

**COURSE STRUCTURE FOR SEMESTER SYSTEM**  
**STATISTICS HONOURS(w.e.f. July 2015)**

SEM	PAPER	MODULE	MARKS	TOPIC
<b>Sem1</b>	<b>I GrA</b>	101	25	Probability Theory I
	<b>I GrB</b>	102	15+10	Real Analysis I & Numerical Analysis
	<b>IIA</b>	103	25	Descriptive Statistics I
	<b>IIB(Pr)</b>	104	25	PRACTICAL( <b>Including some uses of C</b> )
		<b>TOTAL</b>	<b>100</b>	
<b>Sem2</b>	<b>III GrA</b>	201	20	Probability Theory II (Upto discrete distribution)
	<b>III GrB</b>	202	20+10	Linear Algebra I + Real Analysis II
	<b>IVA</b>	203	25	Descriptive Statistics II
	<b>IVB(Pr)</b>	204	25	PRACTICAL
		<b>TOTAL</b>	<b>100</b>	
<b>Sem3</b>	<b>VGrA</b>	301	30	Probability Theory III (Including Continuous distribution)
	<b>VGrB</b>	302	20	Population Statistics
	<b>VIA</b>	303	25	Official & Economic Statistics(Including Demand analysis), Time Series Analysis
	<b>VIB(Pr)</b>	304	25	PRACTICAL
		<b>TOTAL</b>	<b>100</b>	
<b>Sem4</b>	<b>VII GrA</b>	401	10	Linear Algebra II
	<b>VII GrB</b>	402	40	Sampling Distributions & Statistical Inference I
	<b>VIIIA</b>	403	25	Statistical Quality Control
	<b>VIIIB(Pr)</b>	404	25	PRACTICAL
		<b>TOTAL</b>	<b>100</b>	
<b>Sem5</b>	<b>IX GrA</b>	501	20	Multivariate Analysis
	<b>IX GrB</b>	502	30	Statistical Inference II
	<b>X GrA</b>	503	30	ANOVA, Regression analysis & Designs of Experiments I
	<b>X GrB</b>	504	20	Sample Survey Methods I
	<b>XI(Pr)</b>	505	50	PRACTICAL
	<b>XII(Pr)</b>	506	50	PRACTICAL( <b>Computer</b> )
		<b>TOTAL</b>	<b>200</b>	
<b>Sem6</b>	<b>XIII GrA</b>	601	20	Large Sample Theory
	<b>XIII GrB</b>	602	30	Statistical Inference III
	<b>XIV GrA</b>	603	30	Designs of Experiments II
	<b>XIV GrB</b>	604	20	Sample Survey Methods II
	<b>XV(Pr)</b>	605	50	PRACTICAL
	<b>XVI(Pr)</b>	606	30+20	PRACTICAL( <b>Project+Grand Viva</b> )
		<b>TOTAL</b>	<b>200</b>	

**Ramakrishna Mission Residential College (Autonomous), Narendrapur**

**DEPARTMENT OF STATISTICS**  
**MARKS DISTRIBUTION**

**( HONOURS)**

<b>SEMESTER</b>	<b>THEORETICAL</b>	<b>PRACTICAL</b>	<b>TOTAL</b>
I	75	25	100
II	75	25	100
III	75	25	100
IV	75	25	100
V	100	100	200
VI	100	100	200
TOTAL	500	300	800

**(GENERAL)**

<b>SEMESTER</b>	<b>THEORETICAL</b>	<b>PRACTICAL</b>	<b>TOTAL</b>
I	50	25	75
II	50	25	75
III	50	25	75
IV	50	25	75

**(ACADEMIC CALENDER)**

<b>SEMESTER</b>	<b>STARTS FROM</b>	<b>END WITH</b>	<b>EXAMINATION</b>	<b>RESULT</b>
I	1 <sup>st</sup> week of July	Last week of November	Mid December	By 31 <sup>st</sup> January
II	1 <sup>st</sup> week of January	1 <sup>st</sup> week of May	3 <sup>rd</sup> week of May	By 30 <sup>th</sup> June
III	1 <sup>st</sup> week of July	Last week of November	Mid December	By 31 <sup>st</sup> January
IV	1 <sup>st</sup> week of January	1 <sup>st</sup> week of May	3 <sup>rd</sup> week of May	By 30 <sup>th</sup> June
V	1 <sup>st</sup> week of July	Last week of November	Mid December	By 31 <sup>st</sup> January
VI	1 <sup>st</sup> week of January	1 <sup>st</sup> week of May	3 <sup>rd</sup> week of May	By 30 <sup>th</sup> June

**SEMESTER-I : (JULY -DECEMBER)**

*. PAPER I (Theo)	: Module 101 &102	50 marks
PAPER II A(Theo)	: Module 103	25 marks
PAPER II B(Pract.)	: Module 104	25 marks

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TOTAL 100 marks

**SEMESTER- II : (JANUARY -JUNE)**

* PAPER III (Theo)	: Module 201 &202	50 marks
PAPER IV A(Theo)	: Module 203	25 marks
PAPER IV B(Pract.)	: Module 204	25marks

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TOTAL 100 marks

**SEMESTER- III : (JULY - DECEMBER)**

*. PAPER V (Theo)	: Module 301 &302	50 marks
PAPER VI A(Theo)	: Module 303	25 marks
PAPER VI B(Pract.)	: Module 304	25 marks

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TOTAL 100 marks

**SEMESTER – IV : (JANUARY – JUNE)**

* PAPER VII (Theo)	: Module 401 &402	50 marks
PAPER VIII A(Theo)	: Module 403	25 marks
PAPER VIII B(Pract.)	: Module 404	25 marks

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TOTAL 100 marks

**SEMESTER-V : (JULY - DECEMBER)**

*. PAPER IX (Theo)	: Module 501 &502	50 marks
PAPER X (Theo)	: Module 503 & 504	50 marks
PAPER XI (Pract.)	: Module 505	50 marks
PAPER XII(Pract)	: Module 506	50 marks

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TOTAL 200 marks

**SEMESTER-V I : (JANUARY - JUNE)**

*. PAPER XIII (Theo)	: Module 601 &602	50 marks
PAPER X IV (Theo)	: Module 603 & 604	50 marks
PAPER XV(Pract.)	: Module 605	50 marks
PAPER XVI(Pract)	: Module 606	50 marks

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TOTAL 200 marks

**QUESTION PATTERN FOR B.Sc. HONS. EXAMINATION IN STATISTICS  
SEMESTER SYSTEM  
W.E.F 2013**

<p><b><u>A group having a total marks - 10</u></b>  *Short questions of 5 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>5 \times 2 = 10</math></p>	<p><b><u>A group having a total marks - 20</u></b>  * Short questions of 5 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>5 \times 2 = 10</math>    * Broad questions of 10 marks each :  Number of questions to be given = 2  Number of questions to be answered = 1  Total marks = <math>10 \times 1 = 10</math></p>
<p><b><u>A group having a total marks - 25</u></b>    * Short questions of 5 marks each :  Number of questions to be given = 2  Number of questions to be answered = 1  Total marks = <math>5 \times 1 = 5</math>    * Broad questions of 10 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>10 \times 2 = 20</math></p>	<p><b><u>A group having a total marks - 30</u></b>    * Short questions of 5 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>5 \times 2 = 10</math>    * Broad questions of 10 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2    Total marks = <math>10 \times 2 = 20</math></p>
<p><b><u>A group having a total marks - 40</u></b>    * Short questions of 5 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>5 \times 2 = 10</math>    * Broad questions of 15 marks each :  Number of questions to be given = 4  Number of questions to be answered = 2  Total marks = <math>15 \times 2 = 30</math></p>	

## **Modules of new syllabus (2015) Statistics Honours (semester system):**

[ L denotes lecture hours]

**Semester – 1**

**PAPER I (50 marks):**

**GR A(25 marks)**

***101 Probability Theory I (25 marks)***

Random Experiment: Trial, Sample point, Sample space, Different types of events. (5L)

Definition of probability: Classical and relative-frequency approach to probability, Kolmogorov's Axiomatic definition (detailed discussion on discrete space only), limitations of Classical definition. Probability of union and intersection of events, Probability of occurrence of exactly  $m$  and atleast  $m$  events out of  $n$  events. Conditional probability and Independence of events, Bayes' Theorem and its applications. Examples based on classical approach and repeated trials (20L)

***References:***

1. Chung K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa
2. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
4. Rohatgi V.K. (1984): An Intro. to Probability Theory & Math. Statistics, John Wiley
5. Hoel P.J., Port S.C. & Stone C.J. ( ): Introduction to Probability Theory (Vol-1), Mifflin & UBS
6. Cramer H. (1954): The Elements of Probability Theory, John Wiley
7. Parzen E. (1972): Modern Probability Theory and its Applications, John Wiley
8. Uspensky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
9. Cacoullos T. (1973): Exercises in Probability. Narosa
10. Rahman N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993): Probability, Narosa
12. Stirzaker D. (1994): Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001): A First Course in Probability, Narosa
14. Bhat B.R. (1999): Modern Probability Theory, New Age International

**GR B (25 marks)**

***102 Real Analysis I & Numerical Analysis (25 marks)***

***Real Analysis I(15 marks)***

Sequence and series of real numbers, Concept of convergence & divergence. Simple tests of convergence. Statement of some important limit theorems and their applications. Absolute & conditional convergence, rearrangement of series. (5L)

Sequences and series of functions: Point wise and uniform convergence, Power series and Taylor series expansion. (4L)

Calculus of single variable: Limit, continuity & differentiability of functions; Maxima & minima of functions. Integration: Improper integral, Beta and Gamma integrals. (6L)

**References**

1. Apostol T.M. (1985): Mathematical Analysis, Narosa
2. Apostol T.M. (1968): Calculus ( Vols 1 & 2)
3. Goldberg R.R. (1953): Methods of Real Analysis, Oxford & IBH Pub. Co.
4. Widder D.V. (1994): Advanced Calculus
5. Piskunov N. (1977): Calculus ( Vols 1 & 2 )
6. Malik S.C. & Arora S.(1991): Mathematical analysis
7. Narayan S. (1984): A course of Mathematical Analysis, S.Chand & Company Ltd.
8. Bartle R.G. and Sherbert D.R (third edition): Introduction to Real Analysis.

***Numerical Analysis(10 marks):***

Interpolation: Polynomial approximation, Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms . (3L)

Numerical differentiation and its applications.

Numerical integration:Trapezoidal & Simpson's 1/3 rd rule. (3L)

Numerical solution of equations: method of fixed point iteration and Newton-Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to two unknowns (without convergence) Stirling's approximation to factorial n (4L)

***References :***

1. Scarborough J.B. (1958): Numerical Mathematical Analysis, Oxford Univ. Press
2. Atkinson K. (1985): Elementary Numerical Analysis
3. Sastry S.S. (1998): Intriductory Methods of Numerical Analysis
4. Hildebrand F.B. (1974): Introduction to Numerical Analysis, Tata McGraw-Hil (4L)

**PAPER IIA(25 marks)**

***103 Descriptive Statistics I (25 marks )***

Introduction : Nature of Statistics, Uses of Statistics, Statistics in relation to other disciplines, Abuses of Statistics.

(2L)

Types of Data: Concepts of population and sample, quantitative and qualitative data, cross-sectional and time-series data, discrete and continuous data, different types of scales.

(3L)

Collection of Scrutiny of Data: Primary data – designing a questionnaire and a schedule, checking its consistency. Secondary data – its major sources. Complete enumeration. Controlled experiments, Observational studies and Sample Surveys. Scrutiny of data for internal consistency and detection of errors in recording. Ideas of cross-validation.

(3L)

Presentation of data: Construction of Tables with one or more factors of classification, diagrammatic representations, frequency distributions and cumulative frequency distributions and their graphical representations, stem and leaf displays.

(4L)

Univariate data – different measures of location, dispersion, relative dispersion, skewness and kurtosis, Moments, Liapounov's inequality, Quantiles and measures based on them – comparison with moment measures. Box Plot. Outlier Detection.

(13L)

***References :***

1. Goon A.M.,Gupta M. K., Dasgupta B.(1998): Fundamentals of Statistics (V-1),World Press
2. Yule G.U & Kendall M.G. (1950): An Introduction to the Theory of Statistics, C.Griffin
3. Snedecor & Cochran (1967): Statistical Methods (6<sup>th</sup> ed), Iowa State Univ. Press
4. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall
5. Wallis F.E. & Roberts H.V. (1957): Statistics- a new approach, Methuen
6. Tukey J.W. (1977): Exploratory Data Analysis, Addison-Wesley Publishing Co.

**PAPER IIB(PR)(25 marks)**

***104 PRACTICAL (25 marks):Based on topics in Paper I & IIA.***

**Semester – 2**

**PAPER III (50 marks)**

**GR A(20 marks)**

***201 Probability TheoryII (20 marks)***

Random Variables : Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (with proof), probability mass function (p.m.f.) and probability density function (p.d.f.), Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles, convex function and moments inequalities. (6L)

Generating Functions: Probability generating function and moment generating function. (2L)

Univariate Discrete Distributions: Uniform, Bernoulli, Hypergeometric, Binomial, Poisson, Negative Binomial, Geometric distributions and their properties. (6L)

***References:***

1. Chung K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa
2. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory( Vol-1), World Press
4. Rohatgi V.K. (1984): An Intro. to Probability Theory & Math. Statistics, John Wiley
5. Hoel P.J., Port S.C. & Stone C.J. ( ): Introduction to Probability Theory (Vol-1), Mifflin & UBS
6. Cramer H. (1954): The Elements of Probability Theory, John Wiley
7. Parzen E. (1972): Modern Probability Theory and its Applications, John Wiley
8. Uspesky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
9. Cacoullos T. (1973): Exercises in Probability. Narosa
10. Rahman N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993): Probability, Narosa
12. Stirzaker D. (1994): Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001): A First Course in Probability, Narosa
14. Bhat B.R. (1999): Modern Probability Theory, New Age International

**GR B(30 marks)**

***202:LINEAR ALGEBRA I & Real AnalysisII (20 +10 marks)***

***Linear Algebra I (20 marks)***

Vector Algebra: Vector spaces with real field and vector subspaces, Concept of Spanning, Basis and dimension of a vector space, Euclidean Space: Orthogonal vectors, Gram-Schmidt Orthogonalization, Orthogonal basis, Ortho-complement of Subspace. (7L)

Matrix Algebra : Matrices, Matrix operations, Different types of matrices. Determinants: Definition, Properties, Evaluation of some standard determinants. . Inverse matrix: Definition & Properties .Inverse of some standard matrices. (6L)



Rank of a matrix: Row space and column space, concept of rank, standard results on rank. Methods of finding rank: Echelon Matrices, the sweep-out and the pivotal condensations, normal form, minor and rank. Null space and rank. Rank factorization. Linear Transformation: Kernel & Image, Matrix representation. (7L)

**References:**

1. Hadley G. (1995): Linear Algebra, Addison Wesley/ Narosa
2. Rao A.R. & Bhimasankaran P. (1996): Linear Algebra
3. Searle S.R. (1982): Matrix Algebra – useful for Statistics, John Wiley
4. Rao C.R. (1974): Linear Statistical Inference & its Applications, Wiley Eastern
5. Rao C.R. (1952) : Advanced Statistical Inference in Biometric Research, John Wiley

**Real AnalysisII (10 marks)**

Calculus of several variables: Limit, continuity & differentiability of functions ; Maxima & minima for functions ; constrained maximization and minimization – Use of Lagrangian Multiplier, Multiple integrals, Transformation of variables and Jacobian: Polar and orthogonal transformations. (10L)

**References**

1. Apostol T.M. (1985): Mathematical Analysis, Narosa
2. Apostol T.M. (1968): Calculus ( Vols 1 & 2)
3. Goldberg R.R. (1953): Methods of Real Analysis, Oxford & IBH Pub. Co.
4. Widder D.V. (1994): Advanced Calculus
5. Piskunov N. (1977): Calculus ( Vols 1 & 2 )
6. Malik S.C. & Arora S.(1991): Mathematical analysis
7. Narayan S. (1984): A course of Mathematical Analysis, S.Chand & Company Ltd.
8. Bartle R.G. and Sherbert D.R (third edition): Introduction to Real Analysis

**PAPER IV A(25 marks)**

***203 Descriptive Statistics II (25 marks)***

Bivariate data – scatter diagram, correlation coefficient and its properties, Correlation ratio, Correlation Index, Intraclass correlation, Concept of Regression, Principles of least squares, Fitting of polynomial and exponential curves. Rank correlation – Spearman's and Kendall's measures. (17L)

Analysis of Categorical Data: Consistency of data, independence and association of attributes, measures of association – Pearson's and Yule's measures, Goodman-Kruskal's  $\gamma$ . Odds Ratio. Fitting of logit model through least squares. (8L)

***References :***

1. Goon AM, Gupta MK, Dasgupta B. (1998): Fundamentals of Statistics (V-1), World Press
2. Yule G.U & Kendall M.G (1950): An Introduction to the Theory of Statistics, C. Griffin
3. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vols 1 & 2)
4. Snedecor & Cochran (1967): Statistical Methods (6<sup>th</sup> ed), Iowa State Univ. Press
5. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall
6. Wallis F.E. & Roberts H.V. (1957): Statistics- a new approach, Methuen
7. Lewis-Beck M.S. (edt.) (1993) : Regression Analysis, Sage Publications
8. A. Agresti (1984): Analysis of Ordinal Categorical Data

**PAPER IV B(PR) (25 marks)**

***204 PRACTICAL (25 marks): Based on topics in Paper III & IVA***

**Semester – 3**

**PAPER V (50 marks)**

**GR A (30 marks)**

***301 Probability Theory III (30 marks)***

Univariate Continuous Distributions: Rectangular, Normal, Cauchy, Gamma, Beta, Exponential, Laplace, Logistic, Pareto, Log-normal distributions and their properties. Truncated distributions.

(8L)

Use of continuous distributions in scaling , income or allied distributions.

(3L)

The c.d.f., p.m.f. and p.d.f. in bivariate case. Marginal and Conditional distributions, Independence, Conditional Expectation, Correlation and Regression. Theorems on sum and product of expectations of random variables, generating functions in bivariate cases

(7L)

Probability Inequalities: Markov's & Chebyshev's inequalities. Convergence in Distribution, Convergence in probability and related results (without proof), Weak law of large numbers and Central limit theorem and their applications.

(10L)

Bivariate Normal Distribution and its properties.

(3L)

***References:***

1. Chung K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa
2. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
4. Rohatgi V.K. (1984): An Intro. to Probability Theory & Math. Statistics, John Wiley
5. Hoel P.J., Port S.C. & Stone C.J. ( ) : Introduction to Probability Theory (Vol-1), Mifflin & UBS
6. Cramer H. (1954): The Elements of Probability Theory, John Wiley
7. Parzen E. (1972): Modern Probability Theory and its Applications, John Wiley
8. Uspeky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
9. Cacoullos T. (1973): Exercises in Probability. Narosa
10. Rahman N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993): Probability, Narosa
12. Stirzaker D. (1994): Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001): A First Course in Probability, Narosa
14. Bhat B.R. (1999): Modern Probability Theory, New Age International

**GR B (20 marks)**

**302 Population Statistics (20 marks)**

Introduction: Sources of Population Data – Census data, Registration data and the errors in such data. Rates and ratios of vital events.

(2L)

Measurements of Mortality: Crude Death rate, Specific Death Rate, Standardized death Rate, Cause of death rate, Maternal Mortality Rate, Infant Mortality Rate, Neonatal and Perinatal Mortality Rates

(6L)

Life tables: Descriptions of Complete and Abridged Life Tables and their uses, Cohort (Or Current) vs. Generation Life Tables, Stable population and Stationary population, Construction of complete life table from population and death statistics.

(5L)

Measurements of Fertility: Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate.

(4L)

Measurement of Population Growth: Crude Rate of Natural Increase and Vital Index, Gross and Net Reproduction Rates.

(3L)

Population Estimation, Projection and Forecasting: Use of A.P. and G.P. methods for population estimates, Derivation of the equation to the Logistic curve, its properties and fitting to observed data for population forecasting using Rhode's method.

(5L)

***References :***

1. Goon AM, Gupta MK, Dasgupta B (2001): Fundamentals of Statistics (V-2), World Press
2. Spiegelman M. (1980): Introduction to Demography, Harvard University Press
3. Cox P.R. (1976): Demography
4. Biswas S. (1988): Stochastic Processes in Demography and Applications
5. Mishra B.D. (1980): An Introduction to the Study of Population, South Asian Pub.
6. Keyfitz. N and Caswell. H (2005): Applied Mathematical Demography (3<sup>rd</sup> edition), Springer

**PAPER VIA (25 marks)**

**303 : Official & Economic Statistics, Time Series Analysis(25 marks)**

**Official & Economic Statistics (15 Marks)** The Statistical system in India: The Central and State Government organizations, the functions of the Central Statistical Organization (CSO), National Sample Survey Organization(NSSO) (2L)

**Index Numbers:** Price, Quantity and Value indices, Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, various formulae and their comparisons, Chain Index Number. Some Important Indices: Consumer Price Index and Wholesale Price Index– methods of construction and uses.

**Demand Analysis:** Demand & supply, Price elasticity of demand, Income elasticity of demand, Partial & cross elasticities of demand, Engel's law & Engel curves, basic concept of utility function. (13L)

**References:**

1. C.S.O. (1984) : Statistical System in India
2. Goon A. M.,Gupta M. K., and Dasgupta. B. (2001): Fundamentals of Statistics (V-2),World Press
3. Yule G.U. & Kendall M.G. (1953): An Introduction to the Theory of Statistics, C.Griffin
4. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vol 3), C.Griffin
5. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall
6. Mudgett B.D. (1951): Index Numbers, John Wiley
7. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan
8. Mukhopadhyay P. (1999): Applied Statistics
9. Johnston J. & Dinardo J. (1997): Econometric Methods, McGraw Hill
10. Nagar A.L. & Das R.K. (1976): Basic Statistics

**Time Series Analysis (10 marks)**

Introduction: Examples of time series from various fields, Components of a times series, Additive and Multiplicative models. Trend and Seasonal Components: Estimation of trend by linear filtering (simple and weighted moving-averages ) and curve fitting ( polynomial, exponential and Gompertz ), Detrending. Estimation of fixed seasonal component by ratio to moving-average method and ratio to trend method, Deseasonalization..

Stationary Time series: Weak stationary, Autocorrelation Function and Correlogram  
Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR(1) and AR(2) – Yule-Walker equations, Exponential smoothing method of forecasting (10L)

**References:**

1. Kendall M.G. (1976): Time Series, Charles Griffin
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall
3. Mukhopadhyay P. (1999): Applied Statistics
4. Johnston J. & Dinardo J. (1997): Econometric Methods, McGraw Hill

**PAPER VI GRB(PR) 304: PRACTICAL (25 marks): Based on topics in PaperV & VIA**

#### Semester 4

#### **PAPER VII (50 marks)**

#### ***401 : Linear algebra II, Sampling Distributions and Statistical Inference-I(50 marks)***

#### ***Gr A(10 marks)***

#### ***Linear algebra II (10 marks)***

System of linear equations: Homogeneous and non-homogeneous systems – conditions for solvability. Gaussian Elimination. (2L)

Quadratic forms ;classification and canonical reduction. Properties of n.n.d /n.p.d matrices. (4L)

Characteristic roots and vectors of a matrix, Properties of Characteristic roots and vectors of symmetric matrix and canonical reduction of quadratic forms. Cayley -Hamilton theorem. (4L)

#### ***References:***

1. Hadley G. (1995): Linear Algebra, Addison Wesley/ Narosa
2. Rao A.R. & Bhimasankaran P. (1996): Linear Algebra
3. Searle S.R. (1982): Matrix Algebra – useful for Statistics, John Wiley
4. Rao C.R. (1974): Linear Statistical Inference & its Applications, Wiley Eastern
5. Rao C.R. (1952) : Advanced Statistical Inference in Biometric Research, John Wiley

#### **GRB(40 marks):**

#### ***402 Sampling Distributions and Statistical Inference-I (40 marks)***

#### ***Sampling Distributions( (20 marks)***

Transformation of Random variables (5L)

Introduction: Concepts of Random Sampling, Statistics and Sampling Distributions of Statistics. Illustrations using different distributions, reproductive properties of the distributions. (2L)

Some Standard Sampling Distributions :  $\chi^2$  distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions, distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population, distribution of the simple regression coefficient (for both stochastic and non-stochastic independent variable cases). (11L)

Distributions of Order Statistics and Sample Range.

#### ***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
2. Johnson, N.I. & Kotz S. (1970): Distributions in Statistics, John Wiley
3. Ross S.M. (1972): Introduction to Probability Models, Academic Press
4. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup> ed), McGraw Hill
5. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley

6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
8. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
9. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1), World Press
10. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley

***Statistical Inference I (20 marks)***

Idea of Inference - Point & Interval Estimations and Testing of Hypothesis (1L)

Point estimation: Requirements of a good estimator – notions of Mean Square Error, Unbiasedness: Minimum Variance Unbiasedness and Best Linear Unbiasedness, (4L)

Elements of Hypothesis Testing : Null and Alternative hypotheses, Simple and Composite hypotheses, Critical Region, Type I and Type II Errors, Level of Significance and Size, p-value, Power (4L)

Tests of Significance related to a single Binomial proportion and Poisson parameter; two Binomial proportions and Poisson parameters; the mean(s) and variance(s) of a single univariate normal distribution, two independent normal distributions and a single bivariate normal distribution; regression and correlation coefficients of a single bivariate normal distribution, (11L)

***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1), World Press
2. Johnson, N.I. & Kotz S. (1970): Distributions in Statistics, John Wiley
3. Ross S.M. (1972): Introduction to Probability Models, Academic Press
4. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup> ed), McGraw Hill
5. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
8. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
9. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1), World Press
10. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley

**PAPER VIII A(25 marks)**

**403 Statistical Quality Control (25 marks)**

Introduction: Concepts of Quality and Quality Control, Process Control and Product Control (5L)

Process Control: Control Charts and their uses, Choice of Subgroup sizes, Construction of control charts by attributes (p, c, np) (including unequal subgroup size) and variables ( $\bar{x}$ , R). Interpretation of non-random patterns of points. (10L)

Product Control: Producer's Risk, Consumer's Risk, Acceptance Sampling Plan, Single and Double sampling plans by attributes, their OC, ASN ( and ATI ), LTPD and AOQL. Single sampling plan for inspection by variables (one-sided specification, known and unknown  $\sigma$  cases), Use of IS plans and tables (10L)

***References :***

1. Goon A. M., Gupta M. K., Dasgupta B. (2001): Fundamentals of Statistics (V-2), World Press
2. Duncan A.J. (1953): Quality Control and Industrial Statistics, Richard D Irwin
3. Cowden D.J. (1957): Statistical Methods in Quality Control, Prentice Hall
4. Grant E.L. & Leavenworth (1964): Statistical Quality Control, McGraw Hill
5. Bowley A.H. & Goode H.P. (1952): Sampling Inspection by Variables, McGraw Hill
6. Ekambaram S. K. (1960): The Statistical Basis of Quality Cont. Charts, Asia Publishing House
7. Montgomery D.C. (1985): Introduction to Statistical Quality control, John Wiley
8. IS2500 Part I and Part II
9. Bureau of Indian Standards (1994): Handbook on Statistical quality Control
10. Indian Standards Institution (1982): Manual on Basic Principles of Lot Sampling

**PAPER VIII B(PR) (25 marks)**

***404 PRACTICAL (25 marks): Based on topics in PaperVII & VIIIA***



**Semester – 5**

**PAPER IX (50 marks)**

**GR A(20 marks)**

***501 Multivariate Analysis (20 marks)***

Multivariate data – multiple regression, multiple correlation and partial correlation – their properties and related results. (5L)

Random Vector: Probability mass and density functions, Distribution Function, Mean vector and Dispersion matrix, Marginal and Conditional Distributions, Ellipsoid of Concentration, Multiple Regression, Multiple Correlation, Partial Correlation. (8L)

Multivariate Distributions: Multinomial, Multivariate Normal distributions and their properties. (7L)

***References:***

1. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vol 3), C.Griffin
2. Anderson T.W. (1958): An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup> edition, Wiley interscience
3. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Volumes 1 & 2), World Press
4. Rohatgi V.K. (1984): An Introduction to Probability Theory & Math. Statistics, John Wiley
5. Johnson, N.L. & Kotz S. (1970): Distributions in Statistics, John Wiley
6. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
7. Rao C.R. (1974): Linear Statistical Inference and its Applications, John Wiley
8. Mukhopadhyay P. (1996): Mathematical Statistics
9. Johnson R. A. and Wichern, W (2001): Applied Multivariate Statistical Analysis, 5<sup>th</sup> edition, Prentice Hall

**GR B(30 marks)**

***502 Statistical Inference II (30 marks)***

Point Estimation: Sufficiency, Factorization Theorem (Discrete case only), Properties of minimum variance unbiased estimators, consistent estimators and asymptotic efficiency, Completeness and Exponential Family of Distributions, Cramer-Rao lower bound, Rao-Blackwell Theorem, Lehman-Scheffe Theorem. (20L)

Theory of Hypothesis Testing: Most Powerful (MP), Uniformly Most Powerful (UMP), Randomized and Nonrandomized tests, Neyman-Pearson Fundamental Lemma (sufficiency part only), and its use in the construction of MP and UMP tests (single parameter with range independent of the), Uniformly Most Powerful Unbiased (UMPU) tests (definition only). (10L)

***References :***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-2), World Press
2. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup> ed), McGraw Hill
3. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
4. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
5. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
6. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin

**PAPER X (50 marks)**

***Gr A(30 Marks)***

***503 ANOVA, Regression Analysis and Designs of Experiments I(30 marks)***

Introduction: Heterogeneity and Analysis of Variance and Covariance, Linear Hypothesis, Orthogonal splitting of total variation, Selection of Valid Error. (4L)

Applications of the ANOVA technique to: one-way classified data, two-way classified data with equal number of observations per cell, testing simple regression coefficients, tests for parallelism and identity, correlation ratio, linearity of simple regression, multiple correlation and partial correlation coefficients. (8L)

Principles of experimental design: Randomization, Replication and Local Control, Uniformity trials, Shapes and Sizes of Plots and Blocks. (4L)

Standard Designs and their Analyses: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), comparison of efficiencies. Applications of the techniques of ANOVA to the analysis of the above designs. (14L)

***References:***

1. Goon A. M. ,Gupta M. K., Dasgupta B.(2001): Fundamentals of Statistics (V-2),World Press .
2. Scheffe H. (1959): The Analysis of Variance, John Wiley8. Kempthorne O. (1965): The Design and Analysis of Experiments, Wiley Eastern
3. Das M.N. & Giri N.C. (1986) : Design and Analysis of Experiments. (2<sup>nd</sup> edition), Wiley Eastern
4. Montgomery D.C. (1976): Design and Analysis of Experiments, John Wiley
5. Cochran W.G. & Cox G.M. (1957): Experimental Designs, John Wiley
6. Federer W.T. (1975): Experimental Designs – Theory and Application, Oxford & IBH
7. Mukhopadhyay P. (1999): Applied Statistics

**GR B(20 marks)**

***504. Sample Survey Methods I (20 Marks )***

Introduction: Concepts of Finite Population and Sample, Need for Sampling, Complete Enumeration and Sample Survey. General Ideas: Planning and execution of sample surveys, analysis of data and reporting, Biases and Errors. Judgement and probability sampling schemes. Tables of Random Numbers and their uses Simple Random Sampling with and without replacement, Determination of sample size in simple random sampling. Stratified random sampling, Associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators . Linear and Circular Systematic Sampling (20L)

***References:***

1. Goon A. M. ,Gupta M. K., Dasgupta B.(2001): Fundamentals of Statistics (V-2),World Press
2. Murthy M.N. (1977): Sampling Theory and Methods, Statistical Pub. Soc., Calcutta
3. Des Raj & Chandhok P.(1998): Sample Survey Theory, Narosa Publishing House
4. Cochran W.G. (1984): Sampling Techniques (3<sup>rd</sup> edition), Wiley Eastern
5. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice Hall
6. Sukhatme P.V. & Sukhatme B.V. (1970): Sampling Theory of Surveys with, Asia Publishing House
7. Sampathy S. (2001): Sampling Theory and Methods, Narosa
8. NSSO Publications

**PAPER XI (PR) (50 marks)**

***505 PRACTICAL (50 marks):Based on topics in paper IX & X***

**PAPER XII(PR) (50 marks)**

***506 PRACTICAL(50 marks): COMPUTER:Solving statistical problems using C programming & Minitab.***

**Semester – 6**

**PAPER XIII (50 marks)**

**Gr A(20 marks)**

***601 Large Sample Theory(20marks)***

Delta method, Derivation of large sample standard error of sample moments, standard deviation, coefficient of variation,  $b_1$  and  $b_2$  measures, and correlation coefficient and their uses in large sample tests under normality assumption, Large sample distribution of sample quantile (8L)

Transformations of Statistics to stabilize variance: derivation and use of  $\text{Sin}^{-1}$ , square root, logarithmic and z-transformations. (4L)

Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients.. (3L)

Large Sample distribution of Pearsonian  $\chi^2$  –statistic and its uses. Yate’s correction in a 2 x 2 contingency table. Combination of probabilities (5L)

***References:***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1 and 2), World Press
2. Serfling R.J. (1980): Approximation Theory of Mathematical Statistics, John Wiley
3. Chandra T.K. (1999): A First Course in Asymptotic Theory in Statistics, Narosa
4. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics

**GRB(30 marks)**

**602 Statistical Inference III (30 marks)**

Methods of Estimation – Moment, Least-square, Maximum Likelihood & Minimum  $\chi^2$  methods and their properties (excluding proofs of large sample properties) .(6L)

Likelihood Ratio tests and its applications to tests for the equality of means and variances of several normal populations, SPRT for simple null against simple alternatives, expressions of OC & ASN functions ( without proof). (9L)

Interval Estimation: Confidence intervals, Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses. (3L)

Nonparametric Methods: Sign test, Median test, Wilcoxon signed rank test, Mann-Whitney test, Run test, Test of randomness, Confidence limits for Quantiles based on Sign test statistic, Tolerance limits. ( 12L)

***References :***

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-2), World Press
2. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory of Statistics (3<sup>rd</sup> ed), McGraw Hill
3. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
4. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
5. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, John Wiley
6. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
7. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1 and 2), World Press
8. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley

**PAPER XIV (50 marks)**

**Gr A(30 marks)**

***603 Design of Experiments II ( 30 marks)***

Split Plot Design and Strip arrangements. Groups of Experiments using RBD and LSD (7L)

Factorial Experiments: 2<sup>n</sup> experiments, Advantages, Total and Partial Confounding, Analysis. (12L)

Missing Plot Technique: Analysis with one missing plot in a RBD and in a LSD. (5L)

Analysis of Covariance (ANCOVA): Application of the ANCOVA technique to one-way classified data and to two-way classified data with equal number of observations per cell, use in the control of error in CRD, RBD & LSD. (6L)

***References:***

1. Kempthorne O. (1965): The Design and Analysis of Experiments, Wiley Eastern
2. Das M.N. & Giri N.C. (1986) : Design and Analysis of Experiments. (2<sup>nd</sup> edition), Wiley Eastern
3. Montgomery D.C. (1976): Design and Analysis of Experiments, John Wiley
4. Cochran W.G. & Cox G.M. (1957): Experimental Designs, John Wiley
5. Federer W.T. (1975): Experimental Designs – Theory and Application, Oxford & IBH
6. Mukhopadhyay P. (1999): Applied Statistics

**GRB(20 marks)**

**604 Sample Survey MethodsII ( 20 marks)**

, Cluster sampling, Two -stage (with equal-sized first stage units) sampling with equal selection probabilities at each stage. Associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators. Optimum choice of sampling and sub-sampling fractions in two - stage sampling, Interpenetrating sub-sampling technique for unbiased variance estimation in systematic sampling

( 15L)

Ratio and Regression methods of estimation in simple random sampling. Double sampling for ratio and regression estimators. ( 4L)

Randomised Response Technique- Warner's model (1L)

***References:***

1. Goon A. M. ,Gupta M. K., Dasgupta B.(2001): Fundamentals of Statistics (V-2),World Press
2. Murthy M.N. (1977): Sampling Theory and Methods, Statistical Pub. Soc., Calcutta
3. Des Raj & Chandhok P.(1998): Sample Survey Theory, Narosa Publishing House
4. Cochran W.G. (1984): Sampling Techniques (3<sup>rd</sup> edition), Wiley Eastern
5. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice Hall
6. Sukhatme P.V. & Sukhatme B.V. (1970): Sampling Theory of Surveys with, Asia Publishing House
7. Sampathy S. (2001): Sampling Theory and Methods, Narosa

**PAPER XV(PR) (50 marks :**

**605: PRACTICAL (50 marks): Based on topics in paper XIII & XIV**

**PAPER XVI(PR) (50 marks:**

**606 : PRACTICAL (30+20 marks): (PROJECT + VIVA)**