Yashavantrao Chavan Institute of Science, Satara (Autonomous)
Department of Statistics
Syllabus of M.Sc.-II (Statistics)

1. **TITLE : M. Sc. (Statistics)**

2. **YEAR OF IMPLEMENTATION:** 2019-20

3. **GENERAL OBJECTIVES OF THE COURSE**:

1. The students are expected to understand the principles, concepts and recent developments in the Statistics.
2. To enhance student sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportive environment.
3. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in Statistics.

4. **STRUCTURE OF COURSE:**

Notations:

A six-character code is given to each paper. In MST and MSP, "M" stands for M.Sc., "S" stands for Statistics, "T" stands for Theory and "P" stands for practical. The first digit following MST is Semester Number.

- **Course Structure with details :**

M.Sc. (Statistics) Semester – III

Course Code	Title of the Course	Instruction Hrs/week	Duration of Exam (Hrs)	Marks End Semester	Marks Internal	Credits
MST 301	Asymptotic Inference	4	3	80	20	4
MST 302	Survival Analysis	4	3	80	20	4
MST 303	Regression Analysis	4	3	80	20	4
MST 304	Data Mining	4	3	80	20	4
MST 305	Clinical Trials	4	3	80	20	4
MSP 306	Practical-III	12	3	-	100	4

M.Sc. (Statistics) Semester – IV

Course Code	Title of the Course	Instruction Hrs/week	Duration of Exam (Hrs)	Marks End Semester Exam(ESE)	Marks Internal Assessment(ISE)	Credits
MST 401	Optimization techniques -II	4	3	80	20	4
MST 402	Elementary Stochastic Processes	4	3	80	20	4
MST 403	Time Series Analysis	4	3	80	20	4
MST 404	Planning and Analysis of Industrial Experiments	4	3	80	20	4
MST 405	Actuarial Statistics	4	3	80	20	4
MSP 406	Practical-IV	12	3	-	100	4

Note:- There shall be Continuous Internal Evaluation pattern in which internal examination will be for 20 marks, while End Semester Examination will be for 80 marks.

Nature of the Theory and Practical Question Paper at the M.Sc. Statistics course under the Semester Scheme:

Nature of the theory question papers

i) End Semester Examination (ESE) :-

a) There shall be 7 questions each carrying 16 marks.

b) Question No.1 is compulsory. It consists of 8 questions for 2 marks each.

c) Students have to attempt any 4 questions from question No. 2 to 7.

d) Question No. 2 to 6 shall contain 2 to 4 sub-questions.

e) Question No. 7 shall contain 4 short note type questions, each carrying 4 marks.

ii) Practical Examination:-

For Semester III and IV : "Practical MSP-306 and MSP-406"

1. There shall be 20 marks for day-to-day performance and journal.

2. Examination (60): Practical Examinations will be conducted in the middle of the term and at the end of the term. Each exam will be of 3 hrs. duration carrying 60 marks. There shall be 8 questions each of 12 marks, of which a student has to attempt any 5 questions. The average of these two tests will be considered as final score out of 60.

3. Practical VIVA will be for 20 marks.

4. **Project work** carries 40 marks per year. Project work consists of understanding the domain of the problem, formulation of the problem, collection of the relevant data, Analysis of the data and report writing. They are expected to use software for which they are trained. 20 marks are reserved for project based VIVA. Project report will be evaluated for 20 marks. The project work should be preferably based on field work or problem in industry.

M.Sc. II : Semester-III

MST 301: ASYMPTOTIC INFERENCE

Unit 1: Review of Consistency of an estimator, weak and strong consistency, joint and marginal consistency, invariance property under continuous transformations, methods of constructing consistent estimators, asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators. (12)

Unit 2: CAN and BAN estimators in one parameter and multi-parameter exponential family of distributions, BAN estimators, super efficient estimators, Crammer regularity conditions, Cramer – Huzurbazar results. Sheffe's theorem, Polya's theorem and Slutsky's theorem. (12)

Unit 3: Variance stabilizing transformations; their existence; their applications in obtaining large sample tests and estimators. Asymptotic Confidence Intervals based on CAN estimators and based on VST, Asymptotic disribution of function of sample moments. Asymptotic Confidence regions in multi-parameter families. Gauss-Legendre-Boscovich Revisited, unbiased confidence intervals. (12)

Unit 4: Likelihood ratio test and its asymptotic distribution, Wald test, Rao's Score test, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. Consistent test, comparison of tests: asymptotic relative efficiency of tests (Pitman and Bahadur efficiency). (12)

References:

1) Kale B.K. (1999): A first course on parametric inference, Narosa Pub.
2) Zacks S. (1971): Theory of statistical inference, Wiley & Sons inc.
3) Rohatagi V.K. and Saleh A. K. Md. E.(2001) : Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.
4) Ferguson, T.S. (1996): A Course in Large Sample Theory. Chapman and Hall
5) Lehmann E L (1999): Elements of Large Sample Theory, Springer.
6) DasGupta A. (2008): Asymptotic Theory of Statistics and Probability, Springer Texts in Statistics.
7) Manoj Kumar Srivastava, Statistical Inference, PHI learning pvt.ltd.

MST-302 SURVIVAL ANALYSES

Unit-1: a) Concept of ageing, Functions Characterizing life-time random variables: Survival function, distribution function, hazard function, cumulative hazard function. Characterizing of IFR, IFRA, NBU, NBUE class. Parametric analysis of Survival data.
b) Concept of censoring, various types of censoring, type-I, type-II, random censoring, progressive censoring. Writing likelihood function under all these censoring schemes, estimation and testing of parameters under above types of censoring. (12)

Unit-2: a)Estimation of survival function: Nelson-Aalen estimators, Actuarial Estimator, Kaplan Meir product limit estimator, properties: self-consistency and MLE, redistribution to the right algorithm.
b) Concept of TTT Transform and its applications. Test for exponentiality against alternatives IFRA, NBU and NBUE. (12)

Unit-3: a) Two-sample problem: Gehen test, Log rank test, Mantel Haenszel test.
b) Competing risk models, parametric and nonparametric inference for this model. (12)

Unit-4: a) Semi parametric regression for failure rate – Cox's proportional hazards model with one and several covariates, related estimation and test procedures.
b) Introduction to accelerated time models: Linear rank tests, Least squares, Miller, Buckley-James and kaul-SusaraVan-ryzin estimators. (12)

References:

1. Barlow R. E. & Proschann F. (1965): Mathematical Theory of Reliability, John Wiley & Sons, Inc.
2. Deshpande J. V. and Purohit S.G. (2005): Life Time Data: Statistical Models and Methods, world scientific publishing.
3. Lawless J. F.(1982): Statistical Models and Methods of Failure Time Data, John Wiley.
4. Miller R. G.(1981): Survival Analysis, John Wiley and Sons.
5. Bain L. O.(1978): Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker,
6. Nelson W. (1982): Applied Life Data Analysis, Jhon Wiley and Sons Inc.
7. Smith P.J. (2002): Analysis of Failure and Survival data 5. Medhi J.(1994): Stochastic Processes (second edition)

MST 303 : REGRESSION ANALYSIS

Unit 1: Multiple regression model. Least square estimate and their Properties. Hypothesis testing, general linear hypothesis testing. Dummy variable. Residuals and their properties, Residual diagnostics. Transformation of variables: VST and Box-Cox Power transformation. Variable Selection Procedure: R –square, adjusted R-square, Mallows' Cp, forward, backward selection methods. AIC, BIC., Autocorrelation & Durbin – Watson test. (12)

Unit 2 : Multicollinearity and Ridge regression. Robust Regression: Influential observation, leverage, outlier. Methods of detection of outlier and Influential observation. Estimation in presence of outlier: M estimator. Breakdown point, efficiency. Nonlinear regression models: Parameter estimation in a linear system. Transformation to a linear model. Statistical inference in non linear regression. (13)

Unit 3 : Generalized linear models, Link function, ML and Quasi-likelihood estimation. Large sample tests about parameters, goodness of fit. Deviance analysis. Residual analysis : raw, Pearson, deviance, Anscombe, quantile. AIC, BIC. Logistic regression: logit, probit and cloglog model for single and multiple variables..ML estimation, Large sample test about parameter. Hosmer-Lemeshow test. ROC curve. Logistic regression for Nominal response . Proportional odds model. (15)

Unit 4: Poisson Regression : ML estimation using power link function. Testing significance of coefficients. Goodness of fit. Over dispersion. NB-2 model. Generalized linear mixed model: Structure of the model. Random effects. Marginal versus conditional models. Estimation by generalized equation and conditional likelihood. Testing of hypothesis. (8)
4) Page No.9 to 18, 28 to 32, 49

References:

1. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley.
2. Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley
3. Seber, G. E. F. and Wild, C. J. (1989). Nonlinear Regression, Wiley.
4. McCulloch, C.E., & Searle, S.R. (2003). Generalized, linear, and mixed models, Wiley series in probability and statistics, New York.
5. McCullagh, P. and Nelder, J. A. (1989). Generalized Linear Models, Chapman& Hall.
6. Hilbe. J. (2011) : Negative binomial regression, Cambridge University. Press, 2nd Edition.

MST - 304 : DATA MINING

Unit-1: Data understanding and data cleaning, concept of supervised and unsupervised learning. Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, classification based on logistic regression, Bayesian belief Network., CART(classification and regression trees) (10)
(Ref.: page no. 423, 332, 351,396.)

Unit-2: Model evaluation and selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves. Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data. (12)
(Ref.: page no.364-383.)

Unit-3: ANN and SVM: Artificial Neutral Network (ANN): Introduction to ANN, types of activation function, McCulloch-Pitts AN model, single layer network, multilayer feed forward network model, training methods, ANN & regression models. Convexity and optimization: Convexity, unconstrained and constrained optimization, KKT conditions. Support vector machine: Introduction to support vector machine, loss functions, soft margin, optimization hyperplane, support vector classification, support vector regression, linear programming support vector machine for classification and regression. (14)
(Ref.: page no.398-415.)

Unit-4: Unsupervised learning: Clustering: k-mediods, CLARA, DENCLUE, DBSCAN, Probabilistic model based clustering. Market Basket Analysis: Association rules and prediction, Apriori Algorithm, data attributes, applications to electronic commerce. (12)
(Ref.: page no.454, 476, 471, 244-254.)

References:

1. Berson and Smith S.J. (1997) : Data warehousing, Data Mining, and OLAP, McGraw-Hill.
2. Breiman J.H Friedman, R.A. Olshen and stone C.J. (1984) : Classification and Regression Trees, Wadsworth and Brooks / Cole.
3. Han, J. and Kamber, M. and Pei, J. (2012) : Data Mining: Concepts and Techniques. Morgan Gaufmann.3rd Edition.
4. Mitchell T.M. (1997) : Machine Learning , McGraw-Hill.
5. Ripley B.D. (1996) : Pattern Recognition and Neural Networks. Cambridge University Press.
6. Vapnik V.N. The nature of Statistical learning theory, Springer.

MST -305 CLINICAL TRIALS

Unit-1: Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice, Concept of Randomization and blinding. (12)

Unit-2: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, Active control trials and combination trials, design and monitoring of Phase III trials with sequential stopping. (12)

Unit -3: Design of bioequivalence trials, Classical methods of interval hypothesis, testing for bioequivalence Baysian methods, non-parametric methods, Assesment of inter and intra subject variability, drug interaction study, Dose proportionality steady state analysis, Clinical end points, alpha spending function. (12)

Unit-4: Analysis and Reporting of clinical trials: Concept of sample size and it's calculation, Analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. (12)

References:

1. S. Piantadosi (1997). Clinical Trials : A Methodologic Perspective, Wiley and Sons.
2. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. L. M. Friedman, C. Furburg, D. L. Demets (1998). Fundamentals of Clinical Trials,SpringerVerlag.
4. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments.Wiley and Sons.
5. S.D.Wang & A. Bakhai (2006): Clinical trials : Analysis and Reporting.
6. Todd A Durham & J. Rick Turner :Introduction to Statistics in Pharmaceutical Clinical Trials.

MSP- 306 PRACTICAL-III

1. Construction of Consistent/CAN Estimators.
2. Construction of BAN Estimators and confidence interval based on it.
3. Confidence interval based on CAN.
4. Confidence interval based on VST.
5. Parametric analysis of survival data.
6. Estimation of Survival Function.
7. Estimation of parameters in PH model.
8. Analysis of two sample non-parametric problem.
9. Classification.
10. Cluster Analysis.
11. Artificial Neural Network.
12. Support Vector Machine.
13. Multiple Linear Regression Model.
14. Multicollinearity and Nonlinear regression.
15. Logistic Regression.
16. Poisson Regression.
17. Pharmokinetics.
18. Confidence interval.
19. Analysis of categorical outcomes.
20. Non-parametric test based on Clinical Trials.

References:

1) Kale B.K. (1999): A first course on parametric inference, Narosa Pub.
2) Miller R. G.(1981): Survival Analysis, John Wiley and Sons.
3) Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley.
4) Berson and Smith S.J. (1997) : Data warehousing, Data Mining, and OLAP, McGraw-Hill.
5) S. Piantadosi (1997). Clinical Trials : A Methodologic Perspective, Wiley and Sons

M.Sc. II Semester-IV

MST-401: OPTIMIZATION TECHNIQUES -II

Unit 1: Goal Programming: Meaning & Concept of GP, Difference between LP & GP Approach, Model Formulation, Graphical Method to Solve GP, Modified Simplex Method (8L)

Unit 2: Deterministic inventory models: The meaning of inventory control, factors involved in inventory problem, inventory model building, Concept of EOQ,

a) **Single item inventory control models without shortages:** Model I (a): EOQ model with constant rate of demand. Model I (b): EOQ model with different rates of demand in different cycles. Model I (c): Economic lot size with finite Rate of replenishment. (EOQ production model)

b) **Single item inventory control models with shortages:** Model II(a): EOQ model with constant demand and variable order cycle time, Model II(b): EOQ model with constant demand and fixed reorder cycle time, Model II (c): The production lot size model with shortages. (16L)

Unit 3: Replacement Problems, Types of failure: Gradual failure, Sudden failure

a) **Replacement policy for items whose efficiency deteriorates with time:** when value of money remains constant and when value of money changes
b) **Replacement of items that completely fail:** Mortality tables, mortality theorem, individual and group replacement policy (12L)

Unit 4. Data Envelopment Analysis (DEA) : Concept of DEA, Meaning of productivity and efficiency. Types of efficiency, variable return to scale, mathematical formulation of DEA model, basic DEA models: CCR and BCC models and their duals. (10L)

References:

1. Hadley G. (1969): Linear Programming, Addison Wesley.
2. Taha H. A. (1971): Operation Research An Introduction- Macmillan
3. Kanti Swaroop & Gupta M. M. (1985): Operations Research, Sultan Chand & P. Gupta
4. D. S. Hira (2010): Operation Research, Sultan Chand &Co.ltd.
5. J. K. Sharma (2003): Operation Research Theory and Applications, Macmillan.
6. Subhash C. Ray (2004): Data envelopment analysis: theory and techniques for economics and operations research

MST-402 : STOCHASTIC PROCESSES

Unit-1: a) Stochastic process: Definition, Classification of Stochastic processes according to state space and time domain, Transition Probability Matrix, Markov chain, Examples of Markov Chain Formulation of Markov Chain models, initial distribution.

b) Chapman-Kolmogorov Equation, calculation of n-step transition probabilities, Classification of States and Limiting Distributions. (12)

Unit-2: a) First entrance theorem, first passage time distribution, random walk model, Gambler's ruin problem.

b) Long-run distributions of Markov chain, relation with mean recurrence time, stationary distribution. (12)

Unit-3: Poisson process, Birth and death processes. Growth model with immigration, Queueing systems, Markovian and non-Markovian queueing systems, embedded Markov chain applications to M/G/1. (12)

Unit-4: a) Renewal and delayed renewal processes, related theorems, key renewal theorem, Galton-Watson Branching process. probability of ultimate extinction.
b) Simulation of Markov Chain, Poisson process and branching process. (12)

References:

1. Medhi J. (1982): Stochastic Process, Wiley Eastern.
2. Karlin & Taylor: A First Course in Stochastic Process, Vol. -1, Academic Press.
3. Cinlar E.: Introduction to Stochastic Process, Prentice Hall.
4. Ross S.: Introduction to Probability Module.
5. William Feller: An Introduction to Probability Theory and Its Applications, Vol. 1, 3rd Edition.
6. Hoel P, Port S, Stone C: Introduction to Stochastic Processes. Waveland Pr Inc. publisher.

MST-403 TIME SERIES ANALYSIS

Unit-1: Time series as a discrete parameter stochastic process, Auto - Covariance, Autocorrelation functions and their properties. Partial auto covariance function. Stationary time series, Exploratory time series analysis, Exponential and moving average smoothing, Holt –Winter smoothing, forecasting based on smoothing. (12)

Unit-2: Wold representation of linear stationary processes, linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average models. Concept of Causality, invertibility, computation of π -weights and ψ- weights, computation of ACVF, ACF and PACF. Autoregressive Integrated Moving Average models. (12)

Unit-3: Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory, Residual analysis and diagnostic checking. Minimum mean squared error Forecasting for ARIMA models. Introduction to SARIMA models. (12)

Unit-4: Introduction to spectral analysis, Spectral Representation of the ACVF, Spectral density of an ARMA process, its computation for simple models. Introduction to ARCH and GARCH models. Properties and estimation under ARCH(1) and GARCH(1,1) model, Estimation and forecasting extension of ARCH and GARCH . (12)

References:

1. Box, G.E.P and Jenkins G.M, Gregory C. Reinsel. (1970) Time Series Analysis, Forecasting & Control, Holden-Day.
2. Brockwell, P.J and Davis R.A. (1987) Time Series: Theory and Methods, Springer-
3. Tsay R. S. Analysis of Financial Time Series, 3rd Ed. (Wil. Ser. in Prob. and Statistics)
4. Kendall, M.G. (1978) Time Series, Charler Graffin
5. Chatfield, C. (2004) The Analysis of Time Series - An Introduction, Sixth edition, Chapman and Hall.
6. James D. Hamilton- Time Series Analysis

MST-404: PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Review:i)Basic concepts of design of experiment.
ii) Methods to study Analysing Design.
iii) Nested and Split Plot Design

Unit-1: 2^k factorial Experiments: Concepts of main effects, interaction, their graphicalrepresentation, Analysis of full 2k replicated and unreplicated factorial designs.
Concept of Confounding: Total and partial confounding, construction and analysis confounded design. **(**12)

Unit-2: 3^k factorial Experiments: Concepts of main effects, interaction, their graphicalrepresentation, linear and quadratic components, Analysis of full 3^k replicated and unreplicated factorial designs.
Confounding: construction and analysis confounded design, Factorials with mixed levels. (12)

Unit-3: Fractional Factorial: Fractional replication for symmetric factorials, concept of generator, defining contrasts, aliasing, resolution and minimum aberration, construction and analysis of 2^{k-p} and 3^{k-p}fractional designs, Central composite designs. (12)

Unit-4: Response surface experiments :linear and quadratic model, test for curvature,stationary point, central ridge systems, Rotatability, Multiple responses. **Taguchi methods:** Concept of noise and control factors, inner and outer arrays, concept of loss function, S/N ratio, orthogonal arrays, linear graphs, interaction tables, ANOVA. (12)

References:

1. Montgomery D.C. (2013): Design and Analysis of Experiments, 8th edition, Wiley India PvtLtd.
2. Davies.O.L(1954):The design and analysis of industrial experiment,Oliver and Boyd.
3. Voss, D., Dean, A., and Dean, A.(1999).Design and Analysis of Experiments, Springer verlag Gmbh.
4. Wu, C. F., Hamada M. S.(2000). Experiments: Planning, Analysis and Parameter Design Optimization, 2nd edition, John Wiley & Sons.
5. CochranW.G.andcox,G.M.(1959): Experimental Design.

MST -405 ACTUARIAL STATISTICS

Unit 1: Introduction to Insurance Business, Concept of risk, types of risk, characteristics of insurable risk ,Risk models for Insurance: Individual and aggregate Risk models for short term, Distribution of aggregateclaims, compound Poisson distribution and its applications. Survival function and Life tables:Survival function, Distribution function, Density functions and Force of mortality. Time-until death random variable and Curtate-future lifetime random variable. (8)

Unit 2: Life tables, Select and ultimate life tables. Assumptions for fractional ages and some analytical laws of mortality.Life Insurance: Principles of compound interest: Nominal and effective rates of interest and force of interest and discount, compound interest,Insurance payable at the moment of death and at the end ofthe year of death ,Whole life insurance, endowment insurance, term insurance, deferred insurance and varying benefit insurance..

(14)

Unit 3: Annuities: annuity certain, discrete annuity, monthly annuity, continuous annuity, deferred annuity, present values and accumulated values of these annuities, Continuous life annuity, discrete life annuity, such as whole life annuity, temporary life annuity, n-year certain and life annuity, life annuities with mthly payments, Present value random variables for these annuity payments, their means and variances, Actuarial present value of the annuity. (14)

Unit 4: Loss at issue random variable, various principles to decide net premiums for insurance products and annuity schemes defined in unit II and III, fully continuous premiums and fully discrete premiums, True monthly payment premiums. Extended equivalence principle to decide gross premiums, Concept of reserve, Fully continuous reserve, Fully discrete reserve. (12)

References:

1.Deshmukh S. R.,An Introduction to Actuarial Statistics, University Press, 2009

2.Robin Cunningham, Thomas N. Herzog, Richard L. Models for Quantifying Risk, 4th Edition,ACTEX Publications, 2011.

3.Dickson, David C. M., Hardy, Mary R. and Waters, Howard R., Actuarial Mathematics for life contingent risks, International series on actuarial science, Cambridge 2009.

4.Narang, Uma, Insurance Industry in India: Features, Reforms and Outlook, New Century Publications

MSP- 406 PRACTICAL-IV

1. Goal Programming.
2. Deterministic inventory models
3. Replacement Problems
4. Data Envelopment Analysis (DEA)
5. Realization of stochastic process.
6. Classification of t.p.m. and computation of n- step probability matrix.
7. Classification of states: Computations of absorption probabilities.
8. Stationary distribution and recurrence time.
9. Autocovariance and Autocorrelation.
10. Causal and Invertible
11. Smoothing the series
12. Forecasting.
13. Analysis of full replicated unconfounded 2^n and 3^n factorial experiments.
14. Analysis of single replicated 2^n and 3^n factorial experiments.
15. Analysis of confounded 2^n and 3^n factorial experiments: total and partial confounding.
16. Analysis of response surface 1^{st} and 2^{nd} order experiments.
17. Construction of Life Tables.
18. Computations of benefit premiums for n-year term insurance, whole life insurance, endowment insurance.
19. Computation of Annuities.
20. Computation of Reserve.

References:

1. J. K. Sharma (2003): Operation Research Theory and Applications, Macmillan.

2. Medhi J. (1982): Stochastic Process, Wiley Eastern.

3. Kendall, M.G. (1978) Time Series, Charler Graffin

4. Montgomery D.C. (2013): Design and Analysis of Experiments, 8^{th} edition, Wiley India PvtLtd.

5. Deshmukh S. R.,An Introduction to Actuarial Statistics, University Press, 2009