NORTH MAHARASHTRA UNIVERSITY
JALGAON

SYLLABUS

FOR

M.Sc. STATISTICS
(Semester III and IV)

With specialization in Industrial Statistics

WITH EFFECT FROM ACADEMIC
YEAR 2013-2014

NORTH MAHARASHTRA UNIVERSITY, JALGAON
Syllabus for M.Sc.-II (Statistics)
with specialization in Industrial Statistics
(With effect from Academic Year 2013-2014)
Syllabus Structure

Semester-III

Course No.	Title of the Course	Contact hours / week			Marks Distributions for Examinations						Credits
					Internal		External		Total		
		Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
ST-301	Asymptotic and Nonparametric Inference	04	--	04	40	--	60	--	100	--	04
ST-302	Design, Planning and Analysis of Experiments	04	--	04	40	--	60	--	100	--	04
ST-303	Total Quality Management (TQM) Statistical Process Control (SPC) and Reliability	04	--	04	40	--	60	--	100	--	04
ST-304	Optional Course	04	--	04	40	--	60	--	100	--	04
ST-305	Practicals- III	--	06	06	--	40	--	60	--	100	04

Semester-IV

Course No.	Title of the Course	Contact hours / week			Marks Distributions for Examinations						Credits
					Internal		External		Total		
		Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
ST-401	Optimization Techniques	04	--	04	40	--	60	--	100	--	04
ST-402	Actuarial Statistics	04	--	04	40	--	60	--	100	--	04
ST-403	Optional Course	04	--	04	40	--	60	--	100	--	04
ST-404	Technical Communications and Practicals-IV	--	06	06	--	40	--	60	--	100	04
ST-405	Project	--	06	06	--	--	--	100	--	100	06

Th: Theory **Pr: Practicals/Project** **L: Lectures** **M: Marks**

List of optional courses to be offered in Semester-III

ST-304(A): Design and Analysis of Clinical Trials
ST-304(B): Financial Mathematics

List of optional courses to be offered in Semester-IV

ST-403(A): Time Series Analysis
ST-403(B): Statistical Simulations

Objectives

Main objective of this syllabus is to train students in depth in applied courses and projects in the area of Industrial Statistics which deals with Statistical analysis related to data from Manufacturing, Pharmaceutical, Software, Social Sciences, Financial and Actuarial fields. The course on Technical Communications will enhance their communication and presentation skills.

ST-301: ASYMPTOTIC AND NONPARAMETRIC INFERENCE

- Review of convergence in probability and convergence in distribution, Cramer and Slutsky's Theorems. (2L,2M)
- Consistent Estimation of real and vector parameter. Invariance of Consistent estimator under continuous transformation. (3L,3M)
- Consistency of estimators by method of moments, and method of percentiles, Mean squared error criterion. (4L,4M)
- Asymptotic relative efficiency, Error probabilities and their rates of convergence, Minimum sample sizes required to attain given level of accuracy. (4L,4M)
- Consistent Asymptotic Normal (CAN) estimator, Invariance of CAN estimator under differentiable transformation. (4L,4M)
- CAN property of estimators obtained by moments and percentiles. (3L,3M)
- CAN estimators obtained by moment and MLE method in one parameter exponential family, Extension of multi-parameter exponential family. (3L,3M)
- Examples of consistent but not asymptotically normal estimators. (2L,2M)
- Method of maximum likelihood, CAN estimators for one-parameter Cramer family, Cramer-Huzurbar theorem, Solution of likelihood equations, Method of scoring, Newton-Raphson and other iterative procedures. (6L,6M)
- Fisher Lower Bound to asymptotic variance, extension to multi-parameter cases (without proof.) Multinomial distribution with cell probabilities depending on a parameter. (3L,3M)
- MLE in Pitman Family and Double Exponential distribution, MLE in censored and truncated distribution. (3L,3M)
- Likelihood Ratio Test (LRT), asymptotic distribution of LRT statistic, Wald Test, Rao's score test, Pearson χ^2 test for Goodness of fit, Barlett's Test for homogeneity of variances. Large Sample Tests and confidence intervals based on CAN estimators, Variance stabilizing transformation and large sample tests. Consistency of Large Sample Tests. Asymptotic power of large sample tests. (8L,8M)
- Nonparametric Statistical Inference. (15L,15M)
  - Introduction to Nonparametric Inference.
  - U-Statistics.
  - Some Single-Sample problems.
  - Some Two-Sample problems.
  - Test of Independence.
  - Some Applications of Order Statistics.

REFERENCES

Kale, B.K. A first Course on Parametric Inference, Narosa Publishing House. 2nd Ed. 2005.

Rohatgi V.K. and Ehsanes Saleh A. K. MD. (2003). An Introduction to Probability and Statistics, (Wiley Eastern, 2nd Ed.).

Ferguson, T.S. (1996) A course on Large Sample Theory. Chapman and Hall, London.

Gibbons, J.D. (1985): Nonparametric Statistical Inference, {2nd ed., Marcel Dekkar, Inc.

Lehmann, E.L. (1986). Testing Statistical Hypotheses (Student Edition).

Rao, C.R. (1973): Linear Statistical Inference.

Dudewicz, E.J. and Mishra, S.N.(1988), Modern Mathematical Statistics. Wiley

ST-302: DESIGN, PLANNING AND ANALYSIS OF EXPERIMENTS

- Basic principles of design of experiments: Randomization, replications, local control. (2L,2M)
- Concept of Fixed effect models, Random effect models and Mixed effect models. (1L,1M)
- One way classification models, random effect model for one way classification. (5L,5M)
- Two way classification model with equal number of observations per cell with and without interactions. (6L,6M)
- General two way block designs, various characteristics of general two way block design: connectedness, balancedness and orthogonality, Balanced Incomplete Block Design (BIBD), PBIBD with two associate classes, LSD and Youden Square design. (10L,10M)
- Analysis of covariance (ANCOVA) in a general Gauss-Markov model, Applications and need of ANCOVA technique, Analysis of covariance in one-way and two-way classification model. (4L,4M)
- 2^k Full factorial designs: diagrammatic representation of main effects and first order interactions in the model, analysis of single as well as more than one replicates using ANOVA, technique of confounding, total and partial confounding in 2^k Full factorial designs and analysis of such designs. (5L,5M)
- Total confounding of 2^k design in 2^p blocks with $k > p \geq 2$, Partial confounding in 2^p blocks, p=2,3, analysis of designs with treatments confounded in more than two blocks. (5L,5M)
- Two-level-fractional factorial experiments, Resolution of a design (III, IV & V), abbreviation of a design, aliases, generators of the design, complete defining relation etc. (4L,4M)
- Concept of rotatable design. Central composite designs, 3^2 designs: contrasts for linear and quadratic effects, statistical analysis of 3^2 design. (5L,5M)
- Response surface methodology (RSM): linear and quadratic model, determination of stationary point, ridge systems, multiple responses, blocking in RSM, Plackett-Burman design. (5L,5M)
- Taguchi (orthogonal array) methods: concept of loss function, S/N ratio, Linear graphs ANOM inner and outer arrays, ANOVA. (8L,8M)

REFERENCES

Kshirsagar A.M. (1983) Linear Models (Marcel Dekkar).
John P.W.M.(1971) Linear Models (John Wiley Ltd.)
Montogomery D.C. (2008) Design and Analysis of Experiments (John Wiley), 7th Edition
Ogawa J.(1974) Statistical Theory of the Analysis of Experimental Design (Marcel Dekker).
Phadke, M.S. (1989) Quality Engineering through Robust Design, Prentice Hall.
Kuehl R.O.(1994). Statistical Principals of Research Design and Analysis. Duxbury Press.

ST-303: TOTAL QUALITY MANAGEMENT (TQM), STATISTICAL PROCESS CONTROL (SPC) AND RELIABILITY

- Total Quality Management. (8L,8M)
  - Concept of Quality, Quality improvement, Quality philosophy.
  - Introduction of TQM, evaluation of Total Quality.
  - Some important TQM concepts.
  - TQM Gurus' Ideas.
  - Japanese 5-S Practice.
  - The Impact of National and International Quality Awards on TQM.
  - The European Quality Award.
  - The Deming Application Prize.
  - Six sigma and other Extensions of TQM.
  - Quality systems.
  - The ISO 9000 and other Quality systems.
- Review of some Statistical methods useful in Quality Improvement. (3L,3M)
  - Concept of variation, systematic variation, random variation, stable industrial processes.
  - Describing variation through graphical and numerical methods.
  - Some important Discrete and continuous probability distributions useful in quality control and improvement.
  - Some useful approximations of Distributions.
- Statistical Process Control (SPC).
  - Introduction of SPC. (3L,3M)
    - Basic concept of process monitoring and control.
    - Seven tools of SPC.
    - General theory of Control charts.
    - Different types of limits, Specification limits, Natural tolerance limits, Control limits, Warning limits.
    - OC Curve and ARL of control charts.
  - Control Charts for Attributes. (4L,4M)
    - Control chart for fraction nonconforming.
    - Control chart for fraction nonconformities (defects)
    - OC Curves for Attributes control charts.
  - Control Charts for Variables. (7L,7M)
    - Statistical basis of the charts for variables.
    - $\overline{X}$, R, S, $\overline{X}$ *and* R, $\overline{X}$ *and* S, $\overline{X}$ *and* S^2 Control Charts.
    - Median chart and Midrange chart.
    - Control charts for Individual Measurements.
    - Special control charts: CUSUM, EWMA control charts.
  - Process Capability Analysis. (8L,8M)
    - Capable process and Process capability.
    - Process Capability Analysis using Histogram or Probability plot.
    - Process Capability indices under normal distribution of quality characteristic.
      - Capability indices C_p, C_{pk}, C_{pm}.
      - Connection between proportion of nonconforming and C_p, C_{pk}.
      - Estimation, C.I. and tests of hypotheses relating to C_p.

- Process Capability Analysis for non-normal data.
- Process Capability Analysis for Designed Experiments.
- Gauge and Measurement system capability studies.
- Setting specification limits on discrete components, linear and nonlinear combinations.
- Estimating the Natural tolerance limits of a process.

- SPC for short production. (1L,1M)
- Modified and Acceptance control charts. (1L,1M)
- Group control chart. (1L,1M)
- SPC with autocorrelated process data (2L,2M)
- Multivariate Quality control. (2L,2M)
- Engineering process control(EPC) and SPC (2L,2M)
- Acceptance Sampling. (8L,8M)
  - Single, double and sequential sampling plans for attributes and their properties.
  - Curtailed double sampling plans, operating characteristics functions and other properties of the sampling plans.
  - Sampling plans with rectification. OC, ASN, ATI, AOQ curves, AOQL, Designing of sampling plan. Dodge-Romig acceptance sampling plans.
  - Plan for inspection by variables for one-sided and two-sided specifications; AQL based sampling plans.
- Elements of Reliability: (10L,10M)

  Components and systems, binary coherent structure k-out-of –n: G structure, bridge structure. Cuts and Paths, minimal path sets and minimal cut sets. Reliability of coherent system, bonds on system reliability. Structural and reliability importance of components, Hazard function, distribution with DFR and IFR.

REFERENCES

Besterfield, D.H., Besterfield-Michana, c., Besterfield, G.H., Besterfield-Sacre, M. Total Quality Management; Pearson Education(Singapore) Pte. Ltd. India. 2nd Edition 2001.

Caulcutt, Roland. Achieving Quality Improvement (A practical guide); Chapman and Hall,UK. 1st Edition 1995.

Montgomery, D.C. (2009) Introduction to Statistical Quality Control; Wiley, 6th Edition.

Wadsworth H.M.; Stephens K.S. and Godfrey A.B. Modern Methods for Quality Control and Improvement ,2nd Ed. Wiley.

Ho, Samuel K. TQM An Integrated Approach; Crest Publishing House, New Delhi. 1st Indian Edition 2002.

Wetherill, G.B. and Brown, D.W. Statistical Process Control, Theory and Practice; Chapman and Hall.

Logothetis, N.(1992). Managing Total Quality; Prentice Hall of India.

Oakland J.S. (1989). Total Quality Management; Butterworth-Heinemann.

Mittag H.J. and Rinne H.(1993). Statistical Methods of Quality Assurance.

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

Lawless J.F. (1982) Statistical Models and Methods of LifeTime Data; John Wiley.

ST-304: Optional Course

List of optional courses to be offered for ST-304
(Detailed syllabus is given from page No.12)

ST-304(A): Design and Analysis of Clinical Trials
ST-304(B): Financial Mathematics

ST-305: PRACTICALS - III

(By using statistical software and/or Computer programming language)

A. Practicals based on course ST-301 (22 Hrs,15M)

1. Demonstrating consistency and CANness of consistent estimators.
2. Demonstration of consistency and asymptotic non-normality of estimator that is consistent but not CAN.
3. Computation of moment estimators and demonstration of their asymptotic distributions.
4. Verification of invariance property of consistent and CAN estimators under continuous transformation.
5. Generating consistent estimators by method of percentile.
6. MLE by methods of scoring.
7. Comparison of consistent estimator
   On the basis of their MSE's of different estimators.
   On the basis of requirement of minimum sample size.
8. ACI, Testing of hypothesis by likelihood ratio tests, computation and plotting of power function of test.
9. Fitting of distributions to sample data using following tests:
   Chi-square goodness of fit test
   Kolmogorov Smirnov goodness of fit test
   Lilliefor's goodness of fit test
10. Practical on one sample location problem
    (i) Sign test (ii) Wilcoxon Signed rank test
11. Practical on two sample location problem
    (i) Wilcoxon Rank sum test (ii) Mann Whitney U test
12. Practical on k sample Kruskal Wallis test, Friedman test.

B. Practicals based on course ST-302 (24 Hrs,15M)

1. Estimation of parameters, testing various hypothesis and analysis of variance for the following linear models:
   - Two-way classification model with r observations per cell with/without interaction.
   - Two-way classification model with unequal observations per cell
   - Random effect model for one-way classification model

2. Estimation of parameters, testing various hypothesis and analysis of covariance for the following linear models:

- One-way classification model with one or more than one concomitant variable.
- Two-way classification model with one or more than one concomitant variable.

3. Analysis of BIBD
4. Identification/verification of various properties (balancedness/connectedness, orthogonality) of the given design.
5. Generation and analysis of two-level factorial designs, main effect and interaction plots.
6. Analyzing two-level factorial designs with
   (i) Total confounding (ii) Partial confounding (iii) single replicate
7. Generation and analysis of two-level fractional factorial designs.
8. Analysis of 3^2 factorial design using response surface model (RSM), main effect and interaction plots.
9. Generating CCD and analysis of CCD with RSM, contour plots, response surface plots, calculation of stationary point and optimum response.
10. Generation and analysis of Taguchi orthogonal array designs.

C. Practicals based on course ST-303 (22 Hrs,15M)

1. Graphical tools used in SPC with their interpretations:
   Stem-and-leaf plot, Box plot, Histogram, Probability Plots, cause and effect diagram, Pareto chart, Scatter plot, Check sheet, Control chart.
2. accessing normality of data
3. Plotting and interpretation of Control chart for attribute.
4. Plotting and interpretation of Control chart for variable.
5. Plotting Multivariate Control chart.
6. Process capability analysis for normal data.
7. Process capability analysis for non-normal data.
8. Gauge capability analysis.
9. Control charts for Short Production Runs
10. Single and double sampling plans for attributes: plotting OC, ASN, ATI, AOQ curves, finding AOQL.
11. Single sampling plan for variables.
12. Calculation and/or estimation of reliability in parallel, series and k-out-of-n structures.

D. Practicals based on course ST-304 (22 Hrs,15M)

(About 10-12 practicals to be designed according to optional courses by the concerned teacher)

ST-401: OPTIMIZATION TECHNIQUES

- Mathematical Programming Problem. (1L,2M)
- Convex sets and functions. (3L,5M)
  Convex sets, supporting and separating hyper-plane, convex polyhedron, convex functions. Role of convex sets and function in Mathematical programming Problem.
- Linear Programming Problem (LPP). (6L,9M)
  Linear programming models, Graphical solution to LPP, Standard LPP (SLPP), basic solution and basic feasible solution to SLPP. Method for solving LPP: Simplex Algorithm, Two-phase simplex method, Charne's M-technique.
- Duality in LPP. (5L,5M)
  Dual LP, simplex multipliers and their interpretation with reference to dual variables. Duality theorems, Dual simplex method with justification, Post-optimality (sensitivity) analysis, Changes affecting feasibility and optimality. Economic interpretation of dual variables and dual constraints.
- Integer LPP (ILPP) (5L,6M)
  - Methods for ILPP: Gomory's algorithm for pure ILPP, branch and bound method.
  - Applications of ILPP.
- Quadratic Programming Problem (QPP). (5L,6M)
  Definition of QPP, Kuhn-Tucker conditions, Algorithms for solving QPP: Wolfe's and Beale's algorithm, Dual of QPP.
- Network Models. (5L,6M)
  Network definitions and applications. Shortest route problem and shortest-route algorithm-Dijkstra's algorithm. Maximal flow model and Maximal flow algorithm, Network representation, critical path computations.
- Probabilistic Inventory Models. (5L,6M)
  General Inventory model, Classic EOQ model-lead time, reorders point, Probabilitized EOQ model. Probabilistic EOQ model, single period model: No setup model and setup model (s-s policy), multiperiod model.
- Dynamic Programming (5L,5M)
  Nature of dynamic programming, Deterministic processes, Non-sequential discrete optimization-allocation problems, assortment problems. Sequential discrete optimization long-term planning problems, multistage production processes. Marketing systems, application of dynamic programming to marketing problems.
- Queuing Systems. (10L,10M)
  - Elements of queuing models, Role of exponential distribution in queuing models.
  - Classification of queuing models with standard notations.
  - Poisson Queuing models, Generalized Poisson Queuing model and their steady state distributions.
  - Steady state solutions of M/G/1, G/M/1 and M/D/C queuing models using imbedded Markov chain method.

REFERENCES

Kambo N. S. (1991) Mathematical Programming Techniques.
Hadley G. (1987) Linear Programming.
Taha H.A. (2002) Operations Research 6th ed. (Macmillan).
Panneerselvam, R. Operations Research (Prentic hall of India)
Medhi j. (1984) Stochastic Processes 2nd ed.(New Age International Pvt. Ltd.)

ST-402: ACTUARIAL STATISTICS

- Introduction to Insurance Business. (2L,2M)
- Insurance and utility theory. (3L,3M)
- Risk models for Insurance. (4L,5M)
  - Individual and aggregate Risk models for short term.
  - Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.
- Survival function and Life tables. (8L,10M)
  - Survival function, Distribution function, Density functions and Force of mortality. Time-until-death random variable and Curtate-future lifetime random variable.
  - Life tables, Select and ultimate life tables.
  - Assumptions for fractional ages and some analytical laws of mortality.
- Life Insurance. (8L,10M)
  - Principles of compound interest: Nominal and effective rates of interest and force of interest and discount, compound interest, accumulation factor, continuous compounding.
  - Insurance payable at the moment of death and at the end of the year of death, level benefit insurance, Whole life insurance, endowment insurance, deferred insurance and varying benefit insurance.
  - Recursion equations and commutation functions.
- Annuities. (8L,8M)
  Annuities certain, Continuous and Discrete life annuities. Life annuities with m-thly payments and approtionable annuities. Recursion equations.
- Net premium. (8L,8M)
  - Fully continuous and discrete premiums.
  - True m-thly payment premiums, apportionable premiums and accumulation type benefits. Insurance model including expenses.
- Reserve. (5L,6M)
  Prospective and retrospective reserve. Fully continuous and discrete net premiums reserves. Reserves on a semicontinuous basis and true m-thly premiums. Reserves on an apportionable or discounted continuous basis. Recursive formulates and differential equations for reserves commutation functions.
- Multiple life functions. (3L,4M)
  Joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.
- Multiple decrement models. (4L,4M)
  Deterministic and random survivorship groups associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

REFERENCE

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

Browers, Newton L et al., Actuarial Mathematics 2nd . Society of Actuaries, 1997.

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

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

ST-403: Optional Course

List of optional courses to be offered for ST-403
(Detailed syllabus is given from Page No.15)

ST-403(A): Time Series Analysis
ST-403(B): Statistical Simulations

ST-404: TECHNICAL COMMUNICATIONS AND PRACTICALS-IV

Technical Communications (40 marks Internal Evaluation)

- **Lectures on:** **(14 Hrs, 10M)**
    - Technical and official communication skills.
    - Communication/presentation skills of the student.

- **Seminars by Students(to be assessed by teacher(s))** **(20 Hrs, 30M)**
  Each student will have to prepare his/her presentation/lecturer based on any topic from Statistics and deliver / present it before all students and teachers of the department..

Practicals-IV (60 marks External Practical Examination)
(Based on software and computer programming)

A. Practicals based on course ST-401 **(14 Hrs,14M)**

1. Getting basic feasible solution to given LPP.
2. Graphical solution to LPP with 2 decision variables.
3. Solving the primal LP (or dual LP) by using following methods.
    i) Simplex algorithm.
    ii) Simplex method.
    iii) Charne's Big-M method.
    iv) Dual simplex method.
4. Getting optimal solution for dual LP (without solving DLP) using optimal solution for primal LP.
5. Calculation of Simplex multipliers for given LPP.
6. Solving Quadratic programming problem using Kuhn-Tucker conditions.
7. Solving integer programming problem.
8. Practicals based on inventory models.
9. Simulation of various queuing models and verification of their steady state distributions.

B. Practicals based on course ST-402 **(21 Hrs,23M)**

1. Calculation of simple interest and compound interest.
2. Relation between nominal, effective and force of interest.
3. Plotting of utility functions.
4. Distribution of total claim in short term risk models.
5. Construction of life tables and Problems based on life tables
6. Life table using analytical laws of mortality.
7. Annuity immediate and due.
8. Calculation of premiums.
9. Calculation of reserves.
10. Multiple life functions.

C. Practicals based on course ST-403 **(21 Hrs,23M)**
(To be formulated by concerned teacher based on optional course.)

ST-405: PROJECT

- **Project duration:** 25th November to 30th April. (Students may start preliminary work related to their project after second semester).
- **Project Guide:** Teachers from the Department of Statistics and/or personnel from organization where student is going to visit for field work or training. Each project group will be guided by concerned teacher (guide) for one hour per week throughout the semester.
- **Fieldwork:** Students will be given one month period in December during last semester for their industrial work/data collection/survey or any other fieldwork involved in the project.
- **Project Topic:** Students in consultation with the guide will decide Project Topic/Area. Topic may be decided after completion of second or third semester. Project work may be carried out in a group of students depending upon the depth of fieldwork/problem involved.
- **Project report:** Project report should be submitted in typed form with binding by 5th May (or within 7/10 days after external theory examination). Project viva will be arranged in the 1st or 2nd week of May.
- **Project evaluation:** Project evaluation will be based on
  (i) Project report(60marks)
  (ii) Presentation by student or group of students. (20 marks)
  (iii) Viva voce (20 marks)

  Two examiners will evaluate project work.

Detailed syllabi of optional courses

ST-304(A): DESIGN AND ANALYSIS OF CLINICAL TRIALS

- Introduction to Clinical Trials(CTs) (4L,4M)
  - Need and ethics of CTs
  - History of CTs.
  - Regulatory process and Requirement.
  - Investigational New Drug Application.
  - New Drug Application.
  - Overview of Phases I to IV trials
- Basic Design Consideration. (5L,5M)
  - Introduction.
  - Patient Selection.
  - Selection Control.
  - Statistical Consideration.
- Randomization and Blinding. (6L,6M)
  - Randomization Models.
  - Randomization Methods.
  - Implementation of Randomization.
  - Generalization of Controlled Randomized Trials.
  - Blinding.
- Classification Clinical Trials. (5L,5M)
  - Multicenter Trial.
  - Active Control Trial.
  - Combination Trial.
  - Equivalence Trial.
- Bioavailability and Bioequivalence Studies. (6L,6M)
  - History of Bioavailability Studies.
  - Formulation and Routes of Administration.
  - Pharmacokinetic Parameter.
  - Clinically Importance Differences.
  - Assessment of Bioequivalence.
  - Decision Rules and Regulatory Aspect.
  - Statistical Consideration.
- Designs of Clinical Trials. (6L,6M)
  - Parallel Designs.
  - Crossover Designs.
  - Balanced Incomplete Block Designs
  - Titration Designs.
  - Enrichment Designs.
- Statistical Inference for Effects from a Standard 2x2 Crossover Design. (8L,8M)
  - The Carry-over Effect.
  - The Direct Drug Effect.
  - The Period Effect.
  - The Analysis of Variance.

- Analysis of Continuous Data. (6L,6M)
  - Estimation.
  - Test Statistics.
  - Analysis of Variance.
  - Analysis of Covariance.
  - Nonparametric.
  - Repeated Measure
- Analysis of Categorical Data. (6L,6M)
  - Statistical Inference for One Sample.
  - Inference for Independent Sample.
  - Ordered Categorical Data.
  - Combing Categorical Data.
  - Model-Based Method.
  - Repeated Categorical Data.
- Power and Sample size Determination. (4L,4M)
  - Hypothesis and Type I and Type II Errors.
  - Power and Relative Efficiency
  - Sample size Determination.
- Assumptions and Outlier Detection. (4L,4M)
  - Tests for Assumption.
  - The Definition of Outlying Observation.
  - Detection of Outlying Subject.
  - Detection of Outlying Observation.

LAB WORK for Practicals based on following topics (Use of software packages is desirable).

1. Demonstration of *p*-value, type I and type-II errors using Z-test, t-test, two sample t-test, paired t-test and its interpretation and role in testing of hypothesis in CTs.
2. Relation between sample size and power of the test.
3. Randomization Methods.
4. Statistical Analysis for Parallel Designs.
5. Statistical Analysis for Standard 2x2 Crossover Designs.
6. Analysis of continuous data based on repeated measures under CTs.
7. Nonparametric Tests.
8. Analysis of Categorical Data.
9. Outlier Detection in CTs.
10. Estimation of Pharmacokinetic parameters.

REFERENCES

J.L.Fleiss (1989) The Design and Analysis of Clinical Experiments. Wiley and Sons.
E.Marubeni and M.G.Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational studies, Wiley and Sons.
Shein-Chung Chow and Jen-pei Liu, Design and Analysis of Clinical trial, Wiley and Sons.
Shein-Chung Chow and Jen-pei Liu, Design And Analysis of Bioavailability and Bioequvalence Studies,Marcel Dekker,Inc

ADDITIONAL REFERENCES

S.Paintadosi.(1997) Clinical Trials: A Methodologic Perspective. Wiley and Sons.
L.M.Friedman, C.Furburg, D.L.Demets (1998). Fundamentals of Clinical Trials, Springer Verlag.

ST-304(B): FINANCIAL MATHEMATICS

- The measurement of interest: (8L, 8M)
  Introduction, The accumulation and amount functions, The effective rate of interest, Simple interest, Compound interest, Present value, The effective rate of discount, Nominal rates of interest and discount, Forces of interest and discount, Varying interest, Summary of results.
- Solution of problems in interest: (6L, 6M)
  Introduction, The basic problem, Equation of value, Unknown time, Unknown rate of interest, Determining time periods, Practical examples.
- Basic annuities: (8L, 8M)
  Introduction, Annuity-immediate, Annuity-due, Annuity values on any date, Perpetuities, Unknown time, Unknown rate of interest, Varying interest, Annuities not involving compound interest.
- More general annuities: (8L, 8M)
  Introduction, Differing payment and interest conversion periods, Annuities payable less frequently than interest convertible, Annuities payable more frequently than interest convertible, Continuous annuities, Payments varying in arithmetic progression, Payments varying in geometric progression, More general varying annuities, Continuous varying annuities, Summary of results,
- Amortization schedules and sinking funds: (8L, 8M)
  Introduction, Finding the outstanding loan balance, Amortization schedules, Sinking funds, Differing payment periods and interest conversion periods, Varying series of payments, Amortization with continuous payments, Step-rate amounts of principal.
- Bonds and other securities: (8L, 8M)
  Introduction, Types of securities, Price of a bond, Premium and discount, Valuation between coupon payment dates, Determination of yields rates, Callable and putable bonds, Serial bonds, some generalizations, other securities, Valuation of securities.
- Yield rates: (8L, 8M)
  Introduction, Discounted cash flow analysis, Uniqueness of the yield rate, Reinvestment rates, Interest measurement of a fund, Time-weighted rates of interest, Portfolio methods and investment year methods, Short sales, Capital budgeting-basic technique and other technique.
- Stochastic approaches to interest: (6L, 6M)
  Concept of a stochastic interest rate model and the fundamental distinction between this and a deterministic model, Independent rates of interest, The lognormal model

LAB WORK for Practicals based on following topics by using software package

1. Calculation Present and accumulated value of simple and compound interest.
2. Relation between nominal, effective and force of interest.
3. Calculation of present and accumulated value of annuities.
4. Redemption of loan schedule.
5. Bonds and securities
6. Yield rates.
7. Stochastic interest rates

REFERENCES

1. Kellison Stephen G., The Theory of Interest, 3rd Edition. McGraw-Hill International Edition (2009).
2. UK Institute of Actuaries core reading for the subject CT1-Financial Mathematics.

ST-403(A): TIME SERIES ANALYSIS

- Time series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. (8L,8M)
- Exploratory Time Series Analysis Tests for trend and seasonally. Exponential and Moving Average Smoothing. Holt and Winters smoothing. Forecasting based on smoothing, Adaptive smoothing. (8L,8M)
- Detailed study of the stationary processes: (1) Moving average (MA), (2) Auto regressive (AR) and (3) ARMA process. Discussions (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Partial autocorrelation function. Estimation of Parameters, Choice of AR and MA periods. Order selection for ARMA process, Forecasting ARMA processes, Residual analysis and diagnostic checking. (20L,20M)
- Introduction to spectral analysis of weakly stationary process. Periodogram and correlogram analyses. (6L, 6M)
- Nonstationary and Seasonal Time series Models: Unit-root in nonstationarity, Unit-root tests, Integrated ARMA (ARIMA) models, Box-Jenkins models. Estimation of ARIMA model parameters. Seasonal ARIMA (SARIMA) models (12L, 12M)
- Introduction to Conditional Heteroschedastic Models: Volatility models, ARCH and GARCH, Properties, Examples, Estimation & Forecasting, (6L, 6M)

LAB WORK for Practicals (Use of software package is desirable)

1. Exploratory Analysis.
2. Smoothing.
3. Numerical exercises on MA and AR models Forecasting.
4. Numerical exercises on ARMA and ARIMA models Forecasting.
5. Numerical exercises on Box-Jenkins models.
6. Residual analysis and diagnostic checking.
7. Periodogram analysis and interpretation.
8. Correlogram analysis and interpretation.
9. Numerical exercises on Non-Stationary time series models
10. Volatility models.

REFERENCES

Box, G.E.P and Jenkins G.M. (1994). Time Series Analysis-Forecasting and Control, Holden-day San Francisco.

Anderson. T.W. (1971). The Statistical Analysis of Time Series Wiley, N.Y.

Montgemory, D.C. Johnson L.A (1990) Forecasting and Time Series Analysis, McGraw Hill.

Kendall, Sir Maurice and Ord, J.K. (1990). Time Series (Third Edition), Edward Arnold.

Brockwell, P.J. and Davis R.A.(2006) Time Series: Theory and Methods (Second Edition) Springer-Verlag.

ADDITIONAL REFERENCES

Fuller, W.A (1996) . Introduction to Statistical Time series , John Wiley N.Y.

Granger, C.W.J. and Newbold (1984) Forecasting Economic Time Series, Third Edition, Academic Press.

Kendall, M.G. and Stuart A. (1966). The Advanced Theory of Statistics, Volume 3, Charles Griffing, London.

Koopmans, L.H. (1974), The Spectral Analysis of Time series, Academic Press.

ST-403(B): STATISTICAL SIMULATIONS

- Statistic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates. (15L, 15M)

- Simulating multivariate distributions, MCMC methods and Gibbs sampler, simulating random fields, simulating stochastic process. Variance reduction technique: importance sampling for integration, control variates and antithetic variables. (15L, 15M)

- Simulating a non-homogeneous Poisson process, Optimization using Monte Carlo methods, simulated annealing for optimization. Solving differential equations by Monte Carlo methods. (15L, 15M)

- Jackknife and Bootstrap. Bootstrap methods: re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution. Confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations. (15L, 15M)

REFERENCES

Fishman, G.S. (1996) Mante Carlo: Concepts, Algorithms and Applications. (Springer).

Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley).

Ripley, B.D. (1987) Stochastic Simulations (Wiley).

Ross, S. M. (2002) Simulation (Third Edition) (Academic).

Efron,B. and Tibshirani. R.J. (1993); An introduction to the Bootstrap.

Davison, A.C. and Hinkley,D.V. (1997) Bootstrap methods and their applications (Chapman and Hall).

Sho.J and Tu,D (1995); The Jackknife and the Bootstrap. Springer Verlag.