD
2). Analysis of missing data in LSD
3). Analysis of covariance for one way classification
4). Analysis of covariance for two way classification
5). Analysis of BIBD
6). Analysis of Youden square Design
7). Analysis of 2^3 and 2 factorial experiment without confounding
8). Analysis of completely confounded factorial experiment
9). Analysis of partially confounded factorial experiment
10). Analysis of Split Plot Design

MSFS27: SEMINAR

Topics will be selected by students

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - III

MSSS31: PAPER I - DECISION THEORY AND NON PARAMETRIC METHODS

OBJECTIVES:

Decision making is very important in all walks of life. The statistical aspect of decision making is based on the risk involved in any decision. There are methods which come out with the decision having minimum risk. The objective here is to introduce the topic to the students giving only basic knowledge of it. There are many real life situations where the assumptions required for the application of parametric statistical methods are not satisfied. Nonparametric inference is a branch of statistics which has solutions in such situations. The course includes various non-parametric methods.

OUTCOMES:

At the end of the course, students become well versed with,

1. To formulate decision making problem, methods to solve the problem by defining decision functions and risks involved and the methods of minimizing the risk.
2. How and when to apply various non-parametric methods to different types of data for testing various types of hypotheses.
3. Various nonparametric tests for one sample, paired samples and two independent samples problem.
4. Concept of censoring the data, its need and its types. Parametric and nonparametric methods of analyzing the censored data.

Unit-I **(15 Hrs)**

(A) Decision problem, loss function, expected loss, decision rules (nonrandomized and randomized), decision principles (conditional Bayes, frequentist) inference and estimation problems as decision problems, criterion of optimal decision rules. Concepts of admissibility and completeness, Bayes rules, minimax rules, admissibility of Bayes rules.Existence of Bayes decision rules.

Unit-II **(15 Hrs)**

(B) Definition of non-parametric test, Advantages and disadvantages of Non-parametric tests. Single sample problems :

a) test of randomness

b) test of goodness of fit : Empirical distribution function. Kolmogorov – Smirnov test, □2 test, Comparison of □2 test & KS test

c) One sample problem of location : sign. Test, Wilcoxon's signed rank test, ilcoxons paired sample signed rank test

Unit-III **(15 Hrs)**

(C) Two sample problems: different types of alternatives, sign test, Wilcoxons two sample rank sum test, Wald-Wolfowitz run test, Mann-Whitney-Wilcoxons test, Median test, KS-two sample test. Klotz Normal score test. One sample U-statistic, Kernel and symmetric Kernel Variance of U-Statistic, two-sample U-statistic, Linear rank statistics and their distributional properties under null hypothesis.

Unit-IV **(15 Hrs)**

(D) Concept of time order and random censoring, likelihood in these cases, survival function, hazard function Non-parametric Estimation of Survival function, Cox's proportional hazards model, the actuarial estimator, Kaplan – Meier Estimator

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - III

MSSS32: PAPER II - LINEAR AND NONLINEAR MODELING

OBJECTIVES:

Regression analysis is the most common statistical modelling approach used in data analysis and it is the basis for advanced statistical modelling.

The objective of this course is to impart knowledge about the use different useful tools used in regression analysis. The relationship between variables can be of different types like linear, nonlinear etc. The relationship is represented in terms of a model. The adequacy of any model can be checked using residual plots and residual analysis. Appropriate statistical tools are required to check for the violations of model assumptions and for dealing with problems of multicollinearity etc..

OUTCOMES:

At the end of the course, students become well versed with,

1. Linear and Multiple regression.
2. To interpret different types of plots such as residual plots, normal probability plots etc. To check for the violations of model assumptions using residual analysis and other statistical tests.
3. To differentiate between linear and nonlinear regression under given situation.
4. Generalized Linear Models including logistic

Unit-I **(15 Hrs)**

(A) : MultipleLinear regression : Model assumptions and checking for the violations of model assumption., Residual analysis – definition of residuals, standardized residuals, residual plots, statistical tests on residuals, Press statistics. Transformation of variables, Box-Cox power transformation.

Outliers : Detection and remedial measures, Influential observations : leverage, measures of influence, Cook's D, DFITS AND DFBETAS.

Unit-II **(15 Hrs)**

(B) Multicolinearity : Concept and definition of M.C., sources of M.C. consequences of M.C. identification of M.C. using the correlation matrix, VIF remedial measures (collecting additional data, model respecification,), concept of ridge regression. Auto correlation: consequences, Durbin-Watson test, Estimation of parameters in the presence of autocorrelation.

Unit-III **(15 Hrs)**

(C) Variable selection : Problem of variable selection, criteria for evaluation subset regression models (choosing subsets), coefficient of multiple determination, residual mean square, Mallow's Cp Statistics. Computational Techniques for variable selection-Forward selection, Backward elimination, stepwise regression.

Non-linear regression: Difference between Linear and Non-Linear Regression Models, transformation to a linear model, Intrinsically linear and non-linear models. Parameter estimation using the Newton-Gauss method, Hypothesis testing.

Unit-IV **(15 Hrs)**

(D) Generalized linear models : Exponential families, Definition of GLM, Link function, Estimation of parameters and inference in GLM. Logistic regression model : Link function, logit, probit, complementary log-log, estimation of parameters, odds ratio, hypothesis testing using model deviance.

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - III

MSSS33: PAPER III - CORE ELECTIVE I

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS33A - INDUSTRIAL PROCESS AND QUALITY CONTROL

OBJECTIVES:

In industry, it is important to maintain quality of the product. The quality of the product can be checked with the help of quality control techniques available in statistics. The course includes various methods for monitoring the quality of the product. The control charts can be used to monitor quality of product, process, and services in various disciplines.

OUTCOMES:

At the end of the course, students become well versed with,

1. Various control charts for measurements and attributes useful in industries.
2. EWMA charts, multivariate control charts.
3. Concept of six sigma and its importance.
4. Principle of acceptance sampling problem, various acceptance sampling plans.

Unit-I **(15 Hrs)**

(A) Basic concept of process monitoring General theory and review of Shewhart control charts for measurements and attributes (p, d = np, C, X and R chart) O.C. and ARL for X control chart. General ideas on economic designing of control chart. Assumptions and costs. Duncan's model for the economic design of X chart. Moving average and exponentially weighted moving average charts. Cu-sum charts using v masks and decision intervals.

Unit-II **(15 Hrs)**

(B) Classification of nonconformities and their weighting modification of the c chart for Quality scores and Demerit classifications, Q chart for no. of nonconformities per (u chart) Multivariate Quality control. Hotelling'sT2.

Unit-III **(15 Hrs)**

(C) Concept of six sigma. Evolution of six sigma Quality approach practical approach to six sigma quality Basic steps involved in application of six sigma Define-measure-Analyzeimprove and control approach, Barriers in implementation of six sigma in Indian manufacturing industries (small and medium enterprises). Impact of six sigma in a developing economy.

Unit-IV **(15 Hrs)**

(D) Principle of acceptance sampling problem of lot acceptance. Acceptance sampling plans for attributes. Single double and sequential sampling plans and their properties Dodge Romig sampling plans for attributes (AOQL and LTPD),MIL std plans, continuous sampling plans, Dodge type CSPI, CSPII and CSPIII .

MSSS33: PAPER III - CORE ELECTIVE I

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS33B - SURVIVAL ANALYSIS

OBJECTIVES:

Life time is an important random variable observed in epidemiology, and various industries. The analysis of this variable is studied in survival analysis. Depending upon the distribution of life time, there are separate statistical methods for this kind of analysis . In survival analysis the data is many times a censored data.

OUTCOMES:

At the end of the course, students become well versed with,

1. Types of censoring and estimation of parameters of the distribution using censored data.
2. Life tables and related rates and properties.
3. Survival function and its estimation using parametric and nonparametric methods .
4. Semiparametric regression for failure rate, Cox's proportional hazard models.

Unit-I **(15 Hrs)**

(A) Concepts of Time, order and Random Censoring.

Life distributions Exponntial, Gamma, Weiball, Lognormal, Pareto, Linear failure rate, parameteric inference, point estimation, confidence intervals, scores, tests based on LR, MLE.

Unit-II **(15 Hrs)**

(B) Life tables, Failure rate, mean residual life and their elementary propertics Ageing classes IFR ,IFRA, NBU, NBUE, HNBUE and their duals, Bathtub Failure rate.

Unit-III **(15 Hrs)**

(C) Estimation of survival function Actuarial estimator, Kaplan Meier Estimator, Estimation under the assumption of IFR/DFR. Tests of exponntiality against nonparametric classes Total time on test, Deshpande test, Two sample Problem, Gehan test, Long rank test, Mantel Haenszd Test, Tarone Ware tests.

Unit-IV **(15 Hrs)**

(D) Semi Parametric regression for failure rate Cox's Proportional hazards model with one and several covariates.

MSSS33: PAPER III - CORE ELECTIVE I

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS33C - DEMOGRAPHY

OBJECTIVES:

Demography is statistical analysis of human population which can be studied with the help of different models. It offers a most appropriate approach to study human development across the world. Demographic analysis focuses not only on the changing composition of population by age and gender but also on other observable and measurable characteristics like education, health etc. . The objective of the course is to impart knowledge in various methods of analyzing population data.

OUTCOMES:

At the end of the course, students become well versed with,

1. Basic demographic concepts and different features of population data.
2. Various measures of fertility and mortality.
3. Migration, its rates and ratio.
4. Various measures of population changes, linear and non-linear population growth models.

Unit-I **(15 Hrs)**

(A) Definition and scope : Development of demography as a interdisciplinary discipline, Basic demographic concept and components of population dynamics coverage and content errors in demographic data, use of balancing equations and ChandrasKharan Deming formula to check completeness of registration data. Adjustment of age data Use of whipple, myer and UN indices.Population composition, dependency ratio.

Unit-II **(15 Hrs)**

(B) Measure of Fertility : Stochastic models for reproduction, distribution of time to first birth, inter live birth intervals and of number of births (for both homogeneous and non-homogeneous

groups of women) estimation of Parameters estimation of parity preregression ratios from open birth interval data.

Unit-III **(15 Hrs)**

(C) Measure of Mortality: Various measures of mortality, infant mortality rate, cause specific death rate and standardized death rates. Construction of a bridge life table Distribution of life table functions and their estimation. Migration: Migration Rates and Ratios: Indirect measures of net-internet migration National growth rate method stochastic models for migration and for social and occupational mo0bility based on Markov Chains estimation of Measures of Mobility.

Unit-IV **(15 Hrs)**

(D) Measurement of population change: Linear, Geometric exponential, Gompretz, Logistic population growth models, Methods of population projection, Use of Leslie matrix. Stable and Quasi stable populations, intrinsic growth rate, Models for population growth and their fitting to population data. Stochastic models for population growth.

MSSS33: PAPER III - CORE ELECTIVE I

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS33D -TIME SERIES ANALYSIS

OBJECTIVES:

A time series is a series of data points indexed in time order. When this data is plotted, one can observe trends and other variations. Time series analysis is used to study the patterns of variations in data with time. These methods are useful in finance, weather forecasting, agriculture, etc. where the primary goal is forecasting. Since the observations are in the form of sequence, the methods of modelling are different. Objective here is to introduce the concept of time series, different methods of analysing and modelling the time series data and their use in forecasting.

OUTCOMES:

At the end of the course, students become well versed with,

1. Different methods of data smoothing to remove random variations.
2. Stationary and Nonstationary processes.
3. Estimation of the parameters of the time series model and using the models for forecasting.
4. Multivariate time series models, estimation and forecasting.

Unit-I **(15 Hrs)**

(A) Exploratory time series analysis, tests for trend and seasonality. Exponential and Moving average smoothing. Holt -Winters smoothing. Forecasting based on smoothing, adaptive smoothing. Time - series as a discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

Unit-II **(15 Hrs)**

(B) Stationary processes: General linear processes, moving average (MA), auto regressive

(AR), and autoregressive moving average (ARMA). Auto regressive integrated moving average (ARIMA) models, Box –Jenkins models Stationarity and inevitability conditions. Nonstationaryand seasonal time series models: Seasonal ARIMA (SARIMA) models, Transfer function models (Time series regression)

Unit-III **(15 Hrs)**

(C) Forecasting in time series models, Durbin-Levinson algorithm, innovation algorithm (without proof). Estimation of mean, auto covariance and autocorrelation functions, Yule-Walker estimation, Estimation of ARIMA model parameters, maximum likelihood method, large sample theory (without proofs). Choice of AR and MA periods, FPE, AIC, BIC, residual analysis and diagnostic checking.

Unit-IV **(15 Hrs)**

(D) Multivariate Time series model, VAR models, Vector ARMA models. Conditional heteroscedastic models, ARCH and GARCH, properties, examples, estimation & forecasting, extensions of ARCH & GARCH.

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - III

MSSS34: PAPER IV - CORE ELECTIVE II

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS34A - MATHEMATICAL PROGRAMMING

OBJECTIVES:

Optimization techniques have application in almost all disciplines. To get on optimum solution to the problem under given constraints is always challenging. To get the best solution to such problems, there are different methods depending on the problem and constraints. Various such problems and methods to solve them are part of this course.

OUTCOMES:

At the end of the course, students become well versed with,

1. To formulate and solve linear programming problem (LPP). They also learn various methods to solve LPP.Application of LPP in industry, management, transportation, assignment etc.
2. Sensitivity analysis of LPP by studying the effect of changes in coefficients of constraints on the solutions to the problem. They also learn the effect of any other changes in the constraints, addition of new constraint on the solution to the problem.
3. Pure and mixed integer linear programming problem and formulation of nonlinear programming problem and different methods to solve them.
4. The problem and different methods of solving two person zero sum game.

Unit-I **(15 Hrs)**

(A) L. P. : Simplex method, variants of simplex method, duality in L. P. duality theorem, complementary slackness theorem, dual simplex method, transportation & assignment problems, method of solving transportation & assignment problems. Dynamic Programming : Dynamic programming approach for solving optimization problems, forward & backward recursion formula, minimum path problem, single additive constraint & additively separable

return, single multiplicative constraint & additively separable return, single additive constraint & multiplicatively separable return, Goal Programming.

Unit-II **(15 Hrs)**

(B) Sensitivity analysis of L. P. : Changes in R. H. S. constraint bi, changes in cost coefficient cj, changes in coefficient of constraints aij, addition of new variables, addition of new constraints. I.L.P.P. : Pure & mixed I.L.P.P. , methods for solving pure & mixed I.L.P.P. Gomory's cutting plane method, Branch & Bound technique.

Unit-III **(15 Hrs)**

(C) N.L.P.P. : General N.L.P.P., convex & concave functions, text for concavity & convexity, local optimum, global optimum, basic results for local optimum & global optimum, Lagrange's methods for optimality, KT conditions, Q.P.P. Wolfe's & Beale's method for solving Q.P.P.

Unit-IV **(15 Hrs)**

(D) Game theory : 2 person zero sum game, pure & mixed strategies, saddle point of a matrix game, matrix game without saddle point, methods for solving matrix game without saddle point, 2X2 , mxn, mx2, 2Xn matrix games, dominance principle, use of dominance principle in game theory, solving game problems by simplex method.

MSSS34: PAPER IV - CORE ELECTIVE II

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS34B - DATA MINING

OBJECTIVES:

All over the globe, a huge amount of data is getting generated at a very high rate. This huge data needs to be analysed everywhere around us . Data mining is an interdisciplinary subfield of computer science and statistics. The techniques are useful in discovering patterns in large data sets. Objective here is to introduce the students to this branch of statistics and impart knowledge in data processing, data management, analysis of large data, model and inference consideration and online updating.

OUTCOMES:

At the end of the course, students become well versed with,

1. Use of machine learning and statistical models to uncover the hidden patterns in large volume of data.
2. Clustering methods from statistical and data mining point of view. Unsupervised and supervised learning of data in different cases.
3. Dimension reduction, feature selection. Artificial neural network, extension of regression models.
4. Online analytical data processing. Association rules, predictions and applications.

Unit-I **(15 Hrs)**

(A) Review of classification methods from mullivariate analysis, classification and decision trees, clustering methods from both statistical and data mining viewpoints, vector quantization.

Unit-II **(15 Hrs)**

(B) Unsupervised learning from univariate and multivariate data, Dimension reduction and feature selections.

Unit-III **(15 Hrs)**

(C) Supervised learning from moderate to high dimensional input. Spaces, artificial neural networks and extensions of regression models, regression trees. Introduction to data bases, including simple relational databases, data ware houses and introduction to online analytical data processing.

Unit-IV **(15 Hrs)**

(D) Association rules and prediction, data attributes, applications to electronic commerce.

MSSS34: PAPER IV - CORE ELECTIVE II

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS34C – BIOASSAY

OBJECTIVES:

Bioassay is an analytical method to determine concentration of a substance by its effect on living cells, tissues, insects, etc. There are various types of Bioassays like qualitative or quantitative, direct or indirect. These analytical methods are useful in environmental science, microbiology etc. The method of dose and response relationship in this analysis is used in pharmaceutical sciences. Objective of this course is to train students in analytical methods used in these fields

OUTCOMES:

At the end of the course, students become well versed with,

1. Types of biological assays and methods for estimating dose response relationship.
2. Logit and probit approach for estimating dose-response relationship.
3. Methods of estimation of parameters and dose allocation schemes.
4. Sequential procedures, estimation of safe dose, ANOVA and Bayesian approach to Bioassays..

Unit-I **(15 Hrs)**

(A) Types of biological assays, Direct assays, ratio estimators, asymptotic distributions, Fieller's theorem. Regression approaches to estimating dose-response relationships, Logit and Probit approaches when dose-response curve for standard preparation is unknown.

Unit-II **(15 Hrs)**

(B) Methods of estimation of parameters, estimation of extreme quantiles., dose allocation schemes.Quantal Responses, Polychotomousquantal responses.estimation of points on the quantal response function.

Unit-III **(15 Hrs)**

(C) Sequential procedures, estimation of safe doses.

Unit-IV **(15 Hrs)**

(D) ANOVA and Bayesian approach to Bioassay.

MSSS35: PRACTICAL COURSE I

List of Practicals

1) Problems on Non –Parametric Tests
   - i) Sign test
   - ii) Wilcoxon's Signed Rank test
   - iii) Mann-Whitney U test
   - iv) Median test
   - v) Run test
   - vi) Kolmogorov Smirnov goodness of fit test
   - vii) Kolmogorov Smirnov two sample test
2) Problems on Bayes estimates and minimax decision rule
3) Problems on Bayes estimates and minimax decision rule using risk set
4) Problems on Bayes risks
5) Problems on multiple linear regression
6) Problems on residual plots and residual analysis
7) Problems on transformation of variables
8) Problems on outliers and influential observations
9) Problems on variable selection
10) Problems on multicollinearity
11) Fitting of non linear regression model
12) Regression model with autocorrelated errors
13) Problems on logistic regression model

MSSS36: PRACTICAL COURSE II

List of Practicals

1) Problems on different control charts
2) Problems on X bar and R control chart
3) Problems on EWMA chart
4) Problems on acceptance sampling
5) Problems on sampling inspection plan
6) Problems on Hotelling's T^2 control chart
7) Problems on simplex method
8) Problems on dual simplex method
9) Problems on two phase simplex method
10) Problems on Transportation
11) Problems on Assignment
12) Problems on I.P.P.
13) Problems on NLPP
14) Problems on Wolfe's method
15) Problems on Beale's method
16) Problems on game theory

MSSS37: SEMINAR

Topics will be selected by students

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - IV

MSSS41: PAPER I - MULTIVARIATE ANALYSIS

OBJECTIVES:

Multivariate Analysis is a branch of statistics where data on two or more variables are analyzed simultaneously. Most of the statistical methods in univariate analysis can be extended to the case of two or more variables. There are many situations where we need to study effect of two or more independent variables on one variable. This is studied as an extension of simple correlation and regression in case of one independent variable. This course consists of all such distributions, statistical methods etc. which are multivariate analogues of corresponding univariate analysis. Many results that are derived only for multivariate cases are also included in the course.

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of multiple and partial correlation and multiple regression.
2. Multivariate normal distribution, estimation of parameters of the distribution and its properties.Wishart distribution and its properties.
3. Hotellings T^2, its null distribution and its applications for testing hypotheses associated with mean vector (vectors).
4. Problem of classification, procedure of classification using Fisher's discriminant function.Principal component analysis useful in dimension reduction and analysis using canonical correlation.

Unit-I **(15 Hrs)**

(A) Correlation : multiple and partial correlation. Linear and multiple regression co-efficient of determination and its uses. Tests of significance of multiple and partial correlation coefficient. Multivariate normal distribution, singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions, maximum likelihood estimators of the parameters of multivariate normal distribution

Unit-II **(15 Hrs)**

(B) Wishart matrix-its distribution without proof and properties.Distribution of MLEs of parameters of Multivariate Normal distribution ,Distribution of sample generalized variance, Applications in testing and interval estimation, Wilks λ [Introduction, definition, distribution (statement only)].

Unit-III **(15 Hrs)**

(C) Hotelling's T2 statistic and its null distribution. Application in tests on mean vector for one and more multivariate normal populations and also on the equality of the components of a mean vector in a multivariate normal population. Application of T2 statistic and its relationship with Mahalanobis' D2 statistic. Confidence region for the mean vector. Applications of D2statistics.

Unit-IV **(15 Hrs)**

(D) Classification and discrimination : procedures for discrimination between two multivariate normal populations. Fisher's discriminant function, tests associated with discriminant function, Sample discriminant function. Probabilities of misclassification and their estimation. Classification into more than two multivariate populations.Principal components. Dimension reduction. Canonical variables and anonical correlation, definition, uses, estimation and computation.

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - IV

MSSS42: PAPER II - COMPUTATIONAL STATISTICS

OBJECTIVES:

In many disciplines, results are established with the help of the data by fitting a suitable model . Analyzing the data plays an important role in such cases. Advanced statistical methods and different types of models can be applied to these data, even very big data. The course deals with different computational methods and algorithms necessary for analysis of the data. The course includes different methods that are particularly useful in simulating data from various distributions and analyzing them with the help of computers.

OUTCOMES:

At the end of the course, students become well versed with,

1. Visualization of data and exploratory data analysis.
2. Stochastic simulation techniques like MCMC.
3. Some important methods of handling missing data and incomplete data problems like EM algorithm etc.
4. Jack knife, Bootstarp and nonparametric density estimation using kernels.

Unit-I **(15 Hrs)**

(A) Exploratory data analysis: Components of EDA, transforming data, Clustering : Similarity measures, similarity coefficients, Heirarchical clustering methods : single, complete and average linkage methods, dendrograms. Graphical Methods: Quintile plots, Box Plots, Histogram, Stem & leaf diagram, Q-Q plots, P-P plots,

Unit-II **(15 Hrs)**

(B) Stochastic simulation: generating random variables from discrete and continuous distributions, simulation bivariate/multivariate distributions, simulating stochastic processes such as simple queues. Variance reduction technique: Importance sampling for integration,

control variates, antithetic variables. MCMC methods : Essence of MCMC methods, Time reversible MC, Law of large numbers for MC. Metropolis-Hastings algorithm, Gibbs sampling for bivariate/ multivariate simulation.

Simulated annealing for optimization, simulated annealing for M.C. Simulation based testing : simulating test statistics and power functions, permutation/randomization tests.

Unit-III **(15 Hrs)**

(C) Resampling paradigms: Jack knife and Bootstrap: Delete one J-K, pseudo values, Bias and S.E. Efron's bootstrap, Bootstrap C.I. Bootstrap-t C.I, Bootstrap C.I. (percentile method), Bootstrap in regression, Bootstrap C.I. for linear regression parameters.

Unit-IV **(15 Hrs)**

(D) EM algorithm: Application to missing and incomplete data problems. Mixture models. Smoothing with Kernels: Density estimation, kernel density estimator for univariate data, Bandwidth selection and cross validation, Max likelihood L CV, Least square CV.

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - IV

MSSS43: PAPER III - CORE ELECTIVE III

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS43A - INDUSTRIAL STATISTICS

OBJECTIVES:

Objective here is to introduce to the students a branch of statistics that helps in maintaining quality in the industry. Course contains various methods for quality maintenance.

OUTCOMES:

At the end of the course, students become well versed with,

1. Working of quality systems ISO 9000 and QS 9000.
2. Use of design of experiments for quality improvement and process Capability Analysis, various capability indices.
3. Taguchi philosophy , 6 sigma.
4. Failure model, effect and criticality analysis.

Unit-I **(15 Hrs)**

(A) Quality Systems : ISO 9000 standards. QS 9000 standards.

Total quality management (TQM) : Different definitions and dimensions of quality,basic concept , Total Quality Management Models, Quality Management Tools, Six Sigma and Quality Management, What is Kaizen ? - Five S of Kaizen, Role of Managers in TQM, Role of Customers in Total Quality Management, Comparison of Six Sigma and TQM, Reasons for failure of TQM, Deming's 14 point program, Continuous quality improvement, PDSA cycle , Jurantriology, Quality Gurus

Unit-II **(15 Hrs)**

(B) Use of Design of experiments in SPC factorial experiments, fractional factorial design. Half fraction of the 23 factorial design Basic ideas of response surface methodology.

Specification limits, Natural tolerance limits and control limits. Process capability analysis (PCA) : Process capability analysis using Histogram, and using control chart.

Unit-III **(15 Hrs)**

(C) Probability plotting capability indices Cp, Cpk and Cpm comparison of capability indices. Estimation confidence intervals and tests of hypothesis relating to capability indices for Normally distributed characteristics. Index Cpc for non normal data..

Unit-IV **(15 Hrs)**

(D) Quality at Design stage. Quality function deployment failure mode and effect analysis.Taguchi philosophy system parameter and tolerance designs. Loss functions. Determination of manufacturing Tolerances. Signal to noise ratio and performance measures critique of S/N ratios.]

MSSS43: PAPER III - CORE ELECTIVE III

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS43B - RELIABILITY THEORY

OBJECTIVES:

Man made systems suffer from imperfections for several reasons. Often these imperfections lead to improper functioning resulting in failure of the system It may be the result of defect in the system while producing it or may be because of natural component deterioration on some interacting factors. Probability of non failure is termed as reliability. Reliability models can be developed for predicting the reliability of a component or of system prior to its implementation.

OUTCOMES:

At the end of the course, students become well versed with,

1. Failure time distribution, reliability function, hazard function etc.
2. Increasing failure rate as an effect of ageing, shock models.
3. Reliability estimation in various cases.
4. Reliability growth models.

Unit-I **(15 Hrs)**

(A) Reliability concepts and measures ,components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular compositions, bounds on system reliability, structural and reliability importance of components. Life distributions, reliability functions, hazard rate, common life distributions, exponential, Gamma ,Weibull, Lognormal etc. Estimation of parameters, confidence intervals, LR and MLE tests for these distributions.

Unit-II **(15 Hrs)**

(B) Notions of ageing: IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distributions

arising out of them, bivariate shock model, common bivariate exponential distributions and their properties.

Unit-III **(15 Hrs)**

(C) Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items, stress and strength reliability and its estimation. aintenance and replacement policies, availability of repairable systems, modeling of repairable system by a non-homogeneous Poisson process

Unit-IV **(15 Hrs)**

(D) Reliability growth models, probability plotting techniques, Hollander- Proschan and Deshpande tests for exponentially, tests for HPP vs. NHPP with repairable systems.

MSSS43: PAPER III - CORE ELECTIVE III

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS43C - STATISTICAL GENETICS

OBJECTIVES:

The course includes basic results in genetics from their probability distribution point of view, population equilibrium, dominating alleles and estimation of their probability. Objective is to make the students aware about the concept of natural selection, inbreeding ,linkage, segregation etc which are probability distribution based concepts in genetics. This probability distribution can be used to estimate the frequency of the gene in coming generations. This is very useful in some rare diseases

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of random mating, Hardy Weinberg equilibrium, calculating probabilities for various gene combination and study of X-linked genes.
2. Nonrandom mating, inbreeding, various coefficients of inbreeding.
3. Concept of Natural selection, its effect on equilibrium .
4. Analysis of family data, linkage detection , and estimation of linkage.

Unit-I **(15 Hrs)**

(A) Basic biological concepts in genetics. Mendel's law.Hardy Weinberge equilibrium.Matrix theory of random mating.Mating tables.Estimation of allel frequency for dominant and co dominant cases.Approach to equilibrium for X-linked gene.

Unit-II **(15 Hrs)**

(B) Non random mating.Inbreeding.Coefficients of inbreeding.Inbreeding in randomly mating populations of finite size.Phenotypic assortative mating.

Unit-III **(15 Hrs)**

(C) Natural selection, mutation, genetic drift. Equilibrium when both natural selection and mutation are operative. Statistical problems in human genetics, Blood group analysis.

Unit-IV **(15 Hrs)**

(D) Analysis of family data : (a) Relative pair data, I ,T,O matrices, identity by descent. (b) Family data- estimation ofsegregation ratio under ascertainment bias. (c) Pedigree data – Elston- Stewart algorithm for calculation of likelihoods, linkage, Detection and estimation of linkage, estimation of recombination fraction, inheritance of quantitative trials models and estimation of parameters.

MSSS43: PAPER III - CORE ELECTIVE III

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C, D)

MSSS43D - STOCHASTIC MODELS IN FINANCE

OBJECTIVES:

The objective of this course is to develop interest in the student about modeling in finance.

OUTCOMES:

At the end of the course, students become well versed with,

1. Basic concepts in finance, one step and two step models.
2. Behaviour of stock prices using martingles, Ito integrals etc.
3. Returns, distribution of returns, volatility and its estimation.
4. Risk, its measurement, interest rate derivatives etc.

Unit-I **(15 Hrs)**

(A) Derivatives hedging: forward and future contracts. Markets, prices, arbitrage and hedging Complete market, market risk and credit risks in the use of derivatives.
Options markets, properties of stock option prices.American and European options. Binomial model: One-step and two-step models, Binomial trees. Risk neutral valuation.

Unit-II **(15 Hrs)**

(B) Behavior of stock prices: Conditional expectation, martingales, Brownian motion and Geometric Brownian motion, Markov property, Ito integral, Ito/diffusion and mean reverting processes process, Ito Lemma.

Unit-III **(15 Hrs)**

(C) Black Scholes model: Distribution of returns, volatility, risk neutral pricing, equivalent martingale measure, Black-Scholes-Merton differential equation. Estimating volatility (historical data, implied volatility).Options on stock indices, currencies and futures..

Unit-IV **(15 Hrs)**

(D) Some exotic equity and foreign exchange derivatives. Greek Letters and hedging.Value-at-risk as a measure of risk.Interest rate derivatives, Black model. Models of the term structure of interest rates: one factor diffusion model, Vasicek, Cox-Ingersoll-Ross and Hull white models.

SUBJECT: STATISTICS

M.Sc.– II SEMESTER - IV

MSSS44: PAPER IV - CORE ELECTIVE IV

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS44A - OPERATIONS RESEARCH

OBJECTIVES:

Operations research deals with the application of advanced analytical methods which helps in taking better decisions. The course includes advanced techniques that are useful in business, management, industry, project planning etc.

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis .
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit-I **(15 Hrs)**

(A) Inventory problems : Structure of inventory problem, EOQ formula, EOQ model with uniform rate of demand & having no shortages, EOQ model with different rate of demand in different cycles having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having shortages, EOQ model with uniform rate of demand, infinite rate of replenishment having shortages, EOQ model with single & double price breaks.

Unit-II **(15 Hrs)**

(B) Single period probabilistic inventory models with

i) instantaneous demand & discrete units

ii) instantaneous demand& continuous units

iii) Continuous demand & discrete units

iv) Continuous demand & continuous units

Unit-III **(15 Hrs)**

(C) Processing n jobs through two machines,

Processing n jobs through three machines,

Processing 2 jobs through m machines,

Processing n jobs through m machines,

Traveling salesman problem

Queuing Models : M/M/1 : FCFS/□ / □ / & its generalization

M/M/1 : FCFs/N/□ ,

M/M/C/ : FCFS/ □ / □,

M/Ek/1 : FCFS /□ /□ ,

Unit-IV **(15 Hrs)**

(D) Networking : Basic steps in PERT & CPM, methods of solving PERT problem, crashing the network, updating (PERT & CPM) max. flow min. cut theorem, problems based on max. flow min. cut theorem.

MSSS44: PAPER IV - CORE ELECTIVE IV

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS44B - ACTUARIAL STATISTICS

OBJECTIVES:

Actuarial science includes statistical methods to assess risk mainly in insurance and finance. The course includes these statistical methods based on probability theory and stochastic models. Objective here is to make the students aware about this important branch of statistics.

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis .
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit-I **(15 Hrs)**

(A) Life table and its relation with survival function, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint and last survivor status, insurance and annuity benefits through multiple life functions. Multiple decrement models, deterministic and random survivor groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Unit-II **(15 Hrs)**

(B) Principals of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.Life insurance : Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursion, commutation functions.

Unit-III **(15 Hrs)**

(C) Life annuities : Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursion, complete annuities- immediate and apportionable annuities-due. Net premiums : Continuous and discrete premiums, true monthly payments premiums, apportionable premiums, commutation functions, accumulation type benefits.

Unit-IV **(15 Hrs)**

(D) Net premium reserves : Continuous and discrete net premium reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional duration, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions. Some practical considerations: Premiums that include expenses – general expenses, types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

MSSS44: PAPER IV - CORE ELECTIVE IV

(NOTE: Candidates can choose any one elective paper from Core Elective A, B, C)

MSSS44C - STATISTICAL ECOLOGY

OBJECTIVES:

Ecology is study of interaction of organisms that include biotic and abiotic components and their environment. Ecologists can explain life processes, interactions, adoptions, movement of materials, distribution of organisms, biodiversity etc. by using various statistical methods. The course gives knowledge of these methods and models in this particular branch.

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis .
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit-I **(15 Hrs)**

(A) Population Dynamics One species exponential, logistic and Gompertz models,. Two species competition, coexistence, predator prey oscillation, Lotka-Volterra Equations, isoclines, Lestie matrix model for age structured populations. Survivorship curves constant hazard rate, monotone hazard rate and bath tub shaped hazard rates

Unit-II **(15 Hrs)**

(B) Population density estimation: Capture recapture models, nearest neighbor models, Line transect sampling, Ecological Diversin, Simpsons index, Diversity as average rarity.

Unit-III **(15 Hrs)**

(C) Optimal Harvesting of Natural Resources, Maximum Sustainable field, tragedy of the commons Game theory in ecology, concepts of Evolutionarily stable strategy, its Properties, simple cases such as Hawk-Dove geme.

Unit-IV **(15 Hrs)**

(D) Foraging Theory : Diet choice Problem, patch choice problem mean variance trade off.

MSSS45: PRACTICAL COURSE I

1) Problems on multiple and partial correlation and regression
2) Applications of Hotelling T^2 Statistic
3) Problems on Canonical correlation
4) Generation of random numbers
5) Drawing of random sample from various probability distributions
6) Problems on convolution method
7) Drawing random sample using acceptance rejection technique
8) Problems on Monte Carlo technique
9) Problems on clustering
10) Problems on Jack- Knife and Bootstrap
11) Problems on Variance reduction technique
12) Problems on inventory models(Deterministic)
13) Problems on inventory models(Probabilistic)
14) Problems on sequencing
15) Problems on queuing theory
16) Problems on CPM and PERT

MSSS46: PROJECT

Topics will be selected by students

MSSS47: SEMINAR

Topics will be selected by students