

SYLLABUS

Master of Statistics Part – II

Outlines of Tests Syllabi and Courses of Reading.

Note:-Every theory paper will be of three hours duration.

For Examination of Session 2017-18&2018-19.

3rd Semester

Code	Core/ Elective	Title of paper/ subject	Max Maks		Total	Total Credits
			Internal Asmt.	Univ. Exam.		
MS 231	Core	Statistical Inference-II	30	70	100	6
MS 232	Core	Design of Experiments	30	70	100	6
MS 233	Core	Object Oriented Programming Using 'C++'	30	70	100	6
MS 234	Elective	Optional(Out of the List Attached)	30	70	100	6
MS 235	Core	Computer Oriented Practicals-III	-	100	100	3
Total			120	380	500	27

4th Semester

Code	Core/ Elective	Title of paper/ subject	Max Maks		Total	Total Credits
			Internal Asmt.	Univ. Exam.		
MS 241	Core	Multivariate Analysis	30	70	100	6
MS 242	Core	Industrial Statistics	30	70	100	6
MS 243	Core	Stochastic Processes	30	70	100	6
MS 244	Elective	Optional (Out of the List Attached)	30	70	100	6
MS 245	Core	Computer Oriented Practicals-IV	-	100	100	3
Total			120	380	500	27

**BREAK-UP OF CONTINUOUS ASSESSMENT OF 30 MARKS
OF THEORY PAPERS**

- | | | |
|----|---|----------|
| 1. | Two tests will be held and their average will be considered for assessment. | 18 Marks |
| 2. | Seminars/Assignments/Quizes/
Class participation | 6Marks |
| 3. | Attendance | 6 Marks |
| | Marks will be given according to following criteria: | |
| | 75% attendance & above
but less than 80% | 4 Marks |
| | 80% attendance & above
but less than 85% | 5 Marks |
| | 85% attendance& above | 6 Marks |

PAPER-MS 231:STATISTICAL INFERENCE-II

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Sequential Analysis: Sequential Testing Procedure, Performance Functions : OC and ASN; Wald's SPRT. Strength of a SPRT and Determination of its Stopping Bounds. Properties of the Stopping Rule N in the SPRT (SPRT Terminates with Probability one, MGF of N exists under Certain Conditions). Determination of OC and ASN Functions of the SPRT. Wald's Fundamental Identity and its Use in the Derivations of OC Function & ASN Function of SPRT ,Efficiency of SPRT.

Order Statistics: Concept of Nonparametric and Distribution-Free Methods. Order Statistics and their Marginal and Joint Sampling Distributions. Distribution of Sample Quantiles, Median , Range and Quartile Deviation of Order Statistics. Large Sample Approximate Mean and Variance of a Order Statistics, Statement of Asymptotic Normality of the Distribution of Order Statistics. Sample Quantile, Hypotheses Testing and Confidence Intervals for Quantiles

SECTION-B

Goodness of Fit Problem: Likelihood Ratio Test, Chi-Square Test and Kolmogorov Test and Distribution-Free Nature of these Goodness-of-Fit Tests.

One Sample Problem: Tests for Randomness and Departure from it Based on Runs. One-Sample Location Problem: Ordinary Sign Test, Wilcoxon Signed-Rank Tests, Comparison, Uses, Problems of Zero and Tied Differences in Rank Order Statistics. Use of Wilcoxon Signed-Rank Test for Hypotheses of Symmetry.

Two Sample Problem: Linear Rank (LR) Statistic and Asymptotic Normality, General Two Sample Problem: Hypotheses of Homogeneity of Two Distributions and Alternative Hypotheses .Kolmogorov-Smirnov Test, Wald-Wolfowitz Run Test , Median Test, Mann-Whitney U-Test .Two Sample Location Tests: Wilcoxon Test, Terry-Hoeffding Test,Vander-Waerden Test. Two Sample Scale Tests: Mood Test, Freund-Ansari-Bradley Test ,Siegel-Tukey Test.

Kruskal Wallis ANOVA Test Based on Ranks.

TEXT BOOKS

1. Goon, AM.,Gupta, M.K. Dasgupta, B. An Outline of Statistical Theory, Vol.II, World press, Calcutta, 2008
2. Rohatgi, V.K. An Introduction to Probability Theory and Mathematical Statistics, Wiley Easter, 1985
3. Wald,A. Sequential Analysis, John Wiley and Sons
4. Gibbons, J.D. Nonparametric Statistical Inference, Taylor & Francis,2014

REFERENCE READINGS

1. Dudowicz, E, J.and Mishra, S.N. Modern Mathematical Statistics , J. Wiley 1988
2. Fraser,D.A.S. Non Parametric Methods in Statistics, J. Wiley.
3. Sprent, P.and Smeeton N. C. Applied Nonparametric Statistical Methods,4th Edition, Chapman and Hall.2007
4. Randles,R.H. and Wolfe, D.A. Introduction to the theory of Nonparametric Statistics, J. Wiley, 1979.

PAPER-MS 232 : DESIGN OF EXPERIMENTS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Linear Models: Concept of Fixed Effects , Random Effects and Mixed Effects Models. Linear Estimation Theory: Estimable Linear Function of Parameters, Best Linear Unbiased Estimation (BLUE), Gauss Markoff Theorem. General Linear Models of Full Rank, Least Square Estimates of Regression Coefficients, Estimation of Error Variance, Properties of Least Square Estimators. Basic Principles of Design of Experiments : Randomization , Replication & Local Control, Layout , Description, Analysis of Completely Randomized , Randomized Complete Block and Latin Square Designs and their Relative Merits and Demerits . Missing Plot Technique for Randomized Complete Block and Latin Square Designs. General Block Designs and its C-Matrix, Criteria of Orthogonality , Connectedness, Balance and Resolvability.

SECTION - B

BIB Designs: Definition, Parametric Relations, BIB Designs Related to a given BIBD and Analysis (Without Recovery of Inter-Block Information). PBIB Design: Introduction, Definition of Association Schemes and PBIB Designs with m Associate Classes, Relations between the Parameters of Association Schemes with m-Associate Classes, Association Matrices. Classification of Two Associate Class Association Schemes into Group Divisible(GD), Triangular and Latin Square Schemes only. Youden Squares, Factorial Experiments, Complete and Partial Confounding In 2^n , 3^2 And 3^3 Factorial Experiments. Fractional Replications in 2^n Factorial Experiments . Split Plot Designs (Only Description and Sketch of Analysis).

TEXT BOOKS

1. Graybill, F.A. An Introduction to Linear Statistical Inference Vol-I
2. Raghavarao , D. Construction & combinatorial problems in Design of Experiments, Wiley, New York,1988
3. Kempthorne, O Design and Analysis of Experiments, Wiley
4. Das, M.N.& Giri, N.C. Design and Analysis of experiment Wiley Eastern, 1979
5. Dey, Alok Theory of Block Designs, Wiley Eastern, 1986

PAPER-MS 233 : Object Oriented Programming Using 'C++'

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

NOTE FOR EXAMINATION BRANCH

1. Examination of this paper will consist of two parts Part-A (Theory) and Part-B(Practical).
2. Setting of Part-A(Theory) will be done by an external examiner who will be provided with the syllabi, Part-A (Theory) examination will be conducted along with other theory papers.
3. Setting ,conduct and evaluation of Part-B practical examination will be done on the spot jointly by an external and an internal examiner ,which will be appointed by the Head of the department after the external examiners give consent for the examination date .

(I) Part-A : (THEORY)

Max. Marks : 46

No. of Lectures to be delivered: 40

Min. Pass Marks : 35%

Time Allowed : 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 9 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 7 marks each where as section C will carry 18 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 7 marks each where as section C will carry 18 marks.

Use of scientific non-programmable calculator is allowed

SECTION-A

Evolution of OOP, OOP Paradigm, Advantages of OOP, Comparison between Functional Programming and OOP Approach, Characteristics of Object Oriented Language-objects, Classes, Inheritance, Reusability, User defined Data Types, Polymorphism , Overloading. Introduction to C++ , Identifier and keywords, Constants, C++ Operators, type conversion, Variable declaration, statements, expressions, features of iostream.h and iomanip.h, input and output, conditional expression loop statements, breaking control statements.

Defining a function , types of functions, storage class specifiers, recursion, pre-processor, header files and standard functions, Arrays, pointer arithmetic's, structures, pointers and structures, unions, bit fields typed, enumerations.

SECTION - B

Classes, member functions, objects, arrays of class objects, pointers and classes, nested classes, constructors, destructors, inline member functions, static class member, friend functions, dynamic memory allocation.

Inheritance, single inheritance, types of base classes, types of derivation, multiple inheritance, container classes, member access control.

Function overloading, operator overloading, polymorphism, early binding, polymorphism with pointers, virtual functions, late binding, pure virtual functions, opening and closing of files, stream state member functions, binary file operations, structures and file operations, classes and file operations, random access file processing.

TEXT BOOKS

1. Robert Lafore, "Object Oriented Programming in Turbo C++", Galgotia Publications, 1994.

REFERENCE BOOKS

1. D. Ravichandran, "Programming with C++", TMH, 1996.
2. Timothy Budd, " An Introduction to Object Oriented Programming", 2nd edition, Addison - Wesley - 1997.

(II) PART-B (PRACTICAL)

Max. Marks	: 24
Min. Pass Marks	: 9 (35 percent)
Time allowed	: 3 hours
No. of lab sessions	: 10
(1 session /week each of 2 hrs. duration)	

INSTRUCTIONS FOR THE PAPER SETTERS

Examiner will set two alternative sets each having four practical exercises based on entire syllabus of Part-A (Theory). Candidates are required to attempt any two exercises from the given set .Division of marks out of 24 is as follows :

Exercise	: 16
Sessional work	: 04
Viva-voce	: 04

PAPER-MS 234 : Optional (One out of the list given at the end of the 4th semester)

The teaching of this paper will be decided by the internal members of the Board of Studies of Statistics Department P.U.Patiala.

PAPER-MS 235 : COMPUTER ORIENTED STATISTICAL PRACTICALS-III

Max. Marks : 100
Total Practical Sessions : 35
(each of two hours)

Min. Pass Marks : 35%
Time Allowed : 4 hours

INSTRUCTIONS FOR THE PAPER-SETTERS

1. The paper will be set in two separate parts PART-A and PART-B .The setting and evaluation will be done by a Board of examiners consisting of Head (Chairman), External Examiners and Teacher (S) involved with the teaching of this paper.
2. PART-A of this paper will be set on the spot and will be of one and a half hours duration. This will consist of two problems. The problems will be **based on theory papers MS 231 and MS 232** using Programming in "C++" & / or Statistical Software packages such as MINITAB , SPSS , STATISTICS, etc.
3. PART-B of the paper will be of two and a half hours duration .This will consist of FOUR questions **based on theory papers MS 231 and MS 232** with at least one question from each of these papers. The candidates will be required to attempt any TWO problems using electronic device.
4. The division of marks ,out of a total of 100 and Minimum pass Marks, will be as follows :

Maximum Marks	:	100
Minimum pass Marks	:	35 (35 %)
Sessional work	:	18
Viva	:	20
Exercises based on Part A	:	26
Exercises based on Part B	:	36

SYLLABUS DETAILS FOR PAPER- MS 235 (PRACTICAL)

PART-A : Programming in "C++" &/or Applying statistical software packages for problems based on Theory papers **MS 231 and MS 232**:

Use of Statistical Software packages such as MINITAB ,SPSS , Statgraf etc.

PART-B : Practical Exercises for Statistical techniques based on topics in papers **MS 231 and MS 232**.

RECOMMENDED READINGS

Stoodly.K. : Applied and computational Statistics, Ellis Howard.

4th Semester

PAPER- MS 241: MULTIVARIATE ANALYSIS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Multivariate Normal Distribution: Definition, Marginal and Conditional Distributions , Distribution of Linear Combinations of Normally Distributed Variables , Characteristic Function and Moments ; Maximum Likelihood Estimation of Mean Vector and Dispersion Matrix ; Test of Hypothesis for Specified Value of the Mean when the Dispersion Matrix is Known ; Independence of the Distribution of Sample Mean Vector and Sample Dispersion Matrix . Simple , Partial and Multiple Correlation Coefficients and their Estimation ; Sampling Distribution of Simple , Partial and Multiple Correlation Coefficients when the Corresponding Population Correlation Coefficients are Zero. Testing Hypotheses of Significance of these Distributions.

Hotteling's T^2 - Statistic: Justification ,Distribution and Uses . The Mahalanobis D^2 -Statistic. The Multivariate Behrens- Fisher Problem and its Solution .

SECTION - B

Classification Problem ,Standards of Good Classification . Bayes and Minimax Regions for Classification into one of two known Multivariate Normal Populations when the Parameters are known or unknown , Classification into one of Several Populations. Bayes and Minimax Regions of Classification into one of Several Multivariate Normal Populations. Wishart Distribution : Definition , Characteristic Function and Properties.

Cochran's Theorem and its Applications, Generalized Variance of the Multivariate Normal Distribution, Sample Generalized Variance: Interpretation and Distribution; Distribution of the Set of Correlation Coefficients for a Diagonal Population Dispersion Matrix .

Principal Components in the Population , Canonical Correlations in the Population.

TEXT BOOKS

Anderson T.W. : An Introduction to Multivariate Statistical Analysis,Wiley Eastern , 1983

REFERENCE READINGS

- 1.Khirsagar : Multivariate Analysis , Marcel Dekkar.1972
- 2.Bhuyan , K.C : Multivariate Analysis and its applications,
New Central Book Agency Pvt. Ltd.2008
- 3 Rao, C .R and. : Multivariate Statistics and Probability,
Rao, M.M Elsevier & Academic Press,1989

PAPER-MS 242 : INDUSTRIAL STATISTICS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Analysis of Time Series, Trend Measurement ; Use of Polynomial, Modified Exponential, Gompertz and Logistic Functions . Moving Average Method, Spencer's Formulae; Variate Difference Method , its Use for Estimation of Variance of the Random Component. Measurement of Seasonal Fluctuations, Measurement of Cyclical Movement. Periodogram Analysis.

Concept of Stationary Time Series, Correlogram Analysis, Correlogram of an Autoregressive Scheme, a Moving Average Scheme and a Harmonic Series. Index Numbers : Construction and Uses of Index Numbers; Index Numbers of Prices, Cost of Living Index Number, Base Shifting and Splicing of Index Numbers.

SECTION- B

Statistical Quality Control and its Purposes; 3σ Control Limits, Control Charts for Variables (Mean and Range, Mean and Standard Deviation). Control Chart for Fraction Defective, Control Chart for the Number of Defects per Unit : Natural Tolerance Limits and Specification Limits; Modified Control Limits. Sampling Inspection Plan : Concepts of Acceptance Quality Level (AQL), Lot Tolerance Proportion Defective (LTPD) and Indifference Quality.

The Single, Double and Sequential Sampling Plans and their Four Curves Viz. AOQ, Operating Characteristic (OC), Average Sample Number (ASN) and Average Total Inspection (ATI). The Choice of Sampling Plans by Attributes and Variables. Acceptance Sampling Plan by Variables, Single and Sequential Sampling Plans, Acceptance Sampling by Variables (Known and Unknown σ Cases).

TEXT BOOKS

M.G. Kendall	Time Series, 3 rd Edition, Great Britain: Arnold Press ,1990
S.C. Gupta and	Fundamentals of Applied Statistics, 4 th Edition,
V.K. Kapoor	Sultan Chand & Sons, 2014
S.K. Ekambaram	The Statistical Basis of Acceptance Sampling.
	Asia Publishing House, 1963
Goon, A.M.;	Fundamentals of Statistics, Vol. II, ed. VI, Word Press,
Gupta, M.K. and	Calcutta ,2008
Dasgupta, B.	
Montgomery, D.C.	Introduction to Statistical Quality Control, J. Wiley. 1985

REFERENCE READINGS

Gowden, D.J.	Statistical Methods in Quality Control, Prentice Hall.
Grant, E.L.	Statistical Quality Control, Wiley Eastern.
Hansen, B.L. and	Quality Control and Application, PHI. 1987.
Ghare, P.M.	

PAPER- MS 243 : STOCHASTIC PROCESSES

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Generating Function, Convolutions, Chapman-Kolmogorov Equations , Compound Distribution, Partial Fraction Expansion of Generating Functions, Stochastic Processes: Introduction and its Classification, Recurrent Events, Recurrence Time Distribution: Necessary and Sufficient Condition for Persistent and Transient Recurrent Events & Its Illustrations and Notion of Delayed Recurrent Event.

Random Walk Models : Gambler's Ruin Problem, Probability Distribution of Ruin at nth Trial, Markov Chains : Classification of States and Chains, Evaluation of the nth Power of its Transition Probability Matrix.

SECTION - B

Notions of Markov Processes in Continuous Time. Poisson Process: Simple Birth Process, Simple Death Processes, Simple Birth and Death Process, Effect of Immigration on Birth and Death Process. Polya's Processes, Simple Non-Homogeneous Birth and Death Processes.

Discrete Branching Processes, Chance of Extinction, Means and Variance of the nth Generation. Queueing Processes : Equilibrium Theory, Distribution of Queue Length and Waiting Time Queues with Many Servers.

TEXT BOOKS

1. Bailey, N.T.J. The Elements of Stochastic Processes.(1964 Ed.)

REFERENCE READINGS

1. Medhi , J. Stochastic Processes. Wiley Eastern Ltd.
2. Karlin , S. Introduction to Stochastic Processing, Vol. I, Academic Press.

PAPER-MS 244 : Optional (One out of the list given at the end of the 4th semester)

The teaching of this paper will be decided by the internal members of the Board of Studies of Statistics Department P.U.Patiala.

PAPER-MS 245 : COMPUTER ORIENTED STATISTICAL PRACTICALS -IV

Max. Marks	: 100	Min. Pass Marks	: 35%
Total Practical Sessions	: 35	Time Allowed	: 4 hours

(each of two hours)

INSTRUCTIONS FOR THE PAPER-SETTERS

5. The paper will be set in two separate parts PART-A and PART-B .The setting and evaluation will be done by a Board of examiners consisting of Head (Chairman), External Examiners and Teacher (S) involved with the teaching of this paper.
6. PART-A of this paper will be set on the spot and will be of one and a half hours duration. This part will consist of Two problems. The problems will be based on theory papers **MS 241 and MS 242** using Programming in "C++" & / or Statistical Software packages such as MINITAB , SPSS , STATISTICA, etc.
7. PART-B of the paper will be of two and a half hours duration .This part will consist of FOUR questions **based on theory papers MS 241 and MS 242** with at least one question from each of these papers. The candidates will be required to attempt any TWO problems using electronic device.
8. The division of marks ,out of a total of 100 and Minimum pass Marks, will be as follows :

Maximum Marks	:	100
Minimum pass Marks	:	35 (35 %)
Sessional work	:	18
Viva	:	20
Exercises based on Part A	:	26
Exercises based on Part B	:	36

SYLLABUS DETAILS FOR PAPER- MS -245(PRACTICAL)

PART-A : Programming in "C++" &/or Applying statistical software packages for problems based on Theory **papers MS 241 and MS 242:**

Use of Statistical Software packages such as MINITAB ,SPSS , Statgraf etc.

PART-B :Practical Exercises for Statistical techniques based on topics in papers **MS 241 and MS 242.**

RECOMMENDED READINGS

Stoodly.K. : Applied and computational Statistics, Ellis Howard.

LIST OF OPTIONAL PAPERS:
OPTIONAL-I : OPERATIONS RESEARCH (OPTIMIZATION TECHNIQUES)

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Convex Sets & Its Properties, Extreme Points, Linear Programming Problems(LPP)- Definition, Forms & Mathematical Formulation, Solution Methods: Graphical Method, Simplex Method, Big M Method, Two Phase Simplex Method. The Problem of Degeneracy and its Resolution. Duality in Linear Programming : Mathematical Formulation, Solution of Dual Problems, Complementary Slackness Theorem, Duality and Simplex Method, Dual Simplex Algorithm. Sensitivity Analysis: Variation in the Cost Vector, Requirements Vector and Coefficient Matrix.

SECTION - B

Integer Programming; Pure & Mixed Integer Problems, Solutions; Fractional-Cut and Branch & Bound Methods. Game Theory; Two Person Zero-Sum Games, The Maximin-Minimax Principle, Games without Saddle Points-Mixed Strategies, Graphical Solution of $2 \times n$ and $m \times 2$ Games, Dominance Property, Modified Dominance Property, Arithmetic Method for $n \times n$ Games, Linear Programming Method, Iterative Method. Transportation Problems- Mathematical Formulation & Basic Properties, Initial Basic Feasible Solution by NW Corner Rule, Lowest Cost Entry Method, Vogel's Approximation Method, Optimum Solution of Transportation Problems. Assignment Problem- Formulation and Solution. Non Linear Programming Problems- Mathematical Formulation, Kuhn-Tucker Conditions (Without Proof), Quadratic Programming; Wolfe's Modified Simplex and Beale's Methods.

TEXT BOOKS

1. Kanti Swarup, P.K. Gupta and Man Mohan : Operations Research, Sultan Chand and sons, N. Delhi, Second Edition ; 1986.
2. S. I. Gass : Linear Programming , 3rd Edition, 1969, McGraw Hill
3. Hira, D. S.and Gupta P. K. : Operations Research, Sultan Chand & company Ltd., N. Delhi, 1st Edition.

REFERENCES READING

1. Taha , H. A. : Operations Research, Pearson Education, Seventh Edition , 2004

OPTIONAL-II : RELIABILITY THEORY

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Reliability : Definition , Types, Relation between Hazard rate and Reliability function. Series System, Parallel System, k-out-of-n System, Redundant System & Types of redundancy , Standby Redundant System, Repairable System. Coherent Structures, Representation of Coherent System in Terms of Paths and Cuts, Modular Decomposition, Lower/Upper Bounds on System Reliability. Structural and Reliability Importance of Components. Evaluation of Reliability function, Hazard Rate, Mean and Variance for Exponential, Weibull, Gamma life distributions. Notions of aging , IFR, IFRA, NBU, 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 : Cumulative Damage Model, General Cumulative Damage Model and Successive Shocks Cause Greater Damage Model. Common Bivariate Exponential Distribution and its parameters, Nonfatal Shock Model yielding Bivariate Exponential Distribution.

SECTION - B

Concept of Censoring and its types , Reliability Estimation based on Failure Times in Censored Life Tests: Kaplan –Meier Estimation, Hazard Plotting Technique, Maximum Likelihood Estimation and Probability Plotting Technique. Stress-Strength Reliability and its Estimation, Maintenance and Replacement Policies.

Availability : Definition and Types, System Availability : Independent Component Performance Processes Model , Series System Availability : Functioning Components Suspend Operation during Repair Model. Reliability Growth Models. Tests for HPP vs. NHPP with Repairable Systems. Hollander-Proschan and Deshpande tests for exponentially.

Basic ideas of Accelerated Life Testing and Acceleration Models .

TEXT BOOKS

- 1.Barlow R. E. and Proschan F., Statistical Theory of Reliability and Life Testing ; Holt, Rinehart and Winston (1985).
- 2.Dodson B. and Nolan D.,Reliability Engineering Handbook; Marcel Dekker, Inc., New York(1999)
3. NIST/SEMATECH e-Handbook of Statistical Methods (<http://www.itl.nist.gov/div898/handbook/>)

REFERENCES READINGS

- 1.Lawless J. F. (2002) Statistical Models and Methods of Life Time Data, 2nd edition ; John Wiley .
- 2.Bain L.J. and Engelhardt (1991) Statistical Analysis of Reliability and Life Testing Models, CRC press
3. Nelson , W (1982) Applied Life Data analysis ; John Wiley
4. Zacks S., Introduction to Reliability Analysis , Springer.(1992)

OPTIONAL-III: LINEAR MODELS AND REGRESSION ANALYSIS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION- A

Gauss-Markov set up, Normal equations and Least squares estimates, Error and estimation spaces, variances and covariances of least squares estimates, estimates of error variance, estimation with correlated observations, least squares estimates with restriction on parameters, simultaneous estimates of linear parametric functions.

Tests of hypotheses for one and more than one linear parametric functions, confidence intervals and regions, Analysis of Variance, Power of F-test, Multiple comparison tests due to Tukey and Scheffe, simultaneous confidence intervals.

Introduction to One-Way random effects linear models and estimation of variance components .

SECTION - B

Simple linear regression, multiple regression, fitting of polynomials and use of orthogonal polynomials.

Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies.

Introduction to non-linear models.

Multicollinearity, Ridge regression and principal component regression, subset selection of explanatory variables, Mallows's Cp statistic.

TEXT BOOKS

1. Cook, R.D. and Weisberg , S. (1982). Residual and Influence in Regression. Chapman and Hall.
2. Draper , N. R. and Smith , H. (1988). Applied Regression Analysis. 3rd Ed. Wiley.
3. Gunst , R.F. and Mason, R.L. (1980). Regression Analysis and its Applications-A Data Oriented Approach. Marcel and Dekker
4. Rao , C. R. (1973). Linear Statistical Inference and its Applications. Wiley Eastern.
5. Weisberg , S. (1985). Applied Linear Regression. Wiley.
5. Searle,S.R : Linear Models
6. Seber, R.A.F : Regression Analysis.

OPTIONAL-IV : ADVANCED SAMPLING THEORY

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Two-stage with unequal number of second stage units. Issues in stratified sampling : allocation problems involving several study variables, stratum boundary determination problems, Double sampling .

Introduction to the unified theory of finite population sampling.

Horvitz- Thompson Estimator (HE) of a finite population total/mean, expressions for V (HTE) and its unbiased estimator, Issues in non- negative variance estimation . PPS schemes of sampling due Midzuno-Sen, Brewer, Durbin and JNK Rao (sample size 2 only), Rao-Hartley-Cochran sampling scheme for sample size n with random grouping .

SECTION-B

Issues in small area estimation – synthetic and generalized regression estimators.

Non- sampling errors and biased responses, randomized responses for variables, errors in surveys, modeling observational errors, estimation of variance components, application to longitudinal studies (repetitive surveys).

Variance estimation, method of random groups, balanced half samples (IPNSS), jackknife method .

Introduction to super population models .

TEXT BOOKS

1. Chaudhuri, A and J.W.E. vos (1988) unified theory and Strategies of Survey Sampling, North-Holland, Amsterdam.
2. Chaudhuri, A. and R. Muderjee (1988) Randomized Response : Theory and techniques, New York : Marcel Dekker Inc.
3. Cochran, W.G. (1984) : Sampling Techniques. 3rd Ed. Wiley.
4. Des Raj and Chandhok (1998) : Sampling theory. Narosa.
5. Hedayat, A.S. and Sinha, B.K. (1991) :Design and inference in finite population sampling. Wiley.
6. Mukhopadhyay, P.(1996) : Inferential problems in survey sampling. New Age International (P).
7. Mukhopadhyay, P. (1988) : Small area estimation in survey sampling . Narosa.

**OPTIONAL-V : ADVANCED DESIGN OF EXPERIMENTS
(STRUCTURE AND ANALYSIS)**

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION – A

General analysis of one-way (intra and inter-block) and two-way (intra-block only) elimination of heterogeneity designs. Analysis of Randomized block designs and BIBD as particular case of one-way.

Youden Square and Latin squares as particular cases of two-way elimination of heterogeneity designs. Analysis of Graeco latin squares. Mutually orthogonal latin square (MOLS).

SECTION - B

Block structure properties of BIBD. General properties of incomplete block designs: connectedness, balancing, orthogonality, resolvability, α -resolvability and affine α -resolvability.

PBIB design: Definition and relations between the parameters of PBIB designs with m-associate classes. Classification of two-associate class PBIB designs into group divisible, simple, triangular, latin square type and cyclic designs. Definitions and parameters of their association schemes.

TEXT BOOKS

- | | |
|----------------------|---|
| 1. Chakrabarti, M.C. | : Mathematics of Design and Analysis of Experiments.
Asia Publishing House. |
| 2. Raghavarao, D. | : Construction and Combinatorial Problems in Design of Experiments (John Wiley, New York) |
| 3. Dey, A. | : Theory of Block Designs. |

**OPTIONAL-VI : ADVANCED DESIGN OF EXPERIMENTS
(CONSTRUCTION)**

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION – A

Orthogonal arrays : upper bound for the number of constraints for orthogonal arrays (n, k, s, t) of index unity, upper bound for the number of constraints for orthogonal arrays $(s^2, k, s, 2)$ of strength two; construction of orthogonal arrays $(st, t+1, s, t)$ when s is a prime or a prime power and $t < s$ and of orthogonal arrays $(s^t, t+1, st)$ when s a prime or a prime power and $s > t$: construction of completely resolvable orthogonal arrays $(\lambda s^2, \lambda s, s, 2)$ where λ and s both are powers of the same prime p .

Construction of complete set of mutually orthogonal Latin squares of order 5 when s a prime or a prime power. Mac Neish-Mann Theorem and construction of mutual orthogonal Latin squares of order s when s is a composite number.

SECTION - B

System of distinct representatives and their use in the construction of Youden squares. Balanced incomplete block designs(BIBD's), BIB designs related to a given BIB design Family(A) BIB designs.

Construction of BIB designs through finite geometries and the method of symmetrically repeated differences.

TEXT BOOKS

- 1.Raghavrao, : Construction and Combinatorial Problems in Design of Experiments(Wiley, New York)
- 2.Mann,H.B. : Analysis and Design of Experiments .
- 3.Dey,A. : Theory of Block Designs.

**OPTIONAL-VII: OPERATION RESEARCH
(OPTIMIZATION MODELS)**

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Introduction, definitions of Operation Research, Models in Operation Research, general methods for solving O.R. models. Queueing problems : Characteristics of queueing systems, distributions in queueing systems, Poisson arrivals and exponential service times, the M/M/1 and the M/M/S queueing systems and their steady state solutions. Inventory problems: definition, the nature and structure of inventory systems, deterministic models and their solutions, Multi-item inventory problems ,Introduction to stochastic inventory control.

Cost flow and routing problems : Undirected and directed networks, PERT and CPM.

SECTION - B

Replacement and Maintenance problem : Replacement of capital equipment, discounting cost, Replacement in anticipation of failure, preventive maintenance, the general renewal process.

Dynamic programming: Introduction, principle of optimality; simple multistage problem , discrete dynamic programming. Simulation, methodology of simulation, generation of random numbers, Monte- Carlo simulation technique.

TEXT BOOKS

1. Ackoff and Sasieni Fundamentals of operations Research, Wiley, 1968.
2. Sharma, S.D. Operations research, Kedar Nath and co., Meerut, 1986.

REFERENCES READINGS

1. Taha, H.A. : Operations Research, Pearson Education , 2004.

OPTIONAL-VIII : ECONOMETRICS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Meaning and scope of econometrics. Relationships among economic variables; Economic models and the distinction between structure and model; definitions of endogenous and exogenous variables.

Single equation models : Classical linear regression model; Gauss-Markov theorem; forecasting of the linear function of the coefficient vector ; Forecasting; Maximum likelihood estimation and test of hypotheses in classical normal linear regression model. Orthogonality and multicollinearity ; stepwise regression.

Nonlinear functional forms; Generalized linear regression model; Heteroscedastic and interdependent disturbances, use of extraneous information in the form of exact linear restrictions, extraneous unbiased estimates and extraneous inequality constraints.

SECTION - B

Linear regression with stochastic regressors ; Auto regressive linear regression model and distributed lag models; Instrumental variables and errors in variables.

Simultaneous linear equation model; structural form and reduced form; Identification; Rank and order conditions of identification; reduced form and indirect least squares estimation; Two stage least squares estimators; the (K)—class estimators.

TEXT BOOKS

1. A.S. Goldberger Econometric Theory.

RECOMMENDED READINGS

1. J. Johnston Econometric Methods.
2. H. Theil Principles of Econometrics.

OPTIONAL-IX : APPLIED MULTIVARIATE ANALYSIS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

(IN this paper EMPHASIS is laid on theoretical discussion of techniques. Details of derivation of distribution of criteria are not expected but the candidates are required to be familiar with statement of distributions of criteria required in a technique).

SECTION-A

Estimation of parameters in multivariate linear regression. Likelihood ratio (LR) criteria for hypotheses about regression means, coefficient matrix and confidence region ; tests of quality of means of several normal distributions with common covariance matrix, generalized analysis of variance, different criteria for testing linear hypotheses, LR tests for independence of set of variates, relationship with tests for a null regression of one set on another.

Vector correlation coefficient; Canonical correlation, estimation from sample, tests of significance, canonical component, estimation from sample data, effect of units of measurement of significance of estimated principal components.

SECTION - B

Factor analysis, terminology , factor analysis models, orthogonal and oblique, factor scores and factor loading. Connection of factor analysis. Principal components and canonical factor, factor analysis, alpha factor analysis, Lawley's maximum likelihood method, iterative procedures. Discrimination between several groups; choice of metric and distance measures, Rao's generalization of fisher's procedure. Relationship of discriminate analysis . Cluster Analysis, dissimilarity coefficient, ultra metric inequality, Type A cluster methods ,axiomatic approach, hierarchic cluster methods, Ball and Hall's iterative self organizing data analysis technique, Evaluation of clustering.

TEXT BOOKS

1. T.W. Anderson : An Introduction to Multivariate Statistical Analysis 2nd Ed.
2. R. Gnanadeshikan : Methods for Statistical data Analysis of Multivariate ion (Wiley)
3. A.M. Kashirsagar : Multivariate Analysis (Marcel Dekker)
4. G.A.F.Seber : Multivariate Observation.
5. Chaffield and A.J. Collins : Introduction to Multivariate Analysis
6. Bhuyan, K.C. : Multivarite Analysis and its Applications

OPTIONAL- X : ORDER STATISTICS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Distribution of a single order statistic, joint distribution of two or more order statistics . Distribution of the range and other systematic statistics, order statistics for a discrete parent, distribution-free confidence intervals for quantiles. Distribution-free tolerance intervals . Order statistics as a Markov chain, expected values and moments. Recurrence relations. Bounds and approximations for moments of order statistics; Distribution-free bounds for the moments of order statistics and of the range. Bounds for the expected values of order statistics in terms of quantiles of the parent distribution. Approximations to moments in terms of the inverse CDF and its derivatives.

SECTION - B

Statistics expressible as maxima. Random division of an interval. Order statistics for dependent variates. Asymptotic results. Least squares estimation of location and scale parameters. Estimation of location and scale parameters for censored data short-cut procedures; Quick measures of location and dispersion, Quick tests.

TEXT BOOKS

1. David, H.A. Order Statistics

OPTIONAL-XI ADVANCED DISTRIBUTION THEORY

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION - A

Infinitely divisible distributions ; basic properties, canonical representation of the characteristic function due to Levy - Khintchine (statement only). Limit theorems for sums of independent random variables. Characterization of lass L. Limit laws for sums of i.i.d random variables; stable laws and canonical representation of their characteristic functions (statement only). Domains of attraction and of partial attraction.

SECTION - B

Order statistics:distributions of median and range. Discrete order statistics and their joint probability mass function. Limiting distribution of k-th order statistics. Extreme value laws and their properties ; asymptotic joint distribution of extreme order statistics, asymptotic distribution of central order statistic.

Max- infinite divisible and max – stable distributions Multivariate extreme value distributions; dependence functions.

Record values and limit laws for record values.

Asymptotic distributions of U-statistics, linear functions of order statistics etc.

TEXT BOOKS

Arnold, B.C. Balakrishan, N and Nagaraja , H.N. (1992) : A First Course in Order Statistics, Wiley.

Feller, W. (1971) : An Introduction to Probability theory and its Applications, Vol. II, Willey

Galambos, J. (19788) : the Asymptotic theory of extreme Order Statistics, Wiley.

Gnedenko, B.V. and Kolmogorov , A.N. (1954) : Limit distributions for Sums of Independent Random Variables, Addison-Wesley Publishing company.

Laha, R.G. and Rohatgi, V.K. (1979): Probability theory, Wiley.

Resnick,S.I.(1987): Extreme Values, Regular variation and Point Processes, SpringerVerlag.

OPTIONAL-XII : CLINICAL TRIALS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION - A

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.

SECTION - B

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, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials

Reporting and analysis : analysis categorical outcomes from Phase I – III trials, analysis of survival data from clinical trials.

Surrogate endpoints : selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data.

Surrogate endpoints : selection and design of trials.

Meta-analysis of clinical trials .

TEXT BOOKS

S. Piantadosi (1997). Clinical Trials : A Methodologic Perspective. Wiley and sons.

C. Jennison and B.W. Turnbull(1999) . Group Sequential with Applications to Clinical Trials, CRC Press.

L. M. Friedman, C. Furburg,D.L. Demets (1998). Fundamentals of clinical Trials, Springer Verlag.

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 .

OPTIONAL-XIII : OFFICIAL STATISTICS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION - A

Introduction to Indian and International Statistical system. Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys . Role of National Sample Survey Organization . General and special data dissemination systems .

Population growth in developed and developing countries, evaluation of performance of family welfare programmes , projection of labour force manpower . Scope and content of population census of India .

SECTION - B

System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living inflation, educational and other social statistics.

TEXT BOOKS

Basic Statistics Relating to the Indian Economy (CSO) 1990.

Guide to Official Statistics (CSO) 1999

Statistical system in India (CSO) 1995)

Principles and accommodation of National Population Censuses, UNESCO.

Panse, V.G., Estimation of Crop Yields (FAO).

Family Welfare Yearbook. Annual Publication of D/O Family Welfare.

Monthly Statistics of foreign Trade in India, DGCIS, Calcutta and other Govt. Publications .

OPTIONAL- XIV : ACTUARIAL STATISTICS

Uni. Exam.	: 70	Max. Marks	: 100
Internal Assessment	: 30	Min. Pass Marks	: 35%
No. of Lectures to be delivered	: 60	Time Allowed	: 3 Hours

INSTRUCTIONS FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from the respective sections and section C will consist of one compulsory question having 10/15 parts of short-answer type covering the entire syllabus uniformly. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and compulsory question of section C. All questions of sections A and B will carry 10 marks each where as section C will carry 30 marks.

Use of scientific non-programmable calculator is allowed.

SECTION-A

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, Compound Poisson distribution and its applications.

Distribution of aggregate claims, compound Poisson distribution and its applications.

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding .

SECTION - B

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, recursions, commutation functions.

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payment, commutation functions, varying annuities, recursions, complete annuities- commutation and apportionable annuities-due

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

Payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

Net premium reserves: Continuous and discrete net premium reserves, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, 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.

TEXT BOOK

N.L. Bowers, H.U. Gerber, J.C. Hickman, D. A. Jones and C.J. Nesbitt, (1986), "Actuarial Mathematics, ' Society of Actuaries, Ithaca, Illinois, USA. Second Edition (1997)

Chapters: 1, 2, 3,4, 5, 6, 7, 8, 9, 11, 13, 14

RECOMMENDED READINGS

Spurgeon E.T. (1972), Life Contingencies, Cambridge University Press.

Neill, A. (1977). Life Contingencies, Heineman.