

MAHARSHI DAYANAND UNIVERSITY, ROHTAK
DEPARTMENT OF STATISTICS

Scheme of the examination for M.Sc. (Mathematical Statistics) w.e.f. 2012-13.

The duration of the course of construction for M.Sc. (Mathematical Statistics) degree shall be of two years (Four Semesters). There will be five theory papers and two practicals in each. In addition to theory and practicals, students will have to submit a project work in M.Sc. Second year. The detailed scheme of examination for M.Sc. (Mathematical Statistics) is as follows:

M.Sc. First year

1st Semester

Paper		Max. marks	Internal Assessment	Time Allowed	Teaching hrs. per week.
Paper-I	Measure Theory and Laplace Transforms	64	16	3 hrs.	04
Paper-II	Probability Theory	64	16	3 hrs.	04
Paper-III	Statistical Methods	64	16	3 hrs.	04
Paper-IV	Numerical Methods and Computer Programming	64	16	3 hrs.	04
Paper-V	Applied Statistics-I	64	16	3 hrs.	04

Practical

Paper-VI	Based on Papers III & V	50	-----	03 hrs	04 per group
Paper-VII	Based on Paper IV	50	-----	03 hrs	04 per group

2nd Semester

Paper-VIII	Complex Analysis and Linear Algebra	64	16	3hrs.	04
Paper-IX	Statistical Inference-I	64	16	3hrs.	04
Paper-X	Computer Programming	64	16	3hrs.	04
Paper-XI	Sampling Techniques	64	16	3hrs.	04
Paper-XII	Applied Statistics-II	64	16	3hrs.	04

Practical:

Paper-XIII	Based on Paper IX & X	50	---	03 hrs	04 per group
Paper-XIV	Based on Paper XI & XII	50	---	03 hrs	04 per group

M.Sc. Second year

3rd Semester

<u>Paper</u>	<u>Max.marks</u>	<u>Internal Assessment</u>	<u>Time Allowed</u>	<u>Teaching hrs.per week.</u>
Paper-XV:Multivariate Analysis	64	16	3 hrs.	04
Paper-XVI :Designs of Experiments	64	16	3 hrs.	04
Paper-XVII:Linear Programming	64	16	3 hrs.	04

Paper-XVIII & XIX:Any two of the following:--

Opt. (i) Stochastic Processes	64	16	3hrs.	04
(ii) Methods of Operations Research	64	16	3hrs.	04
(iii)Official Statistics	64	16	3hrs.	04
(iv) Advanced Sample Surveys*	64	16	3hrs.	04

Practical

Paper-XX Based on Paper XV	50		03 hrs	04 per group
Paper-XXI Based on Papers XVI & XVII	50		03 hrs	04 per group

4th Semester

Paper-XXII: Econometrics	64	16	3 hrs.	04
Paper-XXIII:Statistical Inference-II	64	16	3 hrs.	04
Paper-XXIV Game Theory and Non-Liner Programming	64	16	3 hrs.	04

Paper-XXV and paper XXVI. Any two of the following

(i) Queueing Theory	64	16	3 hrs.	04
(ii) Advanced Design of experiments, 64	64	16	3 hrs.	04
(iii) Clinical trials	64	16	3 hrs.	04
(iv) Statistical Genetics*	64	16	3 hrs.	04

Practical

Paper-XXVII Based on paper XXII	50		03 hrs	04 per group
Paper-XXVIII Based on Papers XXIII & XXIV	50		03 hrs	04 per group

*Syllabi will be framed later on.

Project work:

The project work will start in the beginning of 'M.Sc.(Second year)' under approved Supervisors from amongst members of the staff. The last date for the submission of project work will be two months after the theory papers of IVth Semester. However the result may be communicated to the students. The evaluation will be done by single external examiner on the basis of project work and viva voce on five point grading system i.e. A+, A, B+, B and C. The Students securing C has to resubmit his project work.

*This Scheme will be applicable for 'M.Sc. First year' w.e.f. from 2012-13 and 'M.Sc. Second year' w.e.f. 2012-13.

Ist Semester
Paper I (Measure Theory and Laplace Transforms)

Maximum Marks-64
Internal Assessment Marks-16
Time-03 Hours
Teaching hours- 04 hrs

Section –I

Field and Sigma Field. Measure and Probability Measure. Outer Measurability of Sets. Class of Measurable Sets. Construction of Outer Measure using Sequential Concerning Classes. Lebesgue Measure. Construction of Non-Measurable Sets.

Section –II

Simple Functions. Measurable Function as a Random Variable. Sequences and Algebra of Measurable Functions. Approximation Theorem of Measurable Functions. Concepts of Almost Everywhere (a.e) and Almost Uniform Convergence. Egoroffs Theorem. Lusin Theorem.

Section -III

Convergence in Measure. Fundamental in Measure. F.Riesz Theorem for Convergence in Measure. Integral of a Measurable Function w.r.t a Measure. Bounded Convergence Theorem. Fatou's Lemma, Monotone Convergence Theorem. General Lebesgue Integral and Lebesgue Dominated Convergence Theorem.

Section –IV

Laplace and Inverse Laplace Transforms: Definitions and Basic Properties. Convolution Theorem. Applications of Laplace Transforms to The Solution of Linear Ordinary Differential Equations, Partial Differential Equations and Integral Equations.

Books Suggested:-

1. Burrell, C.W. : Measure Theory and Probability
2. Halmos, P.R. : Measure Theory
3. Royden, H.L : Real Analysis
4. Munroe, M.E. : Introduction to Measure and Integration
5. Kingman .J.F.C.
And Taylor,S.J. : Introduction to Measure and Probability
6. Willaims,J. : Laplace Transforms.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper II: (Probability Theory)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching hours: 04 hrs.

Section - I

Random Experiment, Sample Space, Events – Simple, Composite, Mutually Exclusive and Exhaustive Events, Various Definitions of Probability, Properties of probability function, Addition Theorem, Boole's and Bonferroni's Inequalities, Conditional Probability, Multiplication Theorem, Baye's Theorem, Independence of Events.

Section-II

Random Variables and Distribution Functions , Probability Mass function, Probability density Function, Two Dimensional Random Variables- Joint , Marginal and Conditional Distributions, Independence of Random Variables.

Moments of Random Variables – Expectation, Variance, Covariance, Conditional and Marginal Expectation.

Section- III

Probability and Moment Generating Function and their Properties, Characteristic Function and its properties, Continuity Theorem Inversion Theorem , Uniqueness Theorem of Characteristic Function, Moment Inequalities of Hölder, Minkowski, Jensen's , Cauchy- Schwartz and Lyapunov's

Section -IV

Modes of Convergence -Convergence in Probability, almost surely, in the r^{th} mean and in distribution, their relationship. Probability Inequalities of Chebychev and Markov , Weak Law of large numbers- Chebychev's, Bernoulli's and Khintchine's Weak Law of Large Numbers, necessary and sufficient conditions for the WLLN,

Borel Cantelli Lemma, Kolmogorov inequality , Strong law of large numbers-Kolmogorov's theorem. Central limit theorem, Lindeberg - Levy and Demoiivre- Laplace forms of CLT.

Books Recommended

1. Meyer P. L. - Introductory Probability and Statistical Applications (Addison Wesley)
2. Goon, A.M., Gupta, M.K. and Dasgupta. B. (1985): An Outline of Statistical Theory, Vol. I (World Press)
3. Freund J.E. – Mathematical Statistics (Prentice Hall)
4. Mukhopadhyaya P. (1996) Mathematical Statistics (New Central Book Agency)
5. Rohatgi, V. K. and Saleh, A.K. Md. E. (2003): An Introduction to Probability and Statistics, Second Edn., John Wiley.
6. Feller, W. (1968): An Introduction to Probability Theory and its Applications, 3rd Edition, Vol. 1, John Wiley & Sons.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper III (Statistical Methods)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching hours: 0 hrs.

Section-I

Measures of central tendency & Dispersion. Raw and Central Moments, Skewness and Kurtosis. Analysis of Categorical data Consistency of categorical data, Independence and association of attributes.

Section - II

Principle of least squares, fitting of curves, correlation and regression, Correlation ratio. Interclass correlation. Partial and multiple correlations.

Section - III

Probability distributions: Binomial, Poisson, Multinomial, Hyper geometric, Geometric. Negative Binomial, Uniform, Exponential, Laplace, Cauchy, Beta, Gamma, Weibul, Normal (Univariate and bivariate) and Lognormal distributions.

Section - IV

Sampling distribution of Mean and Variance, Chi-square, Student's and Seducer's F, Fisher's-Z distribution and their applications. Elementary ideas of Non-central distributions.

Books suggested:-

- | | |
|--|--|
| 1. Meyer, P.L. | Introductory Probability and Applications |
| 2. Rohtagi, V.K. | An Introduction to Mathematical Statistics |
| 3. Mood A.M., Graybill, F.A. & Boes DC | Introduction to the theory of Statistics |
| 4. Goon A.M., Gupta M.K & Dasgupta B | Outlines of Statistics Volume-I |
| 5. Mukhopadhyaya. P | Mathematical Statistics |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper IV (Numerical Methods and Computer Programming)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching hours: 04 hrs.

Section - I

Numerical differentiation and integration: Trapezoidal, Simpson's $1/3^{\text{rd}}$, Simpson's $3/8^{\text{th}}$ Weddle's rule. Cote's formula, error estimation in integration formula. Simpson's $1/3^{\text{rd}}$ rule with end correction. Richardson extrapolation, Romberg integration. Boundary value problem.

Section -II

Evaluation of Eigen values and eigen vectors of matrices by Power and Jacobi method. Solution of ordinary differential equation ; Taylor's method, Euler's, Modified Euler's, Picard and Runge Kutta Method, Predictor – Corrector Methods, Adams – Moulton Method, Milne's method .

Section – III

Computer organization, Problem analysis, Algorithm development, Flow chart, Introduction to Fortran 77, Data type, operators and expressions, Assignment statement, Arithmetic and logical operation, List directed and Format-directed Input/Output statement.

Section – IV

Control statements: Do Loops, Do Continue, IF Blocks, Unconditional Go To, IF (conditional), Go to Label and Conditional Go To statement. STOP, RETURN and END Statement, COMMON statement. Arrays, Dimension statement, user defined Function, Function Subprograms, Subroutine subprograms, Builtin-Functions, Double precision type, Complex type.

Books Suggested:-

- | | | |
|----|---------------|---|
| 1. | Sastry, S.S | Introduction to Methods of Numerical Analysis |
| 2. | Nielson, K.L. | Methods of Numerical Anal |
| 3. | Ram Kumar | Introduction to Fortran-77 |
| 4. | R.S.Salaria | -do- |
| 5. | V. Raja Ramen | Fortran-77 |
| 6. | Fortran-77 | Schaum Series |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

PAPER V (Applied Statistics-I)

Maximum Marks-64
Internal Assessment Marks—16
Time:-03 Hours
Teaching hours: 04 hrs.

Section-I

Methods of obtaining demographic data, measurement of population at given time, Rates and Ratios, measurement of mortality; Crude death rate, specific death rate, standardized death rate, infant mortality rate. Construction of a complete life table and its uses. Abridged life tables; Kings Method. Reed and Merrill's method. Greville's method, Chiang's method.

Section-II

Measurement of fertility: Crude birthrate, general Fertility rate, age specific fertility rate, Total fertility rate, relation between TFR and CBR, gross reproduction rate and net reproduction rate, replacement index. Standardized fertility Rate. Structure of Population, Stable and Quasi stable populations analysis, intrinsic rate of growth, Population projection by component method and using Leslie matrix, Reduction of modality curves; Gompertz's and Makeham formula, logistic curve and its use in population projection.

Section-III

Demand analysis –laws of demand and supply, price and supply elasticity of demand. Partial and cross elasticity of demand. Income elasticity of demand. Utility function methods of determining demand and supply curves from Family budget and time series data, Leontief's Method, Pigou's Method Engel curve and its different forms,. Pareto's law of income distribution. Curves of concentration.

Section-IV

Index numbers and their construction, uses of index numbers. Price, Quantity and Value relatives, link and chain relatives, Laspeyres's, Paasche's, Marshall –Edge worth and Fisher's index Numbers, Chain base index Numbers, Tests for index numbers. Cost of living index numbers.

Books Recommended:-

1. Biswas, S; Stochastic Processes in Demography and Applications.
2. Goon A.M., Gupta M.K. & Das Gupta, B (2001) Fundamentals of Statistics Volume-11
3. Mukhopadhyay. P. (1999) Fundamental of Statistics Volume-11

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper – VI -Practicals will be based on Theory Papers III & V.

Paper – VII -Practicals will be based on Theory Paper VI

The question paper will consist of five questions and the students will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.

Distribution of marks will be as follows: -

Marks for Question Paper	:	36
Marks for Practical Record book	:	06
Marks for Viva-Voice	:	08
Total	:	50

2nd Semester
Paper VIII (Complex Analysis and Linear Algebra)

Maximum Marks-64
Internal Assessment Marks-16
Time-03 Hours
Teaching
Hours- 04 hrs.

Section –I

Functions of a Complex Variable and Their Analytic Properties. Cauchy's Riemann Equations. Power series and its Radius of Convergence. Elementary idea of Mobius Transformation, Cross Ratio, Invariant Point and Critical point .

Section –II

Regular and Rectifiable Arcs. Contour. Domains: Connected, Simply Connected and Multiply Connected. Complex Line Integrals. Cauchy's theorem, Cauchy's Integral Formulae and Inequality. Morera's Theorem. Liouville's Theorem. Taylor and Laurent Series.

Section –III

Singularities and Their Classification. Poles and Zeros of a Meromorphic Function, Argument Principle. Rouches Theorem. Fundamental Theorem of Algebra. Residues. Cauchy's Residue Theorem. Application of Cauchy's Residue Theorem for Evaluation of Integrals of Real valued Functions.

Section –IV

Linear and Orthogonal Transformation of a Matrix. Eigen Values and Eigen Vectors of a Liner Transformation. Quadratic Forms and Their Reduction to Canonical Form. Signature of A Matrix. Positive Definiteness Matrix.

Books Suggested:-

1. Copson, E.T. : Introduction To The Theory Of Functions Of A Complex Variable
2. Pati, T : Functions Of A Complex Variable.
3. Sharma, J.N. and Swarup, Shanti : Function of a Complex Variable
4. Goyal and Gupta : Function Of A complex Variable (Pargati Parkashan Meerut)
5. Malik, S.C. : Analysis (Jeevan Sons Publication, New Delhi)
6. Data, K.B. : Matrix and Liner Algebra
7. Hadley, G. : Liner Algebra
8. Sushma, V. : Liner Algebra

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E,

there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper IX (Statistical Inference- I)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section -I

Problem of point estimation: Properties of Estimators: Unbiasedness Consistency, Sufficiency, Neymann Factorization theorem, Complete sufficient statistics, efficiency, Minimum – variance unbiased (MVU) estimators, Exponential family of distributions and its properties, Cramer- Rao inequality, Minimum variance bound (MVB) estimators, Bhattacharya's Bounds.

Section - II

Rao-Blackwell theorem, Lehman Scheffe's theorem and its applications in finding Uniformly Minimum Variance Unbiased Estimators
Methods of estimation- Method of Maximum Likelihood, Methods of Moments, Method of Least Square, Minimum chi- square and modified minimum chi- square and their properties.

Section- III

Neymann theory of testing of hypotheses, Simple and Composite hypotheses, Null and Alternative Hypotheses, Two types of Errors, Critical Reason, Level of Significance, Power of the Test, Unbiased Tests, Critical Reason, N-P Lemma, construction of most powerful test, Uniformly Most Powerful test, Uniformly Most Powerful Unbiasedness tests.

Section- IV

Likelihood ratio test: Derivation and its properties, asymptotic distribution of L.R. Test. Interval Estimation: Method of obtaining confidence intervals based on small and large samples. Unbiased and Shortest expected length confidence interval.

BOOKS SUGGESTED

1. Goon, A.M., M.K.Gupta, & B. Das Gupta: Outline of Statistics Vol-II
2. Kendall, M.G. and Straut, A. : Advanced Theory of Statistics
3. Rohtagi, V.K. : Theory of Mathematical Statistical
4. Rao, C .R. Linear Statistical Inference and its Applications

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E,

there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper X (Computer Programming)

Maximum Marks-64
Internal Assessment Marks—16
Time:-03 Hours
Teaching Hours: 04 hrs.

Section-I

History and features of C language, Components of C Language Data type: Basic data type, Enumerated data types, Derived data types, variable declaration: Local, Global, Parametric variables, Assignment of variables. Numeric character, real and string constants. Operators, type modifiers and expressions. Basic input/Output.

Section-II

Control statements, decision making statements, one dimensional, two dimensional and multidimensional arrays. Functions, classification of functions definition and declaration, assessing a function, Return statement. Storage classes. Parameter passing in functions recursion in functions,

Section-III

Pointers; Pointer and array, Pointer and functions: Pointers to Pointers, Pointers to functions, function returning pointers, functions with variable number of arguments Preprocessor, structure and union.

Section-IV

Trees, Binary trees representation. Tree traversal, Trees and their application, Graphs Introduction, Unions representation sorting –Introduction, Inserting sort, Quick sort, Heap sort.

BOOK SUGGESTED: -

1. Kernighan, Brian W. and Ritchie, Dennis M. (1989). - The C Programming Language
2. Knuth, Donald E. (2002). -The Art of Computer Programming, Vol. 2/Seminumerical Algorithms,
3. E. Balaguruswamy - Programming C
4. Yashwant Kanetkar - Let us C
5. R. S. Salaria – A beginner;s Guide to Computer Programming with C

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XI (Sampling Techniques)

Maximum Marks-64
Internal Assessment Marks—16
Time:-03 Hours
Teaching Hours: 04 hrs.

Section-I

Sample versus complete enumeration. Designing of Sample surveys, Sources of errors in sample surveys, types of non-response errors probability and purposive sampling, simple random sampling with of without replacement for the estimation of mean total. Proportion and ratio, determination of sample size for specified precision stratified sampling: Proportional and optimum allocation. Estimation of gain due to stratification. Construction of strata and determination of number of strata.

Section -II

Ratio Estimates, approximate variance, comparison with mean per unit estimate. Conditions under which it is optimum, Bias of the ratio type estimate, unbiased ratio type estimate due to Hartley and Ross, Ratio Estimate in stratified sampling. Regression Estimators (Pre –assigned and estimated from the sampling comparison with the ratio and mean per unit estimates in stratified sampling.

Section -III

Double sampling (two phase sampling) for ratio and regression methods of estimation. Systematic sampling, comparison with stratified and simple random sampling, single stage cluster sampling, variance in terms of inter cluster correlation. Jessen's cost function and determination of optimum sampling unit.

Section –IV

Sampling with varying probability, sampling with probability proportional to size Lahiri Method of selection unequal probability sampling with replacement and without replacement Horvitz Thompson Estimator, Its variance and unbiased estimate of this variance. Two stage sampling, Estimate of population Mean and its variance, optimum allocation for fixed cost.

BOOKS SUGGESTED: -

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|----------------------------------|--|
| 1 .Chochran, W.G. | Sampling Techniques |
| 2. Daroga Singh & F.S. Chaudhary | Theory & Analysis of Sample Survey designs |
| 3. Hasen, Hurwitz and Madow | Sample survey Methods & Sampling |
| 4. Mukhopadhyay, Primal | Theory and Methods of Survey Sampling |

5. Goon A.M. Gupta & M.K. Dass Gupta Out line of Statistics Vol-11
6. P.V. Sukhatme & B.V. Sukhatme Theory and application of Sample Surveys

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XII (Applied Statistics-II)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section-I

Analysis of time series, components of time series, Trend measurement by Mathematical curves: Polynomial, Growth curves. Moving average method, Spencer's formulae, Effect of elimination of trend on other components of time series. Variate difference method and its use for estimation of variance of the random component. Measurement of seasonal Fluctuations measurement of cyclical component; periodogram analysis.

Section-II

Concept of stationary time series, strong and weak stationary: Auto covariance and auto correlation. Correlogram of auto regressive scheme. moving average scheme and a Harmonic series. Box Jenkin's models, Estimation of parameters in ARIMA models, forecasting: Exponential and adaptive Smoothing Models.\

Section-III

Statistical quality control and its purposes, 3 sigma control limit, Shewart control chart. Control charts for variables and attributes, Natural tolerance limits and specification limits: Modified control limits. Sampling Inspection plan, Producer's and Consumer's risk OC and ASN Function, AQL. LTPD and ATI.

Section-IV

The single, double and sequential sampling plans and their curves Viz AOQ, OC, ASN and ATI curves. The choice of sampling plans by attributes and by variables. Acceptance plan by variables, single and sequential sampling plans, acceptance sampling by variables (known and unknown sigma case)

BOOKS SUGGESTED: -

- | | |
|--|--|
| 1. M.G. Kindall | Time series |
| 2. Goon, A.M., Gupta, M.K
and Das Gupta B | Fundamentals of Statistics Vol.-2 |
| 3. Montgomery, D.E. | Introduction to Statistical Quality Control. |
| 4. Croxton and Cowden | Applied General Statistics |

5. Kendall and Stuart
6. Grant E. L

Advances in Statistics Vol-3
Statistics Quality Control, Wiley Easten

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper – XIII -Practicals will be based on Theory Papers IX & X

Paper – XIV -Practicals will be based on Theory Papers XI & XII

The question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.

Distribution of marks will be as follows: -

Marks for Question Paper	:	36
Marks for Practical Record book	:	06
Marks for Viva-Voice	:	08
Total	:	50

3rd Semester
Paper XV (Multivariate Analysis)

Max Marks- 64
Internal Assessment: 16
Time: 03 Hours
Teaching Hours: 04 hrs per week.

Section-I

Multivariate normal distribution, Marginal and Conditional Distributions Characteristic Function, Distribution of Linear Combinations of Normal Vector, Random sampling from a multivariate normal distribution, Maximum likelihood estimators of Mean vector and Covariance Matrix. Distribution of sample mean vector, Distribution of Quadratic forms.

Section –II

Wishart matrix - its distribution(without proof) and properties. Distribution of sample generalized variance, Null Distributions and uses of Simple, Partial and Multiple Correlation Coefficients. Hotelling's T^2 statistic –Derivation and its Null distribution Uses of T^2 statistic, Beheran - Fisher's Problem.

Section –III

Multivariate linear regression model. Estimation of parameters and their properties. Distribution of the matrix of sample regression coefficients, Test of Linear Hypothesis about Regression Coefficients, Multivariate analysis of variance [MANOVA] of one way classified data. Wilk's lambda criterion, Likelihood ratio test criteria for testing independence of sets of variables.

Section -IV

Likelihood Ratio Criteria for testing equality of covariance matrices and Identity of several multivariate normal populations, Fisher's discriminant function, Mahalanobis' Distance, Principal components, its uses and importance, Canonical variables and canonical correlations.

Books Recommended

1. Anderson, T.W. : An Introduction to Multivariate Statistical Analysis, John Wiley
2. Rao, C. R.: Linear Statistical Inference and its Applications, John Wiley
3. Johnson, R. A. and Wichern, D. W. (2001) : Applied Multivariate Statistical Analysis, Prentice Hall of India
4. Rencher, A. C. (2002) : Methods of Multivariate Analysis, 2nd Ed., John Wiley & Sons.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XVI (Designs of Experiments)

Max Marks: 64

Internal Assessment: 16

Time: 3 hrs.

Teaching hrs per week: 04 hrs.

Section- I

Linear models: Standard Gauss Markov models, estimability of parameters, Best Linear Unbiased Estimator (BLUE), method of least squares, Gauss-Markov theorem, variance-covariance matrix of BLUEs.

Section-II

Analysis of Variance for one- way, two -way with one/m observations per cell for fixed, mixed and random effects models, Tukey's test for non- additivity. General theory of Analysis of experimental designs; Completely randomized design, randomized block design and latin square designs, Missing plot techniques in RBD and LSD,

Section- III

Analysis of covariance for CRD and RBD. Split plot and strip plot designs. General factorial experiments: Definition, Estimation of factor's effect. Analysis of the factorial experiments using CRD and RBD.

Section-IV

Incomplete block designs; balanced, connectedness, orthogonality and resolvability. Balanced Incomplete Block Design with and without recovery of inter block information, Youden Squares.

BOOKS SUGGESTED

1. Goon A.M., Gupta ,M.K.and Dass Gupta,B. :Outline of Statistics Vol.-II
2. Dass and Giri :Design and analysis of Experiments
3. Aloke Dey :Theory of Block Designs
4. Raghavrao, D. : Construction & Combinatorial Problems in Design of Experiments (John Wiley, New York)

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

3rd Semester
Paper-XVII (Linear Programming)

Maximum Marks-64
Internal Assessment Marks-16
Time-03 Hours
Teaching Hours- 04 hrs.

Section –I

Convex Sets and Convex Functions. Linear Programming Problems: Formulation, Examples and Forms. Properties of a Solution to the LPP. Generating Extreme Point Solutions. Development of Optimum Feasible Solution. Solution of LPP by Graphical and Simplex Methods. Solution of Simultaneous Equations by Simplex Method.

Section –II

Artificial Variable Techniques: Big-M-Method and Two Phase Simplex Method. Degeneracy in LPP and its Resolution. The Revised Simplex Method. Bounded Variable Technique. Duality in LPP: Symmetric and Un-Symmetric Dual Problems. Fundamental Duality Theorem. Complementary Slackness Theorem. Dual Simplex Method. Economic Interpretation of Duality.

Section –III

Post- Optimization Problems: Sensitivity Analysis and Parametric Programming. Integer Programming Problems(IPP). Gomory's Algorithm for Pure Integer Linear Programs. Solution of IPP by Branch and Bound Method. Applications of Integer Programming.

Section –IV

Transportation Problems: Mathematical Formulation, Fundamental Properties and Initial Basic Feasible Solution by North West Corner Rule, Lowest Cost Entry Method and Vogel's Approximation Method. Optimal Solution of Transportation Problems. Assignment Problems : Mathematical Formulation and Solution by Hungarian Assignment Method. Reduction Theorem. Sensitivity in Assignment Problems.

Books Suggested:-

1. Gass, S.I. : Linear Programming (Methods and Applications)
2. Kambo, N.S : Mathematical Programming Techniques
3. Sinha, S.M. : Mathematical Programming (Theory and Methods)
4. Bazaraa, M.S; : Linear Programming and Network Flows
Jarnis, J and Sherali,H.D.
5. Hadely,G. : Linear Programming

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions

Paper XVIII & XIX Opt. (i) (Stochastic Processes)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section – I

Probability generating function, Binomial, Poisson Geometric and Negative Binomial. Convolution. General Stochastic Process, Definition, classification and examples. Compound distribution.

Section -II

Branching process, Properties of Generating function, Probability of extinction, Distribution of total progeny. Random walk, First passage time, Gambler's ruin problem, duration of the game.

Section - III

Markov chains, higher transition probabilities. Classifications of states and chain, determination of higher transition probabilities. Stability of Markov systems, limiting behaviour.

Section - IV

Poisson process and related distribution. Generalization of Poisson process. Birth process, Yule-Furry process, Generalized Birth death processes, Linear Birth death processes.

Books suggested:-

- | | |
|-------------------|--|
| 1. Medhi, J. | Stochastic Processes |
| 2. Bailey, N.T.J. | Elements of Stochastic Process |
| 3. Bhat, B.R. | Stochastic Models, Analysis and Applications |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XIII & XIX Opt-(ii) Methods of Operations Research

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section -I

Definition and Scope of Operations Research and its role in decision-making, its Characteristics, phases, different types of models, their construction and general methods of solution. Replacement problem, replacement of items that Deteriorate, replacement of items that fails completely Individual Replacement policy : Motility theorems, Group replacement policy, Recruitment and promotion problems.

Section -II

Inventory problems, Costs involved in inventory problems, Classification of Inventory System. Deterministic and probabilistic inventory models, Purchase inventory model, purchase inventory model with one, two and any number of price break.

Section -III

Job Sequencing Problems; Introduction and assumption, Processing of n jobs through two machines (Johnson's Algorithm) Processing of n jobs through three machines and m machines, Processing two jobs through n machines (Graphical Method) Simulation Definition, Types, uses and limitation of simulation phases, simulation models, Monte carlo simulation, application of simulation.

Section -IV

PERT/CPM: development, uses and application of PERT/CPM Techniques, Network diagram representation. Fulkerson 1-J rule for labeling Time estimate and determination of critical Path on network analysis, PERT techniques, crashing.

Books suggested:-

- | | |
|--------------|---------------------------------|
| 1. Churchman | Method's of Operations Research |
| 2. J.H.Taha | Method's of Operations Research |

Additional Book:-

- | | |
|---------------|---------------------------------------|
| 1. S.D.Sharma | Operation Research |
| 2. J.K.Sharma | An introduction & Operations Research |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each. Covering the whole syllabus and the candidate has to attempt all the questions.

Paper XIII & XIX Opt-(iii) Official Statistics

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section-I

Introduction to Indian and International Statistical systems. Present Official Statistical Systems in India, role, functions and activities of central and state organization. Organizations of large scale sample surveys methods of collection of official statistics, their reliability and imitations Role of National Sample Survey Organizations

Section-II

General and special data dissemination systems, population growth in developed and developing countries. Evaluation of performance of family welfare programs projection of labor force and manpower. Scope and content o population of census of India.

Section-III

System of collection of agricultural statistics. Crop forecasting and estimation. Productivity, fragmentation of holdings, support prices buffer stock, impact of irrigation projects.

Section-IV

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

Books Suggested:-

1. Basic Statistics relating to the Indian Economy (CSO) 1990.
2. Statistical system in India (CSO) 1975.
3. Guide to Official Statistics (CSO) 1999.
4. Principles and accommodation of National Populations Census.UNESCO.
5. Panse, V.G., Estimation of crop Fields (FAO).

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper – XX -Practicals will be based on Theory Papers XV.

Paper – XXI -Practicals will be based on Theory Papers XVI & XVII

The question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.

Distribution of marks will be as follows: -

Marks for Question Paper	:	36
Marks for Practical Record book	:	06
Marks for Viva-Voice	:	08
Total	:	50

4th Semester
Paper XXII (Econometrics)

Maximum Marks-64
Internal Assessment Marks—16
Time:-03 Hours
Teaching Hours: 04 hrs.

Section -I

Two variable Linear Regression model- Least Squares Estimators of coefficients and their Properties, Inference in Least Squares Model, The General Linear Regression Model, Ordinary Least Squares Estimator and its Properties, Inference in General Linear Regression Model. Generalized least squares estimation

Section-II

Tests of Linear Restrictions on Regression Coefficients, Use of Extraneous Information on Regression coefficients – Restricted Regression, Restricted Least Squares and its Properties, Mixed Regression and properties of mixed regression estimator, Specification Errors Analysis- Inclusion and Deletion of Explanatory Variables, Effect on Estimation of parameters and Disturbance Variance.

Section -III

Heteroscedasticity, Tests for Heteroscedasticity – Bartlett's, Breusch-Pagan and Goldfeld Quandt Tests

Multicollinearity - Exact and Near Multicollinearity, Consequences and Detection of multicollinearity, Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation, sources and consequences, AR(1) Process Tests for Autocorrelation, Durbin Watson Test, Errors in Variables Model, Instrumental variable method of estimation.

Section -IV

Simultaneous equations models: Structural and Reduced Forms, Identification problem. Rank and Order conditions of Identification, Restrictions on structural parameters. Estimation in Simultaneous Equations Models: Recursive systems, Indirect Least Squares 2SLS estimators, Limited information estimators, k-class estimators,

Books Recommended:

1. Johnston, J. (1991): Econometric Methods, (Mc Graw Hill)
2. Greene, W.H. (2003) Econometric Analysis(Prentice Hall)
3. Damodar N. Gujarati(2004) Basic Econometrics, Fourth Edition (McGraw–Hill)
4. Koutsyannis, A (2004) Theory of Econometrics
5. Judge, G.C., Hill, R.C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988):
Introduction to the Theory and Practice of Econometrics (Second Edition), John Wiley & Sons.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XXIII Statistical Inference- II

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section- I

Sequential analysis; Sequential testing procedure, OC and ASN functions, Wald's SPRT, strength of SPRT and determination of its stopping bounds, Stopping rule. Determinations of OC and ASN functions of SPRT, Wald's fundamental identity and its use in the derivation of ASN function of SPRT.

Section -II

Basic elements of decision theory: Decision function, Risk Function, Randomization, optimal decision rules: Baye's and minimax decision rule, The least favourable distribution , convex loss function. The form of Bayes rules for estimation Admissibility and completeness. Existence of minimal complete class.

Section-III

Non Parametric theory: Concept of non parametric and distribution free methods, Order Statistics , their marginal and joint distributions. Distributions of median, range and coverage; moments of order Statistics. Asymptotic distribution of Order Statistics.

Section-IV

Non parametric tests: One sample and paired sample problems. Ordinary sign test, Wilcoxon signed ranked test, and their comparison. General problem of tied differences. Goodness of fit problem : Chi-Square test and Kolmogrov – Smirnov one sample test, and their comparison. Two sample problems: K-S two sample test, Wald – Wolfwitz run test, Mann –Whitney U test, Median test.

BOOKS SUGGESTED

1. Goon, A.M., M.K.Gupta, & B. Das Gupta Outline of Statistics Vol-II
2. Kendall, M.G. and Straut, A. Advanced Theory of Statistics
3. Rohtagi, V.K. Theory of Mathematical Statistical
4. Rao, C.R. Linear Statistical Inference and its applications
- 5.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

4th Semester

Paper-XXIV (Game Theory and Non-Linear Programming)

Maximum Marks-64

Internal Assessment Marks-16

Time-03 Hours

Teaching Hours- 04 hrs.

Section –I

Theory of Games: Characteristics of Games, Minimax (Maximin) Criterion and Optimal Strategy. Solution of Games with Saddle Point. Equivalence of Rectangular Game and Linear Programming. Fundamental Theorem of Game Theory. Solution of $m \times n$ Games by Linear Programming Method. Solution of 2×2 Games without Saddle Point. Principle of Dominance. Graphical Solution of $(2 \times n)$ and $(m \times 2)$ Games.

Section –II

Non-Linear Programming Problems (NLPP): Formulation of NLPP. Kuhn-Tucker Necessary and Sufficient Conditions of Optimality and Saddle Points. Graphical Solution of an NLPP.

Section –III

Quadratic Programming : Wolfe's and Beale's Method of Solutions. Separable Programming and its Reduction to LPP. Separable Programming Algorithm. Geometric Programming: Constrained and Unconstrained. Complementary Geometric Programming Problems.

Section –IV

Fractional Programming and its Computational Procedure. Dynamic Programming: Balman's Principle of Optimality. Application of Dynamic Programming in Production, Linear Programming and Reliability Problems. Goal Programming and its Formulation .Stochastic Linear Programming.

Books Suggested:-

1. Kambo, N.S. : Mathematical Programming Techniques.
2. Bellman, R. : Dynamic Programming (Princeton University Press, Princeton N.J. (1957)
3. Bellman, R. And Dreyfus, S. : Applied Dynamic Programming (Princeton University Press, Princeton, N.J. 1963)
4. Sinha, S.M. : Mathematical Programming (Theory and Methods)
5. Mitra, G. : Theory and Applications of Mathematical Programming
6. Bazaraa, M.S; Sherali,H.D.and Shetty, C.M. : Non-Linear Programming (Theory and Algorithms)

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XXV & Paper-XXVI Opt-(i) Queuing Theory

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section – I

Description of the Queuing problems. Characteristics of queuing process. Notation, Measures of Effectiveness. Applications of Poisson process and exponential distribution, M/M/I model: steady state solution. Probability generating function of state possibility, Measures of effectiveness. Waiting time distribution. Steady state of Solution of M/M/I/R.

Section - II

Queues with parallel channels. Steady State and Waiting time distribution of M/M/C Queues with parallel channels of Truncation. M/M/C/K, M/M/ ∞ model. Machine interference problem.

Section - III

Bulk input $M^{(x)}/M/1$ queue. Bulk service queuing model: $M/M^{(y)}/1$, $M/M^{(a,b)}/1$, $M/E_K/1$ $E_k/M/1$. Priority queue discipline. Priority queue with no preemptive rule.

Section - IV

Non Markovian queues. Imbedded Markov Chain, Stationary distribution of state probabilities of M/G/1, GI/M/1 and $M/G^{(a,b)}/1$ model. Supplementary variable technique, M/G/1 and $M/G^b/1$ model queuing models.

Books suggested:-

- | | |
|---|-----------------------------------|
| 1. Medhi, J. | Stochastic Processes |
| 2. Gross & Hariss | Fundamentals of Queuing Theory |
| 3. Kashyap, B.R.K. and
Chaudhary, M.L. | An Introduction to Queuing Theory |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XXV & Paper-XXVI Opt-(ii) Advance Design of Experiments

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section-I

General Block designs: C- matrix and its properties. Incomplete block designs: Its information matrix, estimates of estimable linear parametric function. Balanced Incomplete Block Design, Intra block analysis, Inter block analysis, Recovery of inter block information. Connected and disconnected designs. Kronecker- product designs, Resolvability and parametric relations.

Section-II

Latin Squares and Orthogonal Latin Square (OLS), Upper bound for the number of OLS. Construction of complete sets of Mutually Orthogonal Latin Square (MOLS). Construction of BIBD using MOLS.

Section-III

Partially Balanced Incomplete Block designs. Definition and relation between the parameters. Association matrices, its algebraic properties classification of two Associate Class PBIB Designs. Applications of PBIBD.

Section-IV

Concept of confounding. Confounding in $2(n)$ experiments. Complete and Partial confounding in Symmetric factorial experiments.

BOOK SUGGESTED

- | | |
|---|---|
| 1. De, A. | Theory of Block Designs |
| 2. Raghavrao , D. | Construction and combinatorial problems in design of experiments (John Wiley, New York) |
| 3. Goon A.M., Gupta ,M.K.and
Dass Gupta,B. | Outline of Statistics Vol.-II |
| 4. Dass and Giri | Design and analysis of Experiments |

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C, D& E, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper XXV & Paper-XXVI Opt-(iii) (Clinical Trials)

Maximum Marks-64

Internal Assessment Marks—16

Time:-03 Hours

Teaching Hours: 04 hrs.

Section-I

Introduction to clinical trials: the need and ethics of trials, bias and random error in clinical studies, conduct of clinical trials, overview of phase I-IV trials, multi center trials. Data management: data definition. Case report forms, database design, data collection systems for good clinical stopping.

Section-II

Design of clinical trials: parallel vs cross over designs, cross sectional vs longitudinal designs review of factorial design

Section-III

Objective and endpoints of clinical trial, design of phase trials, design of single stage and multi stage phase II trials, design and monitoring of phase III trials with sequential stopping.

Section-IV

Reporting and analysis: analysis of categorical outcomes from phase I- III trials, analysis of survival data from clinical trial.

Books Suggested:-

1. Piantadosi, S (1997) Clinical Trials: A methodological Perspective, Wiley & Sons.
2. Friedman, L.M. Furberg, C. and Demets, D.L. (1998) Fundamentals of Clinical trials, Springer Verlag.
3. Fleiss, J.L. (1989) the Design and Analysis of Clinical Experiments, Wiley and Sons.
4. Marubeni, E. and Valsecchi, M.G. (1994) Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
5. Jelkison and Turnbull, B.W. (1999) Group sequential with application to Clinical Trials, CRC Press.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 12 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

Paper – XXVII -Practicals will be based on Theory Paper XXII

Paper – XXVIII -Practicals will be based on Theory Papers XXIII & XXIV

The question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.

Distribution of marks will be as follows: -

Marks for Question Paper	:	36
Marks for Practical Record book	:	06
Marks for Viva-Voice	:	08
Total	:	50