RAMAKRISHNA MISSION RESIDENTIAL COLLEGE (AUTONOMOUS)
NARENDRAPUR, KOLKATA 700103, WEST BENGAL, INDIA
DEPARTMENT OF STATISTICS

To

Date: 30.07.2018

Dear Sir,

The next meeting of the Board of Studies in Statistics of Ramakrishna Mission Residential College (Autonomous), Narendrapur will be held in the teachers' room of the department of Statistics at 12 noon on 4th August, 2018.

You are requested to make it convenient to attend the meeting.

Thanking You,

Yours sincerely,

Parthasarathi Chakraborty
Co-ordinator

AGENDA:

1. Finalizing the CBCS syllabus with effect from 2018.
2. Selection of paper setters, moderators, examiners for Sem-1, Sem-3 and Sem-5 examinations 2018
3. Miscellaneous

Dept of Statistics

Minutes of BOS in Statistics held on 4/8/2018

1. M Pal
2. S.K. Samanta 4.8.18
3. Saini. 04/Aug/18
4. Kisan Das 4/8/18
5. P.K. Giri
6. Israil 4/8/18
7. Palas Pal.
8. Subhadeep Banerjee.
9. Absent
10. Trivikhrotee.

The following resolutions are taken.

1. Proposed Syllabus for Sem 1 and Sem 2 under CBCS are scrutinised thoroughly. The final syllabus is approved by the committee. This syllabus for Hons. and General both will be effective from the academic session 2018-19.
2. Paper setters, moderators, examiners, reviewers are selected for Sem 1, Sem 3 and Sem 5 examinations 2018.
3. It is decided that the practicals (Hons.) examinations for CC 1 and CC 2 of 30 marks each will be conducted simultaneously on a single day in a single paper having 30+30 = 60 marks and the duration of the examination will be three hours.
   The practical examination for GE-1 (General) of 30 marks will be of 1½ hours duration.
4. The committee decided that, the proposed syllabus may be modified latter on if there is any difficulty during the teaching by the teachers.
5. The meeting ended with vote of thanks.

Proposed Syllabus for Sem 1 & Sem 2 under CBCS and the list of paper setters, examiners etc. are attached herewith.

Absent
4/8/18

RAMAKRISHNA MISSION RESIDENTIAL COLLEGE (AUTONOMOUS)
NARENDRAPUR, KOLKATA 700103, WEST BENGAL, INDIA

To

Date: 09.03.2019

Dear Sir,

The next meeting of the Board of Studies in Statistics of Ramakrishna Mission Residential College (Autonomous), Narendrapur will be held in the teachers' room of the department of Statistics at 2 p.m. on 16th March, 2019.

You are requested to make it convenient to attend the meeting.

Thanking You,

Yours sincerely,

(Dilip Kumar Sahoo)
Head,Dep[artment of Statistics

AGENDA:

1. Review of the syllabus for the CBCS.
2. Selection of paper setters, moderators, examiners for Sem-2, Sem-4 and Sem-6 examinations 2019.
3. Miscellaneous.

RAMAKRISHNA MISSION RESIDENTIAL COLLEGE (AUTONOMOUS)
NARENDRAPUR, KOLKATA 700103, WEST BENGAL, INDIA

Proceedings of the meeting of board of studies of the Department of Statistics held on Saturday the 16th March 2019 at 2 p.m. at the Department of Statistics of the college.

Members present:

1. Prof. Manisha Pal — M. Pal 16/3/2019
2. Dr.Prasanta Kumar Giri — P. K. Giri 16/3/19
3. Dr. Nanda Kisore De — Nanda Kisore De 16.03.2019,
4. Dr. Sisir Kumar Samanta — Sisir K. Samanta 16.3.19
5. Dr. Dilip Kumar Sahoo — Kiran 16.3.2019
6. Dr Parthasarathi Chakraborty — absent
7. Sri Tulsidas Mukhopadhyay — Tulsidas Mukhopadhy 16.3.
8. Sri Palas Pal — Palas Pal. 16.03.2019.
9. Sri Subhaeep Banerjee — Subhadeep Banerjee
10. Dr. Kiranmay Das

Dr. Dilip Kumar Sahoo ,Head of the Department of Statistics was in the chair.

The following resolutions are taken:

(1) Proposed syllabus for Sem1, Sem2, Sem3, Sem4, Sem5 and Sem6 for Statistics Honours & Sem1,Sem2, Sem3 and Sem4 for Statistics General course under CBCS which were scrutinized thoroughly by the committee in it's last meeting held on 4th August 2018 are approved.

(2) The committee decided that the syllabus may be modified latter on if any difficulty arises during the course of teaching.

(3) Paper setters, moderators, examiners, reviewers are selected for the even semester examinations 2019.The lists are attached.

(3) The meeting ended with vote of thanks.

Ramakrishna Mission Residential College
Narendrapur
BSc Statistics Hons

Introduction

The syllabus for Statistics at undergraduate level using the Choice Based Credit system (CBCS) has been framed in compliance with model syllabus given by UGC.

While framing the syllabus as per the UGC guideline, the topics have been kept as generic as possible in order to provide enough freedom to the students for their individualchoice of topics as per their own strength.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to the Core Content, Applications and Techniques used in Statistics.

The ultimate goal of the syllabus is that the students at the end are equipped with adequate knowledge of the subject and skill for its applications. Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques of understanding and mapping of the subject.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

While the syllabus is in compliance with UGC model curriculum, some changes have been made to ensure all topics are covered and any of the subjects don'tbecome difficult to be completed in one semester

STATISTICS
HONOURS

COURSE STRUCTURE FOR CBCS
STATISTICS HONOURS (w.e.f. July 2018)

SEM	PAPER	MARKS	CREDIT	TOPIC
Sem1	**CC1**	100	4 + 2	Descriptive Statistics I & Real Analysis I
	CC2	100	4 + 2	Probability Theory I & Numerical Analysis
	TOTAL	**200**	**8 + 4**	
Sem2	**CC3**	100	4 + 2	Descriptive Statistics II & Real Analysis II
	CC4	100	4 + 2	Probability Theory II & Linear Algebra I
	TOTAL	**200**	**8 + 4**	
Sem3	**CC5**	100	4 + 2	Probability Theory III
	CC6	100	4 + 2	Population Statistics & Linear Algebra II
	CC7	100	4 + 2	Economic Statistics & Time Series Analysis
	TOTAL	**300**	**12 + 6**	
Sem4	**CC8**	100	4 + 2	Sampling Distributions & Statistical Computing I
	CC9	100	4 + 2	Statistical Inference I
	CC10	100	4 + 2	Statistical Quality Control & Sample Survey Methods I
	TOTAL	**300**	**12 + 6**	
Sem5	**CC11**	100	4 + 2	Multivariate Analysis & Large Sample Theory
	CC12	100	4 + 2	Statistical Inference II
	DSE A(1)	100	4 + 2	Choices are listed in Annexure I
	DSE B(1)	100	4 + 2	Choices are listed in Annexure I
	TOTAL	**400**	**16 + 8**	
Sem6	**CC13**	100	4 + 2	Statistical Inference III
	CC14	100	4 + 2	Statistical Computing II
	DSE A(2)	100	4 + 2	Choices are listed in Annexure I
	DSE B(2)	100	4 + 2	Choices are listed in Annexure I
	TOTAL	**400**	**16 + 8**	
T O T A L		**1800**	**72 + 36 = 108**	

Ramakrishna Mission Residential College (Autonomous), Narendrapur

DEPARTMENT OF STATISTICS

MARKS DISTRIBUTION

(HONOURS)

SEMESTER	THEORETICAL	PRACTICAL	INTERNAL ASSESEMENT	TOTAL
I	50 + 50	30 +30	20 +20	200
II	50 + 50	30 +30	20 +20	200
III	50 + 50 + 50	30 +30 +30	20 +20 + 20	300
IV	50 + 50 + 50	30 +30 +30	20 +20 + 20	300
V	50 + 50 + 50 + 50	30 +30 +30 +30	20 +20 + 20 +20	400
VI	50 + 50 + 50	30 +30 +30 + 100	20 +20 + 20	400
TOTAL	850	610	340	1800

Ability. Enhancement. Compulsory. Course (AECC)

1. Compulsory language to be taken in 1st Year.
    a. Subject: English
        i. Marks: 50
        ii. Credit: 2
        iii. Written Test at the Mid & End Semester
    b. Subject: Bengali
        i. Marks: 50
        ii. Credit: 2
        iii. Written Test at the Mid & End Semester

2. Environmental Studies
    i. Marks in Theory: 75
    ii. Credit: 3
    iii. Written Test at the Mid & End Semester
    iv. Marks in Project: 25
    v. Credit: 1
    vi. Each Student will be required to submit a Project Report at the end of Second Semester of First Year. The Project will be an original work which may be related to the Honours Subject of the students but must be some aspect of the environmental studies. However, students may involve his own habitat while doing his Project. In the month of February students should talk to either their teacher of the Environmental Studies or the teachers of their own subject to choose the Project area. The length of the Project Report should be not less than 1500 words but not more than 3000. It may be hand written or typed. The Project must be submitted by 31st May. Students should submit their Project Report Head of the Department and must obtain a Project Completion Certificate from the HoD.

(ACADEMIC CALENDER)

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

SEMESTER- I : (JULY -DECEMBER)

*. CC1 : 4 + 2 = 6 Credits 100 marks
CC2 : 4 + 2 = 6 Credits 100 marks

TOTAL : 8 + 4 = 12 Credits 200 marks

SEMESTER- II : (JANUARY -JUNE)

* CC3	: 4 + 2 = 6 Credits	100 marks
CC4	: 4 + 2 = 6 Credits	100 marks
TOTAL	: 8 + 4 = 12 Credits	200 marks

SEMESTER- III : (JULY - DECEMBER)

*. CC5	: 4 + 2 = 6 Credits	100 marks
CC6	: 4 + 2 = 6 Credits	100 marks
CC7	: 4 + 2 = 6 Credits	100 marks
TOTAL	: 12 + 6 = 18 Credits	300 marks

SEMESTER – IV: (JANUARY – JUNE)

*. CC8	: 4 + 2 = 6 Credits	100 marks
CC9	: 4 + 2 = 6 Credits	100 marks
CC10	: 4 + 2 = 6 Credits	100 marks
TOTAL	: 12 + 6 = 18 Credits	300 marks

SEMESTER-V : (JULY - DECEMBER)

*. CC11	: 4 + 2 = 6 Credits	100 marks
CC12	: 4 + 2 = 6 Credits	100 marks
DSE A (1)	: 4 + 2 = 6 Credits	100 marks
DSE B (1)	: 4 + 2 = 6 Credits	100 marks
TOTAL	: 16 + 8 = 24 Credits	400 marks

SEMESTER-VI : (JANUARY - JUNE)

*. CC13	: 4 + 2 = 6 Credits	100 marks
CC14	: 4 + 2 = 6 Credits	100 marks
DSE A (2)	: 4 + 2 = 6 Credits	100 marks
DSE B (2)	: 4 + 2 = 6 Credits	100 marks
TOTAL	: 16 + 8 = 24 Credits	400 marks

QUESTION PATTERN FOR B.Sc. HONS. EXAMINATION IN STATISTICS
SEMESTER SYSTEM UNDER CBCS
W.E.F 2018

A group having a total marks - 25	**A paper having a total marks - 50**
* Short questions of 5 marks each : Number of questions to be given = 2 Number of questions to be answered = 1 Total marks = 5 x 1= 5	* Short questions of 5 marks each : Number of questions to be given = 7 Number of questions to be answered = 4 Total marks = 5 x 4= 20
* Broad questions of 10 marks each : Number of questions to be given = 4 Number of questions to be answered = 2 Total marks = 10 x 2= 20	* Broad questions of 15 marks each : Number of questions to be given = 4 Number of questions to be answered = 2 Total marks = 15 x 2= 30

New syllabus (2018) under CBCS

Programme: B.Sc. Statistics Honours

Programme Code: (BSHSTA)

[L denotes lecture hours]

Semester	***One***
Name of the Course	***Descriptive Statistics I & Real Analysis I***
Course Code	***HSTA1CC01L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *different types of data, data structure and the art of data handling.* • *the techniques of summarization and identification of the salient features of the data through graphical displays and other descriptive measures.* • *computation and interpretation of various descriptive measures.* • *notion of sequences of real numbers and their properties.* • *notion of series of real numbers and tests for their convergence/divergence.* • *the properties of real valued functions.* • *define and recognise limits of real functions of single variable and their continuity and differentiability* • *mean Value theorems and their applications in various problems.* • *sequences and series of real functions (with special focus on power series) and tests to identify their various modes of convergence.* • *improper integrals with focus on beta and gamma integral and their use in probability distributions*

Syllabus	***GR A: 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. (4L) Collection and 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. (6L) Univariate data – different measures of location, dispersion, relative dispersion, skewness and kurtosis, Moments, Liaponouv's inequality, Quantiles and measures based on them – comparison with moment measures. Box Plot. Outlier Detection. (15L) ***GR B: Real Analysis I (25 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. (10L) Sequences and series of functions: Point wise and uniform convergence, Power series and Taylor series expansion. (10L) Calculus of single variable: Limit, continuity & differentiability of functions; Maxima & minima of functions. Integration: Improper integral, Beta and Gamma integrals. (10L) ***GR C: Practicals based on GR A and GR B of HSTA1CC01L (30 marks)*** ***GR D : Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	***GR A:***

<table>
<tr><td></td><td colspan="2">1. Gun 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 (6th 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.

GR B:

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.</td></tr>
<tr><td rowspan="3">Evaluation</td><td rowspan="2">CIA</td><td rowspan="2">20 marks</td></tr>
<tr></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(Group of 25 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(10 marks each)</td></tr>
<tr><td>1 out of 2</td><td>2 out of 4</td></tr>
</table>

Semester	***One***
Name of the Course	***Probability Theory I & Numerical Analysis***
Course Code	***HSTA1CC02L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *definition of objective probability.* • *different theorems of probability associated with algebra of events.* • *empirical justification of probability.* • *foundation of axiomatic treatment of probability* • *notion of conditional probability and stochastic independece.* • *translation of real-world problems into probability models* • *numerical approximations to functions which are analytically intractable.* • *numerical differentiation, integration and solution of equations.* • *approximation of measures associated with theoretical distributions*

Syllabus	***GR A : Probability Theory I (25 marks)*** Random Experiment: Trial, Sample point, Sample space, Different types of events. (3L) 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 (27L) ***GR B: Numerical Analysis (25 marks)*** Interpolation: Polynomial approximation, Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms. (12L) Numerical differentiation and its applications. Numerical integration: Trapejoidal, Simpson's 1/3rd & 3/8th rule, Weddle's rule. (7L) Numerical solution of equations: Regulafalsi method, 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. (11L) ***GR C: Practicals based on Gr A and Gr B of HSTA1CC02L (30 marks)*** ***GR D: (20 marks) Internal Assessment.*** NB: Revised w.e.f. July-2018
Reference	***GR A:*** 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

<table>
<tr><td></td><td colspan="2">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:

1. Scarborough J.B. (1958): Numerical Mathematical Analysis, Oxford Univ. Press
2. Atkinson K. (1985): Elementary Numerical Analysis
3. Sastry S.S. (1998): Introductory Methods of Numerical Analysis
4. Hildebrand F.B. (1974): Introduction to Numerical Analysis, Tata McGraw-Hil</td></tr>
<tr><td rowspan="3">Evaluation</td><td>CIA</td><td>20 marks</td></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(A group of 25 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(10 marks each)</td></tr>
<tr><td>1 out of 2</td><td>2 out of 4</td></tr>
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Semester	***Two***
Name of the Course	***Descriptive Statistics II & Real Analysis II***
Course Code	***HSTA2CC03L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *the salient features of metric data related to two or more variables.* • *notion of the correlation between two variables.* • *how to develop a prediction model using cause- effect relationship.* • *principle of method of least square estimation* • *correlation between two variables that are not directly measurable* • *classification of categorical variables* • *different measures of categorical variables - computations and interpretations* • *concept of case-control, cohort, cross-sectional studies, odds, relative risks and logistic regression*

	• *define and recognise real functions of several variables and their limits, continuity and differentiability* • *constrained optimisation (with focus on Lagranges method)* • *multiple integrals, jacobian of transformation and their use in probability distributuion.*
Syllabus	**GR A: *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. (20L) Analysis of Categorical Data: Consistency of data, independence and association of attributes, measures of association – Pearson's and Yule's measures, Goodman-Kruskal'sγ. Odds Ratio. Fitting of logit model through least squares. (10L) ***GR B: Real Analysis II (25 marks)*** Calculus of several variables: Limit, continuity & differentiability of functions ; Maxima & minima for functions ; constrained maximization and minimization – Use of Lagrangian Multiplier. (18L) Multiple integrals, Transformation of variables and Jacobian: Polar and orthogonal transformations. (12L) **GR C (30 marks)** **Practicals based on Gr A and Gr B of CC 3.** **GR D (20 marks)** **Internal Assessment.** NB: Revised w.e.f. July-2018
Reference	***GR A:*** 1. Goon AM,GuptaMK,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^{th}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

	GR B: 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure (A group of 25 marks)	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	***Two***
Name of the Course	***Probability Theory II & Linear Algebra I***
Course Code	***HSTA2CC04L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *idea of total quality management (TQM) with focus on Statistical process control (SPC) and lot control* • *philosophy of SPC and definitions of related terms* • *construction of control charts* • *sampling inspection plans - definitions of related terms, their interpretations and optimisations* • *introduction of survey sampling as a sampling enquiry - definition and interpretations of related terminologies* • *role of survey sampling in inductive inference - general ideas* • *bias in sample surveys, sapling and non sampling errors* • *application of simple random sampling and stratified random*

	sampling in real life situations.
Syllabus	***GR A: Probability Theory II (25 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. (14L) Generating Functions: Probability generating function and moment generating function. (6L) Univariate Discrete Distributions: Uniform, Bernoulli, Hypergeometric, Binomial, Poisson, Negative Binomial, Geometric distributions and their properties. (10L) ***GR B: Linear Algebra I (25 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. (10L) Matrix Algebra: Matrices, Matrix operations, Different types of matrices.Determinants: Definition, Properties, Evaluation of some special determinants. Inverse matrix: Definition & Properties .Inverse of some special matrices. (8L) 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 method, normal form, minor and rank. Null space and rank. Rank factorization. (12L) ***GR C: Practicals based on Gr A and Gr B of HSTA2CC04L (30 marks)*** ***GR D: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	***GR A:*** 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

<table>
<tr><td></td><td colspan="2">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:

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</td></tr>
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<tr><td>1 out of 2</td><td>2 out of 4</td></tr>
</table>

Semester	***Three***
Name of the Course	***Probability Theory III***
Course Code	***HSTA2CC05L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *different aspects of univariate continuous probability distribution with applications to real life situations..* • *different aspects of bivariate discrete and continuous probability distribution with applications to real life situations.* • *the applications of different probability inequalities.* • *different modes of convergence with respect to a probability space* • *law of large numbers and central limit theorems*

Syllabus	***Gr A: Probability Theory III (50 marks)*** Univariate Continuous Distributions: Rectangular, Normal, Cauchy, Gamma, Beta, Exponential, Laplace, Logistic, Pareto, Log-normal distributions and their properties. Truncated distributions. (14L) Use of continuous distributions in scaling, income or allied distributions. (5L) 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 (13L) 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. (18L) Bivariate Normal Distribution and its properties. (10L) ***GR B: Practicals based on Gr A of HSTA2CC05L (30 marks)*** ***GR C: Internal Assessment (20 marks)***
Reference	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

Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Semester	***Three***
Name of the Course	***Population Statistics &Linear algebra II***
Course Code	***HSTA2CC06L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description/objective	*At the end of this course a student should be able to understand* • *demographic features of a population (with focus on indian context)* • *measures of moratality, natality and moribidity* • *the concept of a life table and its significance in real life.* • *the notion of growth of a population along with methods of estimating and forecasting the same.* • *systems of linear equations.* • *characteristic roots and vectors along with the understanding of classification of quadratic forms.*

	• *linear transformation in connection to matrices.* * *this course is expected to lay the foundations to learn the courses like Multivariate Analysis and Linear Model.*
Syllabus	***GR A: Population Statistics (25 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 (0r Current) vs. Generation Life Tables, Stable population and Stationary population, Construction of complete life table from population and death statistics. (6L) Measurements of Fertility: Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate. (5L) Measurement of Population Growth: Crude Rate of Natural Increase and Vital Index, Gross and Net Reproduction Rates. (4L) 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. (7L) ***GR B: Linear algebra II (25 marks)*** System of linear equations: Homogeneous and non-homogeneous systems – conditions for solvability. Gaussian Elimination. Linear Transformation: Kernel & Image, Matrix representation. (8L) Quadratic forms ;classification and canonical reduction. Properties of n.n.d /n.p.d matrices. (12L) 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. (10L) ***GR C: Practicals based on Gr A and Gr B of HSTA2CC06L (30 marks)*** ***GR D: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	***GR A :*** 1. Goon AM,GuptaMK,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 (3rd edition), Springer ***GR B :*** 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 25 marks)*	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	***Three***
Name of the Course	***Economic Statistics &Time Series Analysis***
Course Code	***HSTA2CC07L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *preliminary ideas of formulating statistical measures to account for inflation/deflation and economic growth of a country.* • *knowledge on comparative social statistics.* • *basic concepts of demand and supply and related measures.* • *a time series as a sequence of correlated random variables.* • *the difference between time series and time series data.* • *how to decompose time series data into classical components.* • *how to analyse for stationarity for an actual insight into the*

	probability model underlying the series. • *know the basics of forecasting.*
Syllabus	***GR A: Economic Statistics (25 marks)*** **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. (25L) **Demand Analysis:** Demand & supply, Price elasticity of demand, Income elasticity of demand, Partial & cross elasticity's of demand, Engel's law & Engel curves, basic concept of utility function. (5L) ***GR B: Time Series Analysis(25 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. (15L) 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 (15L) ***GR C: Practicals based on Gr A and Gr B of HSTA2CC07L (30 marks)*** ***GR D: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	***GR A :*** 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

	GR B: 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 25 marks)*	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	***Four***
Name of the Course	***Sampling Distributions& Statistical Computing I***
Course Code	***HSTA2CC08L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *the notion of parameter, labelling parameter and statistic in parametric inference* • *some sampling distributions of moments, fractiles and their functions* • *the importance of sampling distributions in Statistical Inference.* • *the basic statistical computations using programming in C and minitab package with applications to problems related to above courses*

<table>
<tr><td>Syllabus</td><td colspan="2">Gr A: Sampling Distributions (50 marks)

Transformation of Random variables (15L)
Introduction: Concepts of Random Sampling, Statistics and Sampling Distributions of Statistics. Illustrations using different distributions, reproductive properties of the distributions. (15L)

Some Standard Sampling Distributions : χ^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) (20L)

Distributions of Order Statistics and Sample Range. (10L)

GR B: Practicals based on Statistical Computing I of HSTA2CC08L (30 marks)

GR C: Internal Assessment (20 marks)

NB: Revised w.e.f. July-2018</td></tr>
<tr><td>Reading/Reference Lists</td><td colspan="2">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 (3rd 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.andDasgupta B. (1997):Fundamentals of Statistics (V-1), World Press
10. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley</td></tr>
<tr><td rowspan="3">Evaluation</td><td rowspan="3">CIA</td><td>20 marks</td></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(A group of 50 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(15 marks each)</td></tr>
<tr><td>4 out of 7</td><td>2 out of 4</td></tr>
</table>

Semester	***Four***
Name of the Course	***Statistical Inference I***
Course Code	***HSTA2CC09L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	At the end of the course a student should be able to understand • the notion of statistical inference with focus on parametric setup. • the basics of point and interval estimation and testing of hypotheses. • the criteria of a good estimator • estimates of parameteric functions related to theoretical distributions covered under above courses

	• test of significance related to theoretical distributions covered in above courses	
Syllabus	***Gr A: Statistical Inference I (50 marks)*** Idea of Inference - Point & Interval Estimations and Testing of Hypothesis (4L) Point estimation: Requirements of a good estimator – notions of Mean Square Error, Unbiasedness: Minimum Variance Uunbiasedness and Best Linear Unbisedness, (18L) 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 (18L) 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. (20L) ***GR B: Practicals based on Gr A of HSTA2CC09L (30 marks)*** ***GR C: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018	
Reference	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 (3rd 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks

		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Semester	***Four***
Name of the Course	***Statistical Quality Control&Sample SurveyMethods I***
Course Code	***HSTA2CC10L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand*

	• *idea of total quality management (TQM) with focus on Statistical process control (SPC) and lot control* • *philosophy of SPC and definitions of related terms* • *construction of control charts* • *sampling inspection plans - definitions of related terms, their interpretations and optimisations* • *introduction of survey sampling as a sampling enquiry - definition and interpretations of related terminologies* • *role of survey sampling in inductive inference - general ideas* • *bias in sample surveys, sapling and non sampling errors* • *application of simple random sampling and stratified random sampling in real life situations.*
Syllabus	***GR A: Statistical Quality Control (25 marks):*** Introduction: Concepts of Quality and Quality Control, Process Control and Product Control (6L) 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. (12L) 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 σ cases), Use of IS plans and tables (12L) ***GR B: Sample Survey Methods I (25 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. (8L) Tables of Random Numbers and their uses. Simple Random Sampling with and without replacement, Determination of sample size in simple random sampling, associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators. Stratified random sampling, Associated unbiased estimators of population total, mean, and proportion, their variances and unbiased variance estimators. (22L) ***GR C: Practicals based on Gr A and Gr B of HSTA2CC10L (30 marks)*** ***GR D: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	***GR A:*** 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

<table>
<tr><td></td><td colspan="2">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

GR B :
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 (3rd 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</td></tr>
<tr><td rowspan="3">Evaluation</td><td rowspan="3">CIA
End-Sem</td><td>20 marks</td></tr>
<tr><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(A group of 25 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(10 marks each)</td></tr>
<tr><td>1 out of 2</td><td>2 out of 4</td></tr>
<tr><td>Semester</td><td colspan="2">Five</td></tr>
<tr><td>Name of the Course</td><td colspan="2">Multivariate Analysis &Large Sample Theory</td></tr>
<tr><td>Course Code</td><td colspan="2">HSTA2CC11L</td></tr>
<tr><td>Theory/Composite</td><td colspan="2">Composite</td></tr>
<tr><td>No. of Credits</td><td colspan="2">(Th 4 + Pr 2 = 6 Credits)</td></tr>
<tr><td>Course description /objective</td><td colspan="2">At the end of the course students should know
• about multivariate probability ddistributions with focus on multinomial and multivariate normal distributions and their properties.
• sampling distributions of some statistics based on samples drawn from multivariate normal distribution.
• different modes of convergence of statistics and their inter-relationship</td></tr>
</table>

	• *the large sample behaviour of different statistics (based on both moments and quantiles) relating to estimation and tests of hypothesis.* • *about various transformations on statistics and their use in inferential problems.* • *about Pearsonian Chi-Square statistic and its uses.* • *about different asymptotic properties of estimators*
Syllabus	***GR A : Multivariate Analysis (25 marks)*** Multivariate data – multiple regressions, multiple correlation and partial correlation – their properties and related results. (6L) 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. (12L) Multivariate Distributions: Multinomial, Multivariate Normal distributions and their properties. (12L) ***Gr B:Large Sample Theory (25 marks)*** 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. (10L) Transformations of Statistics to stabilize variance: derivation and use of Sin^{-1}, square root, logarithmic and z-transformations. (6L) Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients. (7L) Large Sample distribution of Pearsonianχ^2 –statistic and its uses. Yate's correction in a 2 x 2 contingency table. Combination of probabilities (7L) ***GR C: Practicals based on Gr A and Gr B of HSTA2CC11L (30 marks)*** ***GR D: Internal Assessment (20 marks)***
Reference	***GR A :*** 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, 3rd 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, 5th edition, Prentice Hall ***GR B:*** 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 25 marks)*	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	***Five***
Name of the Course	***Statistical Inference II***
Course Code	***HSTA2CC12L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *data reduction technique - sufficiency principle* • *detailed notions of point estimation with focus on OPEF.*

	• *Cramer-Rao inequality, Blackwellisation and Lehman -Scheffe theorem and their applications to find UMVUE.* • *notion of randomised tests* • *different optimum tests (MP, UMP, UMPU) from frequentist approach* • *construction of UMP tests using Neyman Pearson lemma*	
Syllabus	***GR A: Statistical Inference II (50 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. (30L) 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 parameter), Uniformly Most Powerful Unbiased (UMPU) tests (definition only). (30L) ***GR B: Practicals based on Gr A of HSTA2CC12L (30 marks)*** ***GR C: Internal Assessment (20 marks)***	
Reference	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 (3rd 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4
Semester	***FIVE***	
Paper Number	***DSE A (1)***	
Paper Title	***ANY ONE PAPER FROM POOL A OF ANNEXURE I*** ***(100 marks)***	
No. of Credits	***6 Credits***	
Theory/Composite		
Course description /objective		

Syllabus		
Reference		
Evaluation		
Paper Structure		

Semester	***FIVE***
Paper Number	***DSE B (1)***
Paper Title	***ANY ONE PAPER FROM POOL B OF ANNEXURE I (100 marks)***
No. of Credits	***6 Credits***
Theory/Composite	
Course description /objective	
Syllabus	
Reference	
Evaluation	
Paper Structure	

Semester	***Six***
Name of the Course	***Statistical Inference III***
Course Code	***HSTA2CC13L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *different methods to obtain point estimators with focus on MLE* • *how to construct optimum confidence sets - their relations with optimum tests* • *likelihood raio tests - properties and its general applicability.* • *difference between a fixed sample approach and the sequential approach to testing of hypotheses.*

	• *sequential probability raio tets* • *difference among parametric, nonparametric and semiparametric methods in statiistical inference* • *nonparametric location problem and related tests and run test* • *nonparametric interval estimation*approach and the sequential approach to testing of hypotheses. • know nonparametric methods in testing of hypothesis
Syllabus	***GR A: Statistical Inference III (50 marks)*** Methods of Estimation – Moment, Least-square, Maximum Likelihood & Minimum χ^2 methods and their properties (excluding proofs of large sample properties). (12L) 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). (15L) Interval Estimation: Confidence intervals, Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses. (12L) 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. (21L) ***GR B: Practicals based on Gr A of HSTA2CC13L (30 marks)*** ***GR C: Internal Assessment (20 marks)***

<table>
<tr><td>Reference</td><td colspan="2">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 (3rd 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</td></tr>
<tr><td rowspan="3">Evaluation</td><td>CIA</td><td>20 marks</td></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(A group of 50 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(15 marks each)</td></tr>
<tr><td>4 out of 7</td><td>2 out of 4</td></tr>
</table>

Semester	***Six***	
Name of the Course	***Statistical Computing II using computer***	
Course Code	***HSTA2CC14L***	
Theory/Composite	***Composite***	
No. of Credits	***(6 Credits)***	
Course description /objective	At the end of the course a student should be able to understand • advanced techniques of solving different statistical problems in real life using computers.	
Syllabus		
Reference		
Evaluation		
Paper Structure		

Semester	***SIX***

Paper Number	***DSE A (2)***	
Paper Title	***ANY ONE PAPER EXCEPT THE ONE SELECTED IN SEM V FROM POOL A OF ANNEXURE I (100 marks)***	
No. of Credits	***6 Credits***	
Theory/Composite		
Course description /objective		
Syllabus		
Reference		
Evaluation		
Paper Structure		

Semester	***SIX***	
Paper Number	***DSE B (2)***	
Paper Title	***ANY ONE PAPER EXCEPT THE ONE SELECTED IN SEM V FROM POOL B OF ANNEXURE I (100 marks)***	
No. of Credits	***6 Credits***	
Theory/Composite		
Course description /objective		
Syllabus		
Reference		
Evaluation		
Paper Structure		

ANNEXURE I

(A student shall choose any one paper from each of Group A and Group B in fifth semester and sixth semester)

Department Specific Elective Subjects Syllabus

POOL A

Choice 1

Name of the Course	***ANOVA & Regression Analysis***	
Course Code	***HSTADS01L***	
Theory/Composite	***Composite***	
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***	
Course description /objective	*At the end of the course a student should be able to* • *extend the modelling of a response-predictor relationship to the case where there are more than 2 predictors.* • *identify and classify Gauss Markov models.* • *analyse ANOVA models to test for the differential effects of factors and interaction effects between two factors.* • *deal with testing problems related to regression models.*	
Syllabus	***Gr A: ANOVA &Regression Analysis (50 marks)*** Introduction: Heterogeneity and Analysis of Variance, Linear Hypothesis, Orthogonal splitting of total variation, Selection of Valid Error. (12L) Applications of the ANOVA technique to: one-way classified data, two-way classified data with equal number of observations per cell in fixed effects model. Modifications in case of random effects model and mixed effects model. (28L) Analysis of variance to test the presence of regression, linear or polynomial regression in case of presence of regression, testing simple regression coefficients for linear regression, tests for parallelism and identity for both two sample and k sample case, tests in multivariate set up including tests for multiple correlation and partial correlation coefficients. (20L) ***GR B: Practicals based on Gr A of HSTADS01L (30 marks)*** ***GR C: Internal Assessment (20 marks)***	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Choice 2

Name of the Course	***ANOVA & Design of Experiments***
Course Code	***HSTADS02L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***

Course description /objective	*At the end of the course a student should be able to* • *understand the use of concomitant variables in analysing ANOCOVA models* • *understand Randomization and Replication as essential principles and* *Local Control as a desirable principle in statistical designs of experiments.* • *construct standard designs – CRD, RBD and LSD; apply ANOVA techniques to analyse these designs; compare relative efficiencies of one with respect to the other.* • *analyse the standard designs if one observation is missing in the layout.* • *know the notion of Factorial Experiments, completely and partially confounded factorial experiments and their constructions (with focus on 2^n designs)* • *know the notion of assymetric factorial experiments and groups of experiments*
Syllabus	***Gr A: ANOCOVA & Design of Experiments (50 marks)*** Principles of experimental design: Randomization, Replication and Local Control, Uniformity trials, Shapes and Sizes of Plots and Blocks. (8L) 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. Contrasts & orthogonality of designs. (20L) Split Plot Design and Strip arrangements. Groups of Experiments using RBD and LSD (8L) Factorial Experiments: 2^n experiments, Advantages, Total and Partial Confounding, Analysis. (12L) Missing Plot Technique: Analysis with one missing plot in a RBD and in a LSD. (6L) Analysis of Covariance (ANCOVA): Application of the ANCOVA technique in designs of experiments, use in the control of error in CRD, RBD & LSD. (6L) ***GR B: Practicals based on Gr A of HSTADS02L (30 marks)*** ***GR C: Internal Assessment (20 marks)***
Reference	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.

	(2nd 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Choice 3

Name of the Course	***Statistical Data Analysis using R***
Course Code	***HSTADS03L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***

Course description /objective	After completion of the course, students will be able to • handle, organise and complie big data • solve programming related problems using the R language. • get an exposure to basic concepts in R apart from use of different libraries in R, basic statistics concepts using R Commander. • Use their knowledge in real-life projects, R Cloud Labs and case studies.	
Syllabus	**Group A : Statistical Data Analysis using R (50 marks)** Introduction to R: Installation, commandline environment, overview of capabilities, brief mention of open source philosophy. (5L) R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers. Standard functions, e.g., sin, cos, exp, log. (10L) The different types of numbers in R: Division by zero leading to Inf or -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c( ), seq( ) and colon operator. How functions map over vectors. Functions to summarise a vector: sum, mean, sd, median etc. extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting. Plot ( ), lines( ), abline( ). No details about the graphics parameters except colour and line width. Bar plot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x). (20L) Matrix operations in R: Creation. Basic operations. Extracting submatrices. Loading data from a file: read.table ( ) and read.csv ( ). Mention of head=TRUE and head=FALSE. Dataframes. Mention that these are like matrices, except that different columns may be of different types. (15L) Problems on discrete and continuous probability distributions. (10L) ***GR B: Practicals based on Gr A of HSTADS03L (30 marks)*** ***GR C: Internal Assessment (20 marks)***	
Reference	1. Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications. 2. Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York 3. A simple introduction to R by ArnabChakraborty (freely available at http://www.isical.ac.in/~arnabc/) 4. R for beginners by Emmanuel Paradis (freely available at ftp://cran.r-project.org/pub/R/doc/contrib/Paradis-rdebuts_en.pdf)	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks

		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Choice 4

Name of the Course	***Econometrics***
Course Code	***HSTADS04L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description	At the end of the course students should be able to

<table>
<tr><td>/objective</td><td colspan="2">• understand what Econometrics is and how it can be used for validating Economic models.
• translate data into models to make forecasts and to support decision making in a wide variety of fields, ranging from macroeconomics to finance and marketing
• know about the Gauss-Markov linear model more closely and the corresponding inferential problems.
• know how to detect the violation of the assumptions (in particular, Heteroscedasticity, Autocorrelation and Multicollinearity) of the above model.
• know the effects of Heteroscedasticity, Autocorrelation and Multicollinearity and remedial measures.</td></tr>
<tr><td>Syllabus</td><td colspan="2">GR A: Econometrics (50 marks)

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics. Estimation under linear restrictions. Dummy variables, Qualitative data. (10L)

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, (10L)

Autocorrelation: Concept, consequences of auto correlated disturbances, detection and solution of autocorrelation. Generalized least squares estimation. (15L)

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. (20L)

Errors in variables: Correlation between error and regressors. Instrumental variable method (Single-equation model with one explanatory variable) (5L)

GR B: Practicals based on Gr A of HSTADS04L (30 marks)

GR C: Internal Assessment (20 marks)</td></tr>
<tr><td>Reference</td><td colspan="2">1.Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition McGraw Hill Companies
2.Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3.Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, , Palgrave Macmillan Limited
4.Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.</td></tr>
<tr><td rowspan="3">Evaluation</td><td>CIA</td><td>20 marks</td></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
</table>

Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

POOL B

Choice 1

Name of the Course	***Sample Survey Methods II***
Course Code	***HSTADS05L***
Theory/Composite	***Composite***

No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***	
Course description /objective	*Upon successfully completing this course, students will be able to* • *design and implement surveys with systematic sampling, cluster sampling, multistage sampling (with focus on two stage sampling)* • *understand the importance of introduction of auxiliary variable in the improvement of estimation procedures under certain situations.* • *estimate population parameters using auxiliary information. Students would be able to design and implement multiphase sampling (with focus on double sampling)*	
Syllabus	***Gr A: Sample Survey Methods II (50 marks)*** Linear and Circular systematic Sampling. Cluster sampling. (12L) 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 (34L) Ratio and Regression methods of estimation in simple random sampling. Double sampling for ratio and regression estimators. (12L) Randomised Response Technique- Warner's model (2L) ***GR B: Practicals based on Gr A of HSTADS05L (30 marks)*** ***GR C: Internal Assessment (20 marks)***	
Reference	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 (3rd 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	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)

	4 out of 7	2 out of 4

Choice 2

Name of the Course	***Project Work***
Course Code	***HSTADS06L***
Theory/Composite	***Composite***
No. of Credits	***(6 Credits)***
Course description /objective	Implementation of knowledge acquired under the Programme BSHSTA
Syllabus	

Reference		
Evaluation		
Paper Structure		

Choice 3

Name of the Course	***Stochastic Processes and Queuing Theory***
Course Code	***HSTADS07L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should be able to understand* • *probabilistic models that are employed in countless applications in*

	all areas of science and engineering • *The basic knowledge of stochastic models with a special focus on queueing models, that may apply to telecommunications topics, such as traffic modelling, performance evaluation, resource provisioning and traffic management.* • *To develop the modeling and mathematical skills to analytically determine computer systems and analytically determine computer systems and communication network performance.* • *The current performance analysis and queueing theory literature .*	
Syllabus	***Gr A: Stochastic Processes and Queuing Theory (50 marks)*** Stochastic Process: Introduction, Stationary Process. (5L) Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Higher order transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system (25L) Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process. (20L) Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). (10L) ***GR B: Practicals based on Gr A of HSTADS07L (30 marks)*** ***GR C: Internal Assessment (20 marks)***	
Reference	1..Medhi, J. (2009): Stochastic Processes, New Age International Publishers. 2.Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing. 3.Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers. 4.Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India. 5.Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 50 marks)*	Short questions (5 marks each)	Long questions (15 marks each)
	4 out of 7	2 out of 4

Choice 4:

Name of the Course	***Operations Research***
Course Code	***HSTADS08L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of the course a student should* • *Get the idea of linear programming problems (LPPs).* • *Know of the tools to solve LPPs.* • *Know what transportation problem is and how to solve it.*

<table>
<tr><td></td><td colspan="2">• Understand different types of games and their solutions.
• Get knowledge about EOQ models and their analysis.
• Get to know different queuing systems and their analysis.
• Get knowledge about gambler's ruin type problems in queuing theory</td></tr>
<tr><td>Syllabus</td><td colspan="2">Gr A: Operations Research (50 marks)

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne’s M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. (20L)

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel’s approximation method (VAM), MODI’s method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem. (20L)

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. (10L)

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks. (10L)

GR B: Practicals based on Gr A of HSTADS08L (30 marks)

GR C: Internal Assessment (20 marks)</td></tr>
<tr><td>Reference</td><td colspan="2">1.Taha, H. A. (2007): Operations Research: An Introduction, 8 Hall of India.
2.KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3.Hadley, G: (2002) : Linear Programming, Narosa Publications
4.Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research-Concepts and cases, 9th Edition, Tata McGraw Hill</td></tr>
<tr><td rowspan="3">Evaluation</td><td>CIA</td><td>20 marks</td></tr>
<tr><td rowspan="2">End-Sem</td><td>Th 50 marks</td></tr>
<tr><td>Pr 30 marks</td></tr>
<tr><td rowspan="2">Paper Structure
(A group of 50 marks)</td><td>Short questions
(5 marks each)</td><td>Long questions
(15 marks each)</td></tr>
<tr><td>4 out of 7</td><td>2 out of 4</td></tr>
</table>

STATISTICS
GENERAL

(GENERAL)

SEMESTER	THEORETICAL	PRACTICAL	INTERNAL ASSESEMENT	TOTAL
I	50	30	20	100
II	50	30	20	100
III	50	30	20	100
IV	50	30	20	100

Course Structure (Statistics General) for CBCS (W.E.F. 2018)

Semester	Paper	Group	Marks	Topic	Credit
Sem 1	GE 1	A_1(Th)	25	Descriptive Statistics I	4
		A_2(Th)	25	Probability I	
		B(Pr)	30	Practical based on A_1& A_2	2
		C(IA)	20		
TOTAL			**100**		**6**
Sem 3	GE 2	A_1(Th)	25	Descriptive Statistics II	4
		A_2(Th)	25	Probability II, Sampling Distributions & Statistical Inference	
		B(Pr)	30	Practical based on A_1& A_2	2
		C(IA)	20		

TOTAL	**100**		**6**

Semester	Paper	Group	Marks	Topic	Credit
Sem 2	GE 1	A_1(Th)	25	Descriptive Statistics I	4
		A_2(Th)	25	Probability I	
		B(Pr)	30	Practical based on A_1& A_2	2
		C(IA)	20		
TOTAL			**100**		**6**
Sem 4	GE 2	A_1(Th)	25	Descriptive Statistics II	4
		A_2(Th)	25	Probability II, Sampling Distributions & Statistical Inference	
		B(Pr)	30	Practical based on A_1& A_2	2
		C(IA)	20		
TOTAL			**100**		**6**

QUESTION PATTERN FOR B.Sc. GENERAL EXAMINATION IN STATISTICS
SEMESTER SYSTEM UNDER CBCS
W.E.F 2018

GROUP-I (Topics under Group A_1) : **(25 marks):** * Short questions of 5 marks each : Number of questions to be given = 2 Number of questions to be answered = 1 Total marks = 5 x 1= 5	**GROUP-II (Topics under Group A_2):** **(25 marks):** * Short questions of 5 marks each : Number of questions to be given = 2 Number of questions to be answered = 1

* Broad questions of 10 marks each : Number of questions to be given = 4 Number of questions to be answered = 2 Total marks = 10 x 2= 20	Total marks = 1 x 5= 5 * Broad questions of 10 marks each : Number of questions to be given = 4 Number of questions to be answered = 2 Total marks = 10 x 2= 20

Semester	**One**
Name of the Course	***Descriptive Statistics I & Probability I***
Course Code	***HSTA1GE01L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *Different types of data and the art of data handling.* • *The techniques of summarization and identification of the salient features of the data through graphical displays and other descriptive measure.* • *Different definitions and meaning of Probability.* • *Different laws of probability and the theorems connecting them.* • *the application of the laws of probability.* • *the notion of conditional probability.* • *what a random variable and its probability distribution are.*

	• *Different aspects of univariate probability distribution.* • *Probability inequalities*
Syllabus	**Group A_1: Descriptive Statistics I (25 marks)** Types of statistical data, Compilation, Classification, Tabulation and Diagrammatic representation of data, Frequency Distribution, Cumulative Distribution and their graphical representation, Histogram, Frequency Polygon, Frequency Curve and Ogive. (14L) Analysis of Univariate Quantitative Data – concepts of central tendency, dispersion, relative dispersion, skewness and kurtosis and their measures based on quantilesand moments. (16L) **Group A_2: Probability I (25 marks)** Random Experiments and Random Events, Statistical regularity and meaning of Probability, Classical and Axiomatic definitions of Probability (discrete sample space only), Conditional Probability, Independence of Events, Principal Theorems including union and intersection of events and Bayes' Theorem. (15L) Random Variable and its Probability Distribution,Probability Mass Function and Probability Density Function, Mathematical Expectation, Variance and Moments. Cumulative Distribution Function. Standard Univariate Discrete Distributions and their properties – Discrete Uniform, Binomial, Poisson, Hypergeometric, Geometric and Negative Binomial distributions. Standard Univariate Continuous Distributions – Uniform, Normal, Exponential. Fitting of Binomial, Poisson and Normal distributions. Probability Inequalities. Weak Law of Large Numbers, Statement of Central Limit Theorem (i.i.d. case) and its uses. (15L) ***GR B: Practicals based on Gr A_1 and Gr A_2 of HSTA1GE01L (30 marks)*** ***GR C: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	**Group A_1:** 1. Goon A.M., Gupta M. &Dasgupta B.(2001) : Fundamentals of Statistics (Vol. 1), World Press 2. Yule G.U. & Kendall M.G.(1950) : Introduction to the Theory of Statistics, Charles Griffin 3. Nagar A.L. & Das R.K. (1976): Basic Statistics 4. Bhattacharyya G. K. & Johnson R. A. (1977) : Concepts & Methods of Statistics, J.Wiley **Group A_2:** 1. Goon A.M., Gupta M. &Dasgupta B.(1997): An Outline of Statistics(Vol 1), World Press 2. Feller W.(1968) : An Introduction to Probability Theory & its Applications, John Wiley

	3. Cacoullos T. (1973): Exercises in Probability, Narosa 4. Bhattacharyya G. K. & Johnson R. A. (1977) : Concepts & Methods of Statistics, J.Wiley 5. Freund J.E. (2001): Mathematical Statistics, Prentice Hall 6. Pitman J. (1993): Probability, Narosa 7. Stirzaker D. (1994): Elementary Probability, Cambridge University Press 8. Rathie and Mathai: Probability and Statistics	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 25 marks)*	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	**Two**
Name of the Course	***Descriptive Statistics I & Probability I***
Course Code	***HSTA1GE01L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *Different types of data and the art of data handling.* • *The techniques of summarization and identification of the salient features of the data through graphical displays and other descriptive measure.* • *Different definitions and meaning of Probability.* • *Different laws of probability and the theorems connecting them.* • *the application of the laws of probability.*

	• *the notion of conditional probability.* • *what a random variable and its probability distribution are.* • *Different aspects of univariate probability distribution.* • *Probability inequalities*
Syllabus	**Group A_1: Descriptive Statistics I (25 marks)** Types of statistical data, Compilation, Classification, Tabulation and Diagrammatic representation of data, Frequency Distribution, Cumulative Distribution and their graphical representation, Histogram, Frequency Polygon, Frequency Curve and Ogive. (14L) Analysis of Univariate Quantitative Data – concepts of central tendency, dispersion, relative dispersion, skewness and kurtosis and their measures based on quantilesand moments. (16L) **Group A_2: Probability I (25 marks)** Random Experiments and Random Events, Statistical regularity and meaning of Probability, Classical and Axiomatic definitions of Probability (discrete sample space only), Conditional Probability, Independence of Events, Principal Theorems including union and intersection of events and Bayes' Theorem. (15L) Random Variable and its Probability Distribution,Probability Mass Function and Probability Density Function, Mathematical Expectation, Variance and Moments. Cumulative Distribution Function. Standard Univariate Discrete Distributions and their properties – Discrete Uniform, Binomial, Poisson, Hypergeometric, Geometric and Negative Binomial distributions. Standard Univariate Continuous Distributions – Uniform, Normal, Exponential. Fitting of Binomial, Poisson and Normal distributions. Probability Inequalities. Weak Law of Large Numbers, Statement of Central Limit Theorem (i.i.d. case) and its uses. (15L) ***GR B: Practicals based on Gr A_1 and Gr A_2 of HSTA1GE01L (30 marks)*** ***GR C: Internal Assessment (20 marks)*** NB: Revised w.e.f. July-2018
Reference	**Group A_1:** 8. Goon A.M., Gupta M. &Dasgupta B.(2001) : Fundamentals of Statistics (Vol. 1), World Press 9. Yule G.U. & Kendall M.G.(1950) : Introduction to the Theory of Statistics, Charles Griffin 10. Nagar A.L. & Das R.K. (1976): Basic Statistics 11. Bhattacharyya G. K. & Johnson R. A. (1977) : Concepts & Methods of Statistics, J.Wiley **Group A_2:** 1. Goon A.M., Gupta M. &Dasgupta B.(1997): An Outline of Statistics(Vol 1), World Press 2. Feller W.(1968) : An Introduction to Probability Theory & its

	Applications, John Wiley 3. Cacoullos T. (1973): Exercises in Probability, Narosa 4. Bhattacharyya G. K. & Johnson R. A. (1977) : Concepts & Methods of Statistics, J.Wiley 12. Freund J.E. (2001): Mathematical Statistics, Prentice Hall 13. Pitman J. (1993): Probability, Narosa 14. Stirzaker D. (1994): Elementary Probability, Cambridge University Press 8. Rathie and Mathai: Probability and Statistics	
Evaluation	CIA	20 marks
	End-Sem	Th 50 marks
		Pr 30 marks
Paper Structure *(A group of 25 marks)*	Short questions (5 marks each)	Long questions (10 marks each)
	1 out of 2	2 out of 4

Semester	**Three**
Name of the Course	***DescriptiveStatistics II, Probability II, Sampling Distributions & Statistical Inference***
Course Code	***HSTA1GE02L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *the salient features of metric data related to two variables and three variables.* • *analysis of categorical data.* • *different aspects of bivariate discrete and continuous probability distribution.* • *the application of different probability inequalities.*

	• *the notion of sampling distribution of a statistic* • *the importance of sampling distributions in statistical inference.* • *the idea of statistical inference.* • *the basics of estimation and testing of hypotheses.* • *the criteria of a good estimator* • *the basic principle underlying tests of significance with application to different distributions*
Syllabus	**Group A_1: Descriptive Statistics II (25 marks)** Association of attributes- 2X2 contingency table. Analysis of Bivariate Quantitative Data – Scatter Diagram, Product Moment Correlation Coefficient and its properties, Regression Analysis, Fitting of Linear and Polynomial equations by the principle of Least Squares, Correlation Index, Spearman's Rank Correlation Coefficient. (20L) Analysis of Multivariate Quantitative Data – Multiple Regression, Multiple Correlation and Partial Correlation in *three* variables, their measures and related results. (10L) **Group A_2: Probability II, Sampling Distributions & Statistical Inference (25 marks)** Joint Distribution of two random variables, Marginal and Conditional distributions, Covariance and Correlation, Simple Theorems including theorems on expectation and variance of a sum of random variables and expectation of product of random variables, Bivariate Normal distribution and statement of its general properties (6L) Concepts of Population and sample, Random Sampling and Sampling Distributions of Statistics, sampling distribution of sum of independent Binomial and Poisson variables, χ^2, t and F distributions (derivations excluded), sampling distribution of mean and variance of independent Normal variables. (7L) Point Estimation of a population parameter – concepts of Bias and Standard Error of an estimator, concepts of Unbiasedness, Minimum Variance, Consistency and Efficiency of an estimator, Method of Moments, Maximum Likelihood Method of estimation, Method of Least Squares, Point estimators of the parameters of Binomial, Poisson, and univariate Normal distributions. (6L) Statistical tests of Hypotheses and Interval Estimation – Null and Alternative hypotheses, Types of Errors, Critical Region, Level of Significance, Power and p-values, Exact tests of hypotheses under Normal set-up for a single mean, the equality of two means, a single variance and the equality of two variances. ANOVA in one way classified data (fixed effect model). Test of Significance of sample correlation coefficient (null case) and tests of hypotheses for the equality of means and equality of variances of a bivariate Normal distribution. Confidence Interval and Confidence Coefficient, Exact confidence interval under Normal set-up for a single mean, single variance, the

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GR B: Practicals based on Gr A_1 and Gr A_2 of HSTA1GE02L (30 marks)

GR C: Internal Assessment (20 marks)
NB: Revised w.e.f. July-2018</td></tr>
<tr><td>Reference</td><td>Group A_1:

1. Goon A.M., Gupta M. &Dasgupta B.(2001) : Fundamentals of Statistics (Vol. 1), World Press
2. Yule G.U. & Kendall M.G.(1950) : Introduction to the Theory of Statistics, Charles Griffin
3. Nagar A.L. & Das R.K. (1976): Basic Statistics
4. Bhattacharyya G. K. & Johnson R. A. (1977) : Concepts & Methods of Statistics, J.Wiley

Group A_2:

1. Goon A.M., Gupta M. &Dasgupta B.(1997): An Outline of Statistics(Vol 1), World Press
2. Feller W.(1968) : An Introduction to Probability Theory & its Applications, John Wiley
3. Cacoullos T. (1973): Exercises in Probability, Narosa
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<tr><td>Evaluation</td><td>CIA</td><td>20 marks</td></tr>
<tr><td></td><td>End-Sem</td><td>Th 50 marks</td></tr>
<tr><td></td><td></td><td>Pr 30 marks</td></tr>
<tr><td>Paper Structure
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(5 marks each)</td><td>Long questions
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Semester	**Four**
Name of the Course	***DescriptiveStatistics II, Probability II, Sampling Distributions & Statistical Inference***
Course Code	***HSTA1GE02L***
Theory/Composite	***Composite***
No. of Credits	***(Th 4 + Pr 2 = 6 Credits)***
Course description /objective	*At the end of this course a student should be able to understand* • *the salient features of metric data related to two variables and three variables.* • *analysis of categorical data.* • *different aspects of bivariate discrete and continuous probability distribution.* • *the application of different probability inequalities.*

	• *the notion of sampling distribution of a statistic* • *the importance of sampling distributions in statistical inference.* • *the idea of statistical inference.* • *the basics of estimation and testing of hypotheses.* • *the criteria of a good estimator* • *the basic principle underlying tests of significance with application to different distributions*
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