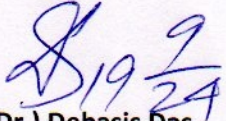# UNIVERSITY OF CALCUTTA

Notification No. CSR/76/2024

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 12.09.2024 approved the new revised syllabus (Semester- 1 to 4) including Question pattern of Statistics (4-year Honours & Honours with Research and Three-year MDC & Minor) under CCF, under this University, as laid down in the accompanying pamphlet.

The above shall take effect from Odd semester Examinations, 2024 and onwards.

SENATE HOUSE

Kolkata-700073

19.09.2024

Prof.(Dr.) Debasis Das

Registrar

UNIVERSITY OF CALCUTTA

Four-year B.Sc. (Honours & Honours with Research) Courses of Studies

in

STATISTICS

(Under Curriculum & Credit Framework, 2022)

Syllabus for Semesters I, II, III and IV

COURSE STRUCTURE-CCF, 2022

	DSCC/ Core (Major)	Minor (m1 & m2)	IDC	AEC	SEC	CVAC	Summer Internship	Dissertation/ Research work	Total Credit
Semester	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3=3	(1x4= 4)+ (1x8= 8) = 12	172
1	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
2	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
3	2x4= 8 2x(3TH+ 1P/TU)	1x4= 4 (m2) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4				21
4	4x4= 16 4x(3TH+ 1P/TU)	1x4= 4 (m2) 3TH+1P/TU		1x2= 2 2TH +0P/TU					22
5	4x4= 16 4x(3TH+ 1P/TU)	m1+m2 2x4= 8 2x(3TH+ 1P/TU)							24
6	3x4= 12 3x(3TH+ 1P/TU)	2x4= 8 m1+m2 2x(3TH+ 1P/TU)							20
7	4x4= 16 4x(3TH+1P/ TU)							1x4*	20
8	3x4= 12 3x(3TH+1P/ TU)							1x8 *	20
Credits	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8		(1x4)+(1X8)= 12	169+3= 172
Marks	22x100= 2200	8x100=800	3x75= 225	4x50= 200	3x100= 300	4x50 = 200		1x100+1x200= 300	Total Marks =4300

Marks= 25 marks per credit.

*Students who will not pursue Dissertation/ Research work then the candidate will have to study additional 1 DSC/Core paper o f 4 credits in the 7th Semester & 2 DSC/ Core Papers of 4 Credits each in the 8th Semester.

Minor courses will come from two subjects of same broad discipline as Major (m1, m2).

Total credit=169+3 (for summer internship) = 172

Structure of Statistics Major Courses

Semester	Course / Paper Code	Course Name
I	STAT-H-CC1-1-Th / P	Descriptive Statistics I & Probability I
	STAT-H-SEC1-1-Th / P	Numerical Computations with C
II	STAT-H-CC2-2-Th / P	Descriptive Statistics II & Probability II
	STAT-H-SEC2-2-Th / TU	Artificial Intelligence for Everyone
III	STAT-H-CC3-3-Th / TU	Real Analysis I
	STAT-H-CC4-3-Th / P	Statistical Inference I
	STAT-H-SEC3-3-P	Introduction to R
IV	STAT-H-CC5-4-Th / P	Linear Algebra
	STAT-H-CC6-4-Th / P	Probability III
	STAT-H-CC7-4-Th / P	Sampling Distributions and Statistical Inference II
	STAT-H-CC8-4-Th / P	Design of Experiments I and Sample Survey I
V	STAT-H-CC9-5-Th / P	Multivariate Analysis I
	STAT-H-CC10-5-Th / P	Statistical Inference III
	STAT-H-CC11-5-Th / P	Linear Models
	STAT-H-CC12-5-Th / P	Demography
VI	STAT-H-CC13-6-Th / P	Applied Multivariate Analysis
	STAT-H-CC14-6-Th / P	Index Numbers and Psychometry
	STAT-H-CC15-6-Th / P	Time Series Analysis
VII	STAT-H-CC16-7-Th / P	Real Analysis II
	STAT-H-CC17-7-Th / P	Statistical Inference IV
	STAT-H-CC18-7-Th / P	Design of Experiments II
	STAT-H-CC19-7-Th / P	Sample Survey II
	STAT-H-CC20-7-P OR STAT-H-CC20-D-7-P	Project Work OR Dissertation
VIII	STAT-H-CC21-8-Th / P	Multivariate Analysis II
	STAT-H-CC22-8-Th / P	Regression Analysis
	STAT-H-CC23-8-Th / P	Statistical Quality Control
	STAT-H-CC24A-8-Th / P OR STAT-H-CC24B-8-Th / P OR STAT-H-CC24-D-8-P	Operations Research OR Development Statistics OR Dissertation
	STAT-H-CC25A-8-Th / P OR STAT-H-CC25B-8-Th / P OR STAT-H-CC25-D-8-P	Statistical Computing with Python OR Reliability Theory OR Dissertation

Structure of Statistics Minor Courses

Semester	Course / Paper Code	Course Name
I	STAT-H-MC1-1-Th / P	Descriptive Statistics I & Probability I
II	STAT-H-MC2-2-Th / P	Descriptive Statistics II & Probability II
III	STAT-H-MC1-3-Th / P	Descriptive Statistics I & Probability I
IV	STAT-H-MC2-4-Th / P	Descriptive Statistics II & Probability II
V	STAT-H-MC3-5-Th / P	Statistical Inference I
VI	STAT-H-MC4-6-Th / P	Design of Experiments I and Sample Survey I

Structure of Statistics Interdisciplinary Course

Semester	Course / Paper Code	Course Name
I	STAT-H-IDC1-1-Th / P	
II	STAT-H-IDC2-2-Th / P	Statistics for Practitioners
III	STAT-H-IDC3-3-Th / P	

SEMESTER - I

STATISTICS MAJOR

STAT-H-CC1-1-Th   **3 Credits**

(Descriptive Statistics I & Probability I)   **THEORY**

Statistics: Definition and scope. Concepts of statistical population and sample.

Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous.

Scales of measurement: nominal, ordinal, interval and ratio.

Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.   (10)

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Ginis Coefficient, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Box Plot. Outliers.   (15)

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability: classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.   (20)

STAT-H-CC1-1-P   **1 Credit**

(Descriptive Statistics I & Probability I)   **PRACTICAL**

List of Suggested Practical

- Diagrammatic representation of data.
- Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation.
- Problems based on moments, skewness and kurtosis.
- Problems related to quantiles and measures based on them, construction of box plot.
- Application problems based on Classical Definition of Probability.
- Application problems based on Bayes' Theorem.

Back to Four-Year Structure

Reference Books:

➢ Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, World Press, Kolkata.

➢ Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.

➢ Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, Pearson Education, Asia.

➢ Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.

➢ Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.

➢ Freedman, D., Pisani, R. and Purves, R.: Statistics, W. W. Norton & Company.

➢ Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.

➢ Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.

➢ Parzen, E.: Modern Probability Theory and its Applications, John Wiley.

➢ Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.

➢ Cacoullos, T.: Exercises in Probability, Narosa.

➢ Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.

➢ Ross, S.: A First Course in Probability, Prentice Hall.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STAT-H-SEC1-1-Th   **2 Credits**

(Numerical Computations with C)   **THEORY**

Approximation of numbers and functions. Absolute and Relative errors.

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

Numerical Differentiation and its applications.

Numerical Integration: Trapezoidal and Simpson's 1/3rd rules.

Numerical solution of equations: method of fixed-point iteration and Newton-Raphson method in one unknown, conditions of convergence (statement only).   (15)

Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program.

Data types: Basic data types, enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, symbolic constants, overflow and underflow of data.

Operators and expressions: library functions.

Managing input and output operations: reading and printing formatted and unformatted data.

Decision making and branching: if...else, nesting of if...else, else if ladder, switch.

Looping in C/C++: for, nested for, while, do...while, and jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. User-defined functions.

                                                                    (15)

STAT-H-SEC1-1-P   **2 Credits**

(Numerical Computations with C)   **PRACTICAL**

List of Suggested Practical

- Finding values of a function $y = f(x)$ for given values of x.

- Roots of a quadratic equation (with imaginary roots also).

- Sorting of an array and hence finding median.

- Mean, median and mode of a grouped frequency Data.

- Variance and coefficient of variation of a grouped frequency data.

- Preparing a frequency table.

- Numerical methods: Interpolation by Lagrange's formula, Solving one-variable equations using Newton-Raphson and iteration methods.

- Trapezoidal and Simpson's 1/3rd rule for numerical integration with convergence.

- Storing the C output in a file.

Reference Books:

- Kernighan, B.W. and Ritchie, D.: C Programming Language, 2nd Edition, Prentice Hall.

- Balagurusamy, E.: Programming in ANSI C, 6th Edition, Tata McGraw Hill.

- Gottfried, B.S.: Schaums Outlines: Programming with C, 2nd Edition, Tata McGraw Hill.

- Jain, M. K., Iyengar, S. R. K. and Jain, R. K.: Numerical methods for scientific and engineering computation, New age International Publisher, India.

- Mukherjee, Kr. Kalyan: Numerical Analysis, New Central Book Agency.

- Sastry, S.S.: Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.

- Scarborough, J.B.: Numerical Mathematical Analysis, Oxford and IBH Publishing.

STATISTICS MINOR

STAT-H-MC1-1-Th   3 Credits
(Descriptive Statistics I & Probability I)   **THEORY**

Statistics: Definition and scope. Concepts of statistical population and sample.

Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous.

Scales of measurement: nominal, ordinal, interval and ratio.

Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.   (10)

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Ginis Coefficient, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Box Plot. Outliers.   (15)

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability: classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.   (20)

STAT-H-MC1-1-P   1 Credit
(Descriptive Statistics I & Probability I)   **PRACTICAL**

List of Suggested Practical

- Diagrammatic representation of data.
- Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation.
- Problems based on moments, skewness and kurtosis.
- Problems related to quantiles and measures based on them, construction of box plot.
- Application problems based on Classical Definition of Probability.
- Application problems based on Bayes' Theorem.

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- Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.
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- Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.
- Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.
- Freedman, D., Pisani, R. and Purves, R.: Statistics, W. W. Norton & Company.
- Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.
- Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.
- Parzen, E.: Modern Probability Theory and its Applications, John Wiley.
- Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.
- Cacoullos, T.: Exercises in Probability, Narosa.
- Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.
- Ross, S.: A First Course in Probability, Prentice Hall.
- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STATISTICS INTERDISCIPLINARY

STAT-H-IDC1-1-Th **2 Credits**
(Statistics for Practitioners) **THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis. (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae). (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data. (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data. (7)

STAT-H-IDC1-1-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.
- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearsons correlation coefficients, Spearman's Rank correlation, measures of association of attributes through contingency table.
- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.
- Applications of ANOVA and Kruskal-Wallis test.
- Sample size determination, estimation of population mean and variability for finite population.
- Fitting of logistic regression for binary response data.

Reference Books:

➢ Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.

➢ Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.

➢ Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.

➢ Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.

➢ Kutner, M.H. et.al.: Applied Linear Statistical Models.

➢ Belsley D.A. et.al.: Regression Diagnostics.

➢ Draper N.R. and Smith, H.: Applied Regression Analysis.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

➢ Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

SEMESTER - II

STATISTICS MAJOR

STAT-H-CC2-2-Th   **3 Credits**

(Descriptive Statistics II & Probability II)   **THEORY**

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation.

Rank correlation: Spearman's and Kendall's measures. (15)

Analysis of Categorical Data: Contingency table, independence & association of attributes. (5)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (without proof), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Variance.

Standard probability distributions: Discrete Uniform, Binomial, Poisson, and Normal. (25)

STAT-H-CC2-2-P   **1 Credit**

(Descriptive Statistics II & Probability II)   **PRACTICAL**

List of Suggested Practical

- Problems based on analysis of bivariate data.
- Problems based on measures of rank correlation.
- Problems based on analysis of categorical data.
- Finding expectation, variance from a given probability distribution.
- Fitting of binomial distributions for n and p = q = 1/2.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of mean.
- Fitting of Poisson distributions after computing mean.
- Application problems based on binomial distribution.
- Application problems based on Poisson distribution.
- Problems based on area property of normal distribution.
- To find the ordinate for a given area for normal distribution.

- Application based problems using normal distribution.

- Fitting of normal distribution when parameters are given.

- Fitting of normal distribution when parameters are not given.

Reference Books:

- Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, The World Press, Kolkata.

- Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.

- Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

- Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

- Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.

- Agresti, A.: Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

- Freedman, D., Pisani, R. and Purves, R.: Statistics, 4th Edition, W. W. Norton & Company.

- Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.

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- Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.

- Ross, S.: A First Course in Probability, Prentice Hall.

- Hogg, R.V., Tanis, E.A. and Rao J.M.: Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

- Myer, P.L.: Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

- Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STAT-H-SEC2-2-Th   **2 credits**

(Artificial Intelligence for Everyone)   **THEORY**

Unit 1: Introduction to Artificial Intelligence (6 Lectures)

- Definition and scope of AI

- Historical overview and key milestones

- Differentiating AI from human intelligence

Unit 2: AI Subfields and Technologies (6 Lectures)

- Machine learning: Supervised, unsupervised, and reinforcement learning

- Deep learning and neural networks

- Natural language processing (NLP) and computer vision

Unit 3: Applications of AI (8 Lectures)

- AI in healthcare: Diagnosis, treatment, and medical imaging

- AI in finance: Fraud detection, algorithmic trading, and risk assessment

- AI in transportation: Autonomous vehicles and traffic optimization

- AI in customer service and chatbots

- AI in education: Personalized learning and intelligent tutoring systems

Unit 4: Ethical and Social Implications of AI (5 Lectures)

- Bias and fairness in AI systems

- Privacy and data protection concerns

- Impact of AI on employment and the workforce

- AI and social inequality

Unit 5: Other Important Issues

- Ethical guidelines and responsible AI practices

- AI and Innovation

- Emerging trends and future directions in AI

- AI and creativity: Generative models and artistic applications

STAT-H-SEC2-2-TU   **2 credits**

(Artificial Intelligence for Everyone)   **TUTORIAL**

Term Paper In lieu of Tutorial paper: Students are required to submit a report which can be based on any topic as given below or as prescribed by the respective faculty/teachers.

Suggested problems for the reports (Term Paper) on Artificial intelligence (A.I.):

- A comparative study on Human Intelligence and Artificial Intelligence in Man-Made Machines.

- Chatbot Development for customer service support and integration of NLP for realistic/human type interactions.

- Development of a sentiment analysis tool that can classify and analyze the sentiment (positive, negative, neutral) in social media posts, reviews, or any text data.

- Use of AI in Image Recognition and Classification.

- Application of Linear regression and A.I/Machine learning on house price prediction- Estimating the selling price of a house based on its features, location, and market trends.

- Application of Linear regression and A.I/Machine learning on the data of Climate prediction.

- Application of Linear regression and A.I/Machine learning on the data of Bank related works.

- Application of Linear regression and A.I/Machine learning on Sales Forecasting: Predicting future sales based on historical sales data and trends.

- Application of Linear regression and A.I/Machine learning on Weather Forecasting, predicting future weather conditions by analyzing historical weather data.

- Application of Linear regression and A.I/Machine learning on Forecasting future energy usage based on past consumption patterns and environmental factors.

- Application of Linear regression and A.I/Machine learning on Risk Assessment: Predicting the likelihood of an event occurring, such as loan default or insurance claims, based on historical data and risk factors.

- Application of Linear regression and A.I/Machine learning on Health Outcome Prediction: Estimating patient outcomes or disease progression based on historical medical data and patient characteristics.

- Different types of Machine learning algorithms and its applications.

- Smart home automation solutions.

- Using AI in autonomous ground and Aerial vehicles.

- Application of AI in healthcare industry, Industrial automation, Smart farming and Internet of Things (IoT).

- Use of AI and its impact in future of education.

- Application of AI in Robotics and Computer Vision.

Note: *The topics listed here are merely examples. Students are encouraged to write a term paper in the form of a report on subjects not limited to these topics; additional suggestions can be provided by teachers, faculty members, or the department.*

Back to Four-Year Structure

STATISTICS MINOR

STAT-H-MC2-2-Th   **3 Credits**

(Descriptive Statistics II & Probability II)   **THEORY**

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation.

Rank correlation: Spearman's and Kendall's measures.   (15)

Analysis of Categorical Data: Contingency table, independence & association of attributes.   (5)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (without proof), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Variance.

Standard probability distributions: Discrete Uniform, Binomial, Poisson, and Normal.   (25)

STAT-H-MC2-2-P   **1 Credit**

(Descriptive Statistics II & Probability II)   **PRACTICAL**

List of Suggested Practical

- Problems based on analysis of bivariate data.
- Problems based on measures of rank correlation.
- Problems based on analysis of categorical data.
- Finding expectation, variance from a given probability distribution.
- Fitting of binomial distributions for n and $p = q = 1/2$.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of mean.
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- Fitting of normal distribution when parameters are not given.

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- Ross, S.: A First Course in Probability, Prentice Hall.
- Hogg, R.V., Tanis, E.A. and Rao J.M.: Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- Myer, P.L.: Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
- Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STATISTICS INTERDISCIPLINARY

STAT-H-IDC2-2-Th   **2 Credits**
(Statistics for Practitioners)   **THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis. (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae). (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data. (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data. (7)

STAT-H-IDC2-2-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.

- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearsons correlation coefficients, Spearman's Rank correlation, measures of association of attributes through contingency table.

- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.

- Applications of ANOVA and Kruskal-Wallis test.

- Sample size determination, estimation of population mean and variability for finite population.

- Fitting of logistic regression for binary response data.

Reference Books:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.

- Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.

- Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.

- Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.

- Kutner, M.H. et.al.: Applied Linear Statistical Models.

- Belsley D.A. et.al.: Regression Diagnostics.

- Draper N.R. and Smith, H.: Applied Regression Analysis.

- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

- Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

SEMESTER - III

STATISTICS MAJOR

STAT-H-CC3-3-Th   **3 Credits**

(Real Analysis I)   **THEORY**

Introduction to Real Numbers

Axiomatic definition of the real number system: Field Axioms, Order Axioms, Archimedean property: Intuition, bounded and unbounded sets, Supremum, Infimum, axiom of LUB. Rational and Irrational Numbers, Absolute value function. Intervals: Types of bounded, Unbounded Intervals. Neighbourhoods: ε-Neighbourhood, Open Neighbourhood.   (10)

Sequences and Series

Definition of sequences, limits and Convergence: Uniqueness of Limits, Algebra of Limits, Squeeze Theorem. Monotone sequences and Monotone Convergence Theorem (MCT). Subsequences: Properties, Cauchy sequences. Bolzano-Weierstrass theorem. Series of real numbers: Cauchy criterion, Convergence tests: Comparison Test, Ratio Test, Root Test, Alternating Series Test (Leibniz's Test) (statements). Absolute and conditional convergence.   (12)

Functions, Limits and Continuity

Bounded and unbounded functions, Monotone functions, Limits of functions, ε-δ definition, one-sided limits. Properties of limits: Uniqueness of Limits, Algebra of Limits: Sequential criterion, infinite limits, limits of +- infinity. Continuous functions: definition of continuity at a point (sequential characterization), continuity on a set, Algebraic Properties, Composition. Continuity on intervals, extreme value theorem. Intermediate value theorem.   (10)

Differentiation

Definition of the derivative; interpretations of the derivative. Criteria for extrema. Theorems involving differentiable functions: Rolle's Theorem, Lagrange's Mean Value Theorem (MVT), Cauchy's Mean Value Theorem, Higher order derivatives, Taylor's Theorem (Statement only).   (8)

Integration

Riemann integration: Definition, properties: Linearity, Additivity, Interval Reversal, Monotonicity, Integrability of monotone functions, continuous functions (without proof), Fundamental theorem of calculus. Improper integrals.   (5)

STAT-H-CC3-3-TU   **1 Credit**

(Real Analysis I)   **TUTORIAL**

Reference Books

➢ Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.

➢ Somasundram, D. And Chaudhary, B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.

➢ Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi.

➢ Apostol, T.M: Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.

➢ Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.

➢ Singal, M.K. and Singal A.R: A First Course in Real Analysis, 24th Edition, R. Chand& Co., New Delhi.

➢ Bartle, R. G. and Sherbert, D. R.: Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.

➢ Ghorpade, Sudhir R. and Limaye, Balmohan V.: A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

➢ Chakraborty, Arnab: Real Analysis, volumes 1,2,3, second edition. Sarat Book House.

➢ Walter Rudin: Principles of Mathematical Analysis

➢ Stephen Abbott: Understanding Analysis

➢ Robert G. Bartle and Donald R. Sherbert: Introduction to Real Analysis

                                                      Back to Four-Year Structure

STAT-H-CC4-3-Th / STAT-H-MC3-5-Th   3 Credits
(Statistical Inference I)   **THEORY**

Basic concepts of Statistical Inference: population & sample, parameter & statistic, population distribution and sampling distribution. Point estimation, interval estimation and testing of hypothesis. Three useful distributions for statistical Inference: χ^2, t and F (derivations excluded).   (5)

Point Estimation: Concepts of estimation, requirements of a good estimator, notions of mean square error, unbiasedness, bias-variance trade off, best linear unbiasedness and minimum variance unbiasedness. Properties of uniformly minimum variance unbiased estimators (UMVUE). Comparison of Estimators, Efficiency. Methods of Estimation: Method of moments, method of maximum likelihood estimation and statements of their small sample properties. Point estimators of the parameters of Binomial, Poisson, and univariate Normal distributions.   (15)

Elements of hypothesis testing: Null and alternative hypotheses, simple & composite hypotheses, critical region, type I and type II errors, level of significance, size, power, p-value. Exact tests and confidence intervals: classical and p-value approaches. Tests relating to Binomial and Poisson distributions, Fisher's exact test. Chi-square tests for association, homogeneity and goodness of fit. Tests of hypotheses for the parameters of normal distribution (one sample and two sample problems), paired t-test. Combination of probabilities in tests of significance.   (20)

Interval Estimation: Confidence Interval and Confidence Coefficient, Exact confidence interval for mean(s) and variance(s) for one and two sample problems under the Normal set-up.   (5)

STAT-H-CC4-3-P / STAT-H-MC3-5-P   1 Credit
(Statistical Inference I)   **PRACTICAL**

List of Suggested Practical

- Maximum Likelihood Estimation.
- Estimation by the method of moments.
- Test of significance for single proportion and difference of two proportions.
- Test of significance for single Poisson mean and difference of two Poisson means.
- Chi square tests for association, homogeneity and goodness of fit.
- Test of significance and confidence intervals for single mean and difference of two means.
- Test of significance and confidence intervals for single variance and ratio of two variances.

Reference Books

- Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. 1. The World Press, Kolkata.
- Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory, Vol-1. World Press.
- Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint). John Wiley and Sons.
- Hogg, R.V., Tanis, E.A. and Zimmerman, D. L.: Probability and Statistical Inference. Pearson Education.
- Johnson, R.A. and Bhattacharya, G.K.: Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
- Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata McGraw-Hill.
- Hogg, R.V., McKean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics, 8th Edition. Pearson.
- Gupta, S.C. and Kapoor, V.K. (2020): Fundamentals of Mathematical Statistics. Sultan Chand and Sons.
- Ramachandran, K.M. and Tsokos, C.P.: Mathematical Statistics with Applications. Academic Press.
- Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STAT-H-SEC3-3-P   **4 Credits**

(Introduction to R)   **PRACTICAL**

Introduction to R:

Overview of R: History and Applications. Installation and Setup (R and RStudio). Basic R Syntax and Commands: Comments, Assignment, Printing Output, installing a Package, Loading a Package. R as a Calculator: Addition, Subtraction, Multiplication, Division, Exponentiation, Modulus (Remainder), Integer Division, Order of Operations (PEMDAS/BODMAS).

Data Types and Structures:

Basic Data Types (Numeric, Integer, Character, Logical). Vectors, Matrices, Arrays: Creation, Operations, Indexing. Lists and Data Frames: Structure, creating a list, Accessing Elements, adding an element, removing an element, creating a data frame, accessing columns, accessing rows, accessing specific elements, adding a new column, removing a column, Adding a new row. Factors and Categorical Data: Creating a factor, checking levels, converting a vector to a factor, creating an ordered factor, converting factor to numeric, Converting factor to character, Data frame with a factor variable.

Data Import and Export:

Reading Data from Files (CSV, Excel, etc.): Basic usage, Example with options, reading an Excel file Using "readxl", "openxlsx" packages, Example with options, Reading TXT Files, Reading Data from R's Built-in Datasets. Writing Data to Files: Writing the data frame to a CSV file, Writing the data frame to an Excel file Using "writexl", "openxlsx" packages, Writing the text vector to a file. Checking for missing values in a vector, removing rows with missing values, removing columns with missing values, Mean/Median/Mode Imputation, Handling "NA"s in common functions.

Basic Data Manipulation:

Subsetting Data: Extracting a specific column of a Data Frame, Extracting multiple columns of a Data Frame, Extracting specific rows and columns of a Data Frame, Extracting specific rows only of a Data Frame, Extracting rows of a Data Frame that meet a condition, Combine multiple conditions, Extracting specific elements of a Vector, Extracting elements of a Vector that meet a condition, Finding indices where the condition is true Using the "which()" Function. Sorting and Ordering Data: Sorting Vectors in Ascending Order, Descending Order, ordering a data frame by one or more columns use the "order()" function, Using "dplyr" package for Sorting. Merging and Joining Data Frames: Using "merge()" Function, Using "dplyr", "data.table" Packages.

Data Visualization:

Base R Graphics (Histograms, Boxplots, Scatterplots): Creating histograms, Boxplots, Scatterplots. Introduction to ggplot. Customizing Plots (Titles, Labels, Legends): Basic Plot Customization like adding X-axis label, Y-axis label, Colour of points, Type of point, Adding Legends. Creating Multi-panel Plots: Using "par()" function for Base R Graphics.

Programming Basics:

Functions and Loops (for, while): basic syntax for defining a function, calling the function, For Loop, While Loop, using loops inside functions or vice versa. Conditional Statements (if, else): "if" Statement, "if-else" Statement, chaining multiple conditions using "if-else if-else" Statement, Nested "if" Statements, applying conditions to each element of a vector using "ifelse". Simulation in the context of Loop, Acceptance-Rejection method, illustration of repeated sampling and large sample properties through simulation. Numerical integration, Numerical solution of equations.

Statistical Analysis with R:

Descriptive Statistics: Mean, Median, Standard Deviation, Variance, Summary Statistics, Quantiles, Range, Interquartile Range. Probability Distributions and Random Number Generation: Density, Cumulative Distribution Function, Quantile Function, Random Generation from Normal Distribution, Binomial Distribution, Poisson Distribution, Exponential Distribution, and Uniform Distribution, Setting Seed for Reproducibility. Hypothesis Testing (t-tests, Chi-square tests): One-sample t-test, Two-sample t-test (independent), Paired t-test, Chi-square test for independence between two categorical variables. Correlation and Regression Analysis: Pearson Correlation, Spearman Correlation, Simple Linear Regression, Plotting the data and regression line, Multiple Linear Regression. ANOVA (Analysis of Variance): Conducting one-way ANOVA, Viewing ANOVA table, conducting two-way ANOVA with interaction, Viewing ANOVA table.

Advanced Data Manipulation:

Applying Functions to Data (apply, lapply, sapply).

Reference Books

- Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications
- Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York
- A simple introduction to R by Arnab Chakraborty

  (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis

  (freely available at https://cran.rproject.org/doc/contrib/Paradisrdebuts_en.pdf)
- Michael J. Crawley (2012): The R Book, Wiley
- Garrett Grolemund (2014): Hands-On Programming with R, O'Reilly Media

STATISTICS MINOR

STAT-H-MC1-3-Th   **3 Credits**
(Descriptive Statistics I & Probability I)   **THEORY**

Statistics: Definition and scope. Concepts of statistical population and sample.

Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous.

Scales of measurement: nominal, ordinal, interval and ratio.

Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.   (10)

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Ginis Coefficient, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Box Plot. Outliers.   (15)

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability: classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.   (20)

STAT-H-MC1-3-P   **1 Credit**
(Descriptive Statistics I & Probability I)   **PRACTICAL**

List of Suggested Practical

- Diagrammatic representation of data.
- Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation.
- Problems based on moments, skewness and kurtosis.
- Problems related to quantiles and measures based on them, construction of box plot.
- Application problems based on Classical Definition of Probability.
- Application problems based on Bayes' Theorem.

Reference Books:

➢ Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, World Press, Kolkata.

➢ Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.

➢ Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, Pearson Education, Asia.

➢ Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.

➢ Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.

➢ Freedman, D., Pisani, R. and Purves, R.: Statistics, W. W. Norton & Company.

➢ Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.

➢ Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.

➢ Parzen, E.: Modern Probability Theory and its Applications, John Wiley.

➢ Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.

➢ Cacoullos, T.: Exercises in Probability, Narosa.

➢ Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.

➢ Ross, S.: A First Course in Probability, Prentice Hall.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STATISTICS INTERDISCIPLINARY

STAT-H-IDC3-3-Th   **2 Credits**

(Statistics for Practitioners)   **THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis.   (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae).   (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data.   (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data.   (7)

STAT-H-IDC3-3-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.
- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearsons correlation coefficients, Spearman's Rank correlation, measures of association of attributes through contingency table.
- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.
- Applications of ANOVA and Kruskal-Wallis test.
- Sample size determination, estimation of population mean and variability for finite population.
- Fitting of logistic regression for binary response data.

Reference Books:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.
- Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.
- Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.
- Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.
- Kutner, M.H. et.al.: Applied Linear Statistical Models.
- Belsley D.A. et.al.: Regression Diagnostics.
- Draper N.R. and Smith, H.: Applied Regression Analysis.
- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.
- Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

SEMESTER - IV

STATISTICS MAJOR

Vector Algebra:

Vectors as points in Euclidean spaces; subspaces of R^n; linear combinations and span; generators of subspaces; linear dependence and independence (of finite sets of vectors); intersections, sums and direct sums of subspaces; complements and projections; basis, characterizations of bases, extensions of linearly independent sets to bases; dimension, connection between dimensions of a pair of subspaces and those of their sum and intersection; (Euclidean) norm and inner product; triangle inequality and Cauchy-Schwarz inequality, orthogonality and orthonormality, Gram-Schmidt process, orthocomplements and orthogonal projections. (20)

Matrix Algebra:

Linear transformations and matrices (w.r.t. standard bases), examples, properties, transposes, compositions, elementary operations, diagonal, triangular, symmetric and skew-symmetric matrices, Echelon matrix, Kronecker product, range and rank, null space and nullity, rank-nullity theorem, ranks of products and sums, row and column spaces, invertibility, operations with partitioned matrices, orthogonal matrices, construction of non-singular and orthogonal matrices with given rows/columns. (12)

Trace and determinant of square matrices, properties, computations. (4)

Systems of simultaneous linear equations: consistency, solution spaces of homogeneous and non-homogeneous systems, existence and uniqueness of solutions, methods of solution. (4)

Eigenvalues and eigenvectors of square matrices, multiplicities, properties, characteristic polynomial, similarity, spectral decomposition of symmetric matrices. Quadratic forms, connections with eigenvalues, idempotent matrices. Cayley-Hamilton Theorem (Statement only) (5)

STAT-H-CC5-4-P   **1 Credit**

(Linear Algebra)   **PRACTICAL**

List of Suggested Practical

- Problems related to vectors and vector spaces – linear dependence and independence, spanning set and bases, orthogonality, projections.
- Problems on matrix operations and reductions.
- Problems on linear transformations.
- Problems on determinants and inverses.
- Problems on rank of matrices.
- Problems on solutions to system of linear equations.
- Problems on quadratic forms.
- Problems on eigen values and eigen vectors.

Reference Books

- Lay David C.: Linear Algebra and its Applications, Addison Wesley.
- Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition.
- Krishnamurthy, V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
- Biswas, S.: A Textbook of Matrix Algebra, New Age International.
- Gupta, S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons.
- Artin, M: Algebra. Prentice Hall of India.
- Datta, K.B: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
- Hadley, G: Linear Algebra. Narosa Publishing House (Reprint).
- Searle, S.R.: Matrix Algebra Useful for Statistics. John Wiley &Sons.
- Chakraborty, Arnab: Linear Algebra, First Edition. Sarat Book House.
- Goon A.M.: Vectors and Matrices, World Press
- Das Roy, A. and Roy, D.: Linear Algebra with Application to Statistics, World Press

STAT-H-CC6-4-Th   **3 Credits**

(Probability III)   **THEORY**

Moments, Quantiles, Skewness and Kurtosis (including discussions of these measures for Binomial, Poisson and Univariate Normal Distributions). Probability inequalities (Markov's and Chebyshev's). Generating functions – probability generating function and moment generating function. Characteristic function (definition only). (10)

Discrete probability distributions: Uniform, Geometric, negative binomial, hypergeometric. Limiting/approximation cases. Truncated distributions. (5)

Continuous probability distributions: uniform, exponential, Cauchy, beta, gamma, lognormal, logistic, double exponential, Pareto and Weibull distributions along with their properties. Truncated distributions. (15)

Two dimensional random variables: joint, marginal and conditional distributions, properties of c.d.f., independence of variables, Theorems on sum and product of expectations of random variables, Conditional Expectation, Correlation and Regression. (10)

Trinomial distribution and its properties. Bivariate Normal Distribution and its properties. (5)

STAT-H-CC6-4-P   **1 Credit**

(PROBABILITY III)   **PRACTICAL**

List of Suggested Practical

- Fitting of negative binomial distribution.
- Application problems based on geometric, negative binomial and hypergeometric distributions.
- Fitting of continuous distributions.
- Application Problems based on continuous distributions.
- Application based Problems on trinomial distributions.
- Application based Problems on bivariate normal distributions.

Reference Books

- Hoel, P.G., Port, S.C. and Stone, C.J.: Introduction to Probability Theory. Houghton Mifflin Company.
- Hogg, R.V., McKean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics, 8th Edition. Pearson.
- Mood A.M, Graybill F.A. and Boes D.C: Introduction to the Theory of Statistics, McGraw Hill.
- Dasgupta, A.: Fundamentals of Probability – A First Course. Springer.
- Goon A.M., Gupta M.K. and Das Gupta. B.: Outline of Statistics, Vol. 1, World Press, Calcutta.
- Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. 1. The World Press, Kolkata.
- Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint). John Wiley and Sons.
- Casella, G. and Berger R.L.: Statistical Inference, 2nd Edition. Thomson Learning.
- Pitman, J.: Probability. Springer.
- Mukhopadhyay, P.: Mathematical Statistics. Books and Allied Publishers, Kolkata.
- Mukhopadhyay, N.: Probability and Statistical Inference. Marcel Dekker, New York.
- Chandra, T.K. and Chatterjee, D.: A First Course in Probability. Alpha Science.
- Cacoullos, T.: Exercises in Probability. Springer Verlag.
- Johnson, N.L., Kotz, S. and Balakrishnan, N.: Continuous Univariate Distributions, Volume 1 and 2. John Wiley and Sons.
- Johnson, N.L., Kemp, A.W. and Kotz, S.: Univariate Discrete Distributions. John Wiley and Sons.
- Ross, S.: A First Course in Probability. Pearson Education.

STAT-H-CC7-4-Th   **3 Credits**

(Sampling Distributions and Statistical Inference II)   **THEORY**

Concepts of random sampling. Sampling distribution of a statistic and its standard error. Distributions of statistics – illustrations using different distributions, reproductive properties of the distributions. *Order Statistics*: Introduction, distribution of the *r*-th order statistic, smallest and largest order statistics. Joint distribution of order statistics, distribution of sample median. (10)

Derivation of some standard sampling distributions: χ^2, t and F, sample mean and variance of a random sample from a univariate normal population, distributions of sample means, sample variances and sample correlation coefficient (null case) of a random sample from a bivariate normal population, distribution of the simple regression coefficient (for non-stochastic independent variable). (10)

Point Estimation: Sufficiency, factorization theorem (proof for discrete case only). Fisher's information (for single parameter only). Cramer-Rao inequality and minimum variance bound (MVB) estimators, Rao-Blackwell theorem and its applications. (10)

Theory of hypothesis testing: Test function, randomized and non-randomized tests, most powerful (MP) test, uniformly most powerful (UMP) test, Neyman - Pearson Lemma (statement and proof of sufficiency part only) and its applications to construct MP and UMP tests, uniformly most powerful unbiased (UMPU) tests (definition only).
Likelihood ratio test, properties of likelihood ratio test (without proof). (10)

Interval Estimation: Confidence intervals, Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses. (5)

STAT-H-CC7-4-P **1 Credit**

(Sampling Distributions and Statistical Inference II) **PRACTICAL**

List of Suggested Practical

- Most powerful critical region.

- Uniformly most powerful critical region.

- Unbiased critical region.

- Power curves.

- Confidence intervals and UMA confidence sets.

- Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis.

- Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis.

Reference Books:

➢ Goon A.M., Gupta M.K.: Das Gupta. B.: An Outline of Statistical Theory, Vol. I & II, World Press, Calcutta.

➢ Rohatgi V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

➢ Miller, I. and Miller, M.: John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.

➢ Mood A.M, Graybill F.A. and Boes D.C: Introduction to the Theory of Statistics, McGraw Hill.

➢ Casella, G. and Berger R.L.: Statistical Inference, 2nd Edn. Thomson Learning.

➢ Bhattacharya, P. K. and Burman, P.: Theory and Methods of Statistics. Academic Press.

➢ Mukhopadhyay, N.: Probability and Statistical Inference. Marcel Dekker, New York.

➢ Kale, B. K.: A First Course on Parametric Inference. Narosa Publishing House.

➢ Lehmann, E. L. and Romano, J. P.: Testing Statistical Hypothesis, 3rd Edition. Springer.

➢ Hogg, R.V., McKean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics, 8th Edition. Pearson.

➢ Mukhopadhyay, P.: Mathematical Statistics. Books and Allied Publishers, Kolkata.

➢ Rajagopalan, M. and Dhanavanthan, P.: Statistical Inference. Prentice Hall India.

➢ Srivastava, M.K. and Srivastava, N.: Statistical Inference: Testing of Hypotheses. Prentice Hall India.

STAT-H-CC8-4-Th / STAT-H-MC4-6-Th   **3 Credits**
(Design of Experiments I and Sample Survey I)   **THEORY**

Design of Experiments I:

Analysis of Variance: Factors, types and effects; Fixed, random and mixed effects models; Analysis of one-way and two-way classified data with equal number of observations in each cell (Fixed Effects Models only).   (10)

Experimental designs: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher).   (2)

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model, Applications of the techniques of ANOVA to the analysis of the above designs. Missing plot techniques in RBD and LSD. Uniformity trial experiments and comparison of designs.   (10)

Sample Survey I:

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, random numbers, procedure of selecting a sample, estimates of population mean, total and proportion, standard errors of these estimates, estimates of their standard errors.   (15)

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS.   (4)

Two-stage sampling (with primary units of equal size and equal selection probability at each stage): unbiased estimation of population mean and total. Ideas of snowball sampling, purposive sampling.
                                                                                     (4)

STAT-H-CC8-4-P / STAT-H-MC4-6-P   **1 Credit**

(Design of Experiments I and Sample Survey I)   **PRACTICAL**

List of Suggested Practical

- Analysis of Variance of a one-way classified data (fixed effects model).
- Analysis of Variance of a two-way classified data with one observation per cell (fixed effects model).
- Analysis of Variance of a two-way classified data with more than one observation per cell (fixed effects model).
- Analysis of a CRD.
- Analysis of an RBD.
- Analysis of an LSD.
- Analysis of an RBD with one missing observation.
- Analysis of an LSD with one missing observation.
- To select a simple random sample with and without replacement.
- Simple random sampling – estimation of population mean, total and proportion; estimation of related standard error.
- Estimate the sample size for SRSWOR.
- Stratified Sampling –estimation of population mean and total, allocation of sample to strata by proportional and Neyman's methods, Comparison of the efficiencies of the above two methods relative to SRS.
- Estimation of gain in precision in stratified sampling.
- Two-stage Sampling – estimation of population mean and total.

Reference Books:

- Renchner, A. C. And Schaalje, G. B.: Linear Models in Statistics (Second edition), John Wiley and Sons.
- Scheffe, H.: The Analysis of Variance, John Wiley.
- Cochran, W.G. and Cox, G.M.: Experimental Design. Asia Publishing House.
- Das, M.N. and Giri, N.C.: Design and Analysis of Experiments. Wiley Eastern Ltd.
- Kempthorne, O.: The Design and Analysis of Experiments. John Wiley.
- Montgomery, D. C.: Design and Analysis of Experiments, John Wiley.

➢ Wu, C. F. J. And Hamada, M.: Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.

➢ Dean, A.M. and Voss, D.: Design and Analysis of Experiments. Springer Texts in Statistics.

➢ Goon, A.M., Gupta, M.K., Das Gupta, B.: An Outline of Statistical Theory, Vol-II, World Press, Calcutta.

➢ Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics, Vol-II, World Press.

➢ Cochran, W.G.: Sampling Techniques (3rd Ed.), Wiley Eastern.

➢ Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C.: Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics.

➢ Murthy, M.N.: Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.

➢ Des Raj and Chandhok P.: Sample Survey Theory, Narosa Publishing House.

STATISTICS MINOR

STAT-H-MC2-4-Th   **3 Credits**

(Descriptive Statistics II & Probability II)   **THEORY**

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation.

Rank correlation: Spearman's and Kendall's measures.   (15)

Analysis of Categorical Data: Contingency table, independence & association of attributes.   (5)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (without proof), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Variance.

Standard probability distributions: Discrete Uniform, Binomial, Poisson, and Normal.   (25)

STAT-H-MC2-4-P   **1 Credit**

(Descriptive Statistics II & Probability II)   **PRACTICAL**

List of Suggested Practical

- Problems based on analysis of bivariate data.
- Problems based on measures of rank correlation.
- Problems based on analysis of categorical data.
- Finding expectation, variance from a given probability distribution.
- Fitting of binomial distributions for n and $p = q = 1/2$.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of mean.
- Fitting of Poisson distributions after computing mean.
- Application problems based on binomial distribution.
- Application problems based on Poisson distribution.
- Problems based on area property of normal distribution.
- To find the ordinate for a given area for normal distribution.
- Application based problems using normal distribution.
- Fitting of normal distribution when parameters are given.
- Fitting of normal distribution when parameters are not given.

Reference Books:

➢ Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, The World Press, Kolkata.

➢ Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.

➢ Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

➢ Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

➢ Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.

➢ Agresti, A.: Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

➢ Freedman, D., Pisani, R. and Purves, R.: Statistics, 4th Edition, W. W. Norton & Company.

➢ Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.

➢ Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.

➢ Parzen, E.: Modern Probability Theory and its Applications, John Wiley.

➢ Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.

➢ Cacoullos, T.: Exercises in Probability, Narosa.

➢ Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.

➢ Ross, S.: A First Course in Probability, Prentice Hall.

➢ Hogg, R.V., Tanis, E.A. and Rao J.M.: Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

➢ Myer, P.L.: Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

➢ Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

UNIVERSITY OF CALCUTTA

Three-year B.Sc. Multidisciplinary Courses of Studies

in

STATISTICS

(Under Curriculum & Credit Framework, 2022)

Syllabus for Semesters I, II, III and IV

COURSE STRUCTURE-MDC

	CC1	CC2	Minor	IDC	AEC	SEC	CVAC	Summer Internship	Total Credit
Semester	8x4= 32	8x4= 32	6x4= 24	3x3=9	4x2= 8	3x4=12	4x2=8	1x3= 3	128
1	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
2	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
3	1x4= 4 (3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+1P/ TU	1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4			21
4	2x4=8 4x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU	1x4= 4 (3TH+1P/ TU)		1x2= 2 2TH +0P/TU				22
5	2x4= 8 2x(3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	2x4= 8 2x(3TH+ 1P/TU						20
6	1x4= 4 (3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)						20
Credits	8x4= 32	8x4= 32	6x4= 24	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3= 3	128
Marks	8x100= 800	8x100= 800	6x100= 600	3x75= 225	4x50= 200	3x100= 300	4x50= 200	3x25= 75	Total Marks =3200

Marks= 25 marks per credit.

Total credit=125+3 (for summer internship) = 128
Summer Internship: As mentioned in clause no. 8 (G)

Structure of Core Courses in Statistics for MDC

Semester	Course / Paper Code	Course Name
I	STAT-MD-CC1-1-Th / P	Descriptive Statistics I & Probability I
II	STAT-MD-CC2-2-Th / P	Descriptive Statistics II & Probability II
III	STAT-MD-CC3-3-Th / P	Statistical Inference I
IV	STAT-MD-CC4-4-Th / P	Design of Experiments I and Sample Survey I
IV	STAT-MD-CC5-4-Th / P	Descriptive Statistics III & Probability III
V	STAT-MD-CC6-5-P	Project Work
V OR VI	STAT-MD-CC7-5-Th / P OR STAT-MD-CC7-6-Th / P	Applications of Statistics I
VI	STAT-MD-CC8-6-Th / P	Applications of Statistics II

Structure of Minor Courses in Statistics for MDC

Semester	Course / Paper Code	Course Name
III	STAT-MD-MC1-3-Th / P	Descriptive Statistics I & Probability I
IV	STAT-MD-MC2-4-Th / P	Descriptive Statistics II & Probability II
V	STAT-MD-MC3-5-Th / P	Statistical Inference I
V	STAT-MD-MC4-5-P	Project Work
VI	STAT-MD-MC5-6-Th / P	Design of Experiments I and Sample Survey I
VI	STAT-MD-MC6-6-Th / P	Descriptive Statistics III & Probability III

Structure of Skill Enhancement Courses in Statistics for MDC

Semester	Course / Paper Code	Course Name
I	STAT-MD-SEC1-1-Th / TU	
II	STAT-MD-SEC2-2-Th / TU	An Introduction to R
III	STAT-MD-SEC3-3-Th / TU	

Structure of Interdisciplinary Courses in Statistics for MDC

Semester	Course / Paper Code	Course Name
I	STAT-MD-IDC1-1-Th / P	
II	STAT-MD-IDC2-2-Th / P	Statistics for Practitioners
III	STAT-MD-IDC3-3-Th / P	

SEMESTER - I

STATISTICS MAJOR

STAT-MD-CC1-1-Th   **3 Credits**

(Descriptive Statistics I & Probability I)   **THEORY**

Statistics: Definition and scope. Concepts of statistical population and sample.

Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous.

Scales of measurement: nominal, ordinal, interval and ratio.

Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.   (10)

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Ginis Coefficient, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Box Plot. Outliers.   (15)

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability: classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.   (20)

STAT-MD-CC1-1-P   **1 Credit**

(Descriptive Statistics I & Probability I)   **PRACTICAL**

List of Suggested Practical

- Diagrammatic representation of data.
- Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation.
- Problems based on moments, skewness and kurtosis.
- Problems related to quantiles and measures based on them, construction of box plot.
- Application problems based on Classical Definition of Probability.
- Application problems based on Bayes' Theorem.

Reference Books:

- Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, World Press, Kolkata.
- Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.
- Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, Pearson Education, Asia.
- Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.
- Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.
- Freedman, D., Pisani, R. and Purves, R.: Statistics, W. W. Norton & Company.
- Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.
- Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.
- Parzen, E.: Modern Probability Theory and its Applications, John Wiley.
- Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.
- Cacoullos, T.: Exercises in Probability, Narosa.
- Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.
- Ross, S.: A First Course in Probability, Prentice Hall.
- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.
- Gupta, S.C., Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons

STAT-MD-SEC1-1-Th   3 Credits
(An Introduction to R)   **THEORY**

Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open source philosophy.

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.   (10)

The different types of numbers in R: Division by zero leading to Infor -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. Barplot, Pie chart and Histogram. Box plot.   (15)

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.   (8)

Numerical Integration in R: Trapezoidal and Simpson's 1/3rd rules.

Numerical solution of equations in R: Method of fixed-point iteration and Newton-Raphson method in one unknown.

Simulation in R: Simulating a coin toss, a die roll and a card shuffle. Finding probabilities of events related to such experiments using simulation.   (12)

STAT-MD-SEC1-1-TU   1 Credit
(An Introduction to R)   **TUTORIAL**

Reference Books:

- Gardener, M.: Beginning R - The Statistical Programming Language, Wiley Publications.
- Braun W J, Murdoch D J: A First Course in Statistical Programming with R. Cambridge University Press. New York.
- A simple introduction to R by Arnab Chakraborty

  (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis

  (freely available at https://cran.r-project.org/doc/contrib/Paradisrdebuts_en.pdf)

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STATISTICS INTERDISCIPLINARY

</div>

STAT-MD-IDC1-1-Th　　　　　　　　　　　　　　　　**2 Credits**
(Statistics for Practitioners)　　　　　　　　　　　　　　　**THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis. (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae). (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data. (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data. (7)

　　　　　　　　　　　　　　　　Back to Three-Year Structure

STAT-MD-IDC1-1-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.

- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearson's correlation coefficient, Spearman's Rank correlation, measures of association of attributes through contingency table.

- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.

- Applications of ANOVA and Kruskal-Wallis test.

- Sample size determination, estimation of population mean and variability for finite population.

- Fitting of logistic regression for binary response data.

Reference Books:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.

- Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.

- Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.

- Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.

- Kutner, M.H. et.al.: Applied Linear Statistical Models.

- Belsley D.A. et.al.: Regression Diagnostics.

- Draper N.R. and Smith, H.: Applied Regression Analysis.

- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

- Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STAT-MD-CC2-2-Th   **3 Credits**

(Descriptive Statistics II & Probability II)   **THEORY**

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation.

Rank correlation: Spearman's and Kendall's measures.   (15)

Analysis of Categorical Data: Contingency table, independence & association of attributes.   (5)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (without proof), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Variance. Standard probability distributions: Discrete Uniform, Binomial, Poisson, and Normal.   (25)

STAT-MD-CC2-2-P   **1 Credit**

(Descriptive Statistics II & Probability II)   **PRACTICAL**

List of Suggested Practical

- Problems based on analysis of bivariate data.
- Problems based on measures of rank correlation.
- Problems based on analysis of categorical data.
- Finding expectation, variance from a given probability distribution.
- Fitting of binomial distributions for n and p = q = 1/2.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of mean.
- Fitting of Poisson distributions after computing mean.
- Application problems based on binomial distribution.
- Application problems based on Poisson distribution.
- Problems based on area property of normal distribution.
- To find the ordinate for a given area for normal distribution.

- Application based problems using normal distribution.
- Fitting of normal distribution when parameters are given.
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STAT-MD-SEC2-2-Th   3 Credits
(An Introduction to R)   THEORY

Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open source philosophy.

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.   (10)

The different types of numbers in R: Division by zero leading to Infor -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. Barplot, Pie chart and Histogram. Box plot.   (15)

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.   (8)

Numerical Integration in R: Trapezoidal and Simpson's 1/3rd rules.

Numerical solution of equations in R: Method of fixed-point iteration and Newton-Raphson method in one unknown.

Simulation in R: Simulating a coin toss, a die roll and a card shuffle. Finding probabilities of events related to such experiments using simulation.   (12)

STAT-MD-SEC2-2-TU   1 Credit
(An Introduction to R)   TUTORIAL

<u>*Reference Books:*</u>

- Gardener, M.: Beginning R - The Statistical Programming Language, Wiley Publications.
- Braun W J, Murdoch D J: A First Course in Statistical Programming with R. Cambridge University Press. New York.
- A simple introduction to R by Arnab Chakraborty
  (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis
  (freely available at https://cran.r-project.org/doc/contrib/Paradisrdebuts_en.pdf)

STATISTICS INTERDISCIPLINARY

STAT-MD-IDC2-2-Th   **2 Credits**
(Statistics for Practitioners)   **THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis.   (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae).   (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data.   (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data.   (7)

STAT-MD-IDC2-2-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.

- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearson's correlation coefficient, Spearman's Rank correlation, measures of association of attributes through contingency table.

- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.

- Applications of ANOVA and Kruskal-Wallis test.

- Sample size determination, estimation of population mean and variability for finite population.

- Fitting of logistic regression for binary response data.

Reference Books:

➢ Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.

➢ Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.

➢ Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.

➢ Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.

➢ Kutner, M.H. et.al.: Applied Linear Statistical Models.

➢ Belsley D.A. et.al.: Regression Diagnostics.

➢ Draper N.R. and Smith, H.: Applied Regression Analysis.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

➢ Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

SEMESTER - III

STATISTICS MAJOR

STAT-MD-CC3-3-Th   **3 Credits**
(Statistical Inference I)   **THEORY**

Basic concepts of Statistical Inference: population & sample, parameter & statistic, population distribution and sampling distribution. Point estimation, interval estimation and testing of hypothesis. Three useful distributions for statistical Inference: χ^2, t and F (derivations excluded).   (5)

Point Estimation: Concepts of estimation, requirements of a good estimator, notions of mean square error, unbiasedness, bias-variance trade off, best linear unbiasedness and minimum variance unbiasedness. Properties of uniformly minimum variance unbiased estimators (UMVUE). Comparison of Estimators, Efficiency. Methods of Estimation: Method of moments, method of maximum likelihood estimation and statements of their small sample properties. Point estimators of the parameters of Binomial, Poisson, and univariate Normal distributions.   (15)

Elements of hypothesis testing: Null and alternative hypotheses, simple & composite hypotheses, critical region, type I and type II errors, level of significance, size, power, p-value. Exact tests and confidence intervals: classical and p-value approaches. Tests relating to Binomial and Poisson distributions, Fisher's exact test. Chi-square tests for association, homogeneity and goodness of fit. Tests of hypotheses for the parameters of normal distribution (one sample and two sample problems), paired t-test. Combination of probabilities in tests of significance.   (20)

Interval Estimation: Confidence Interval and Confidence Coefficient, Exact confidence interval for mean(s) and variance(s) for one and two sample problems under the Normal set-up.   (5)

STAT-MD-CC3-3-P   **1 Credit**

(Statistical Inference I)   **PRACTICAL**

List of Suggested Practical

- Maximum Likelihood Estimation.

- Estimation by the method of moments.

- Test of significance for single proportion and difference of two proportions.

- Test of significance for single Poisson mean and difference of two Poisson means.

- Chi square tests for association, homogeneity and goodness of fit.

- Test of significance and confidence intervals for single mean and difference of two means.

- Test of significance and confidence intervals for single variance and ratio of two variances.

Reference Books

➤ Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. 1. The World Press, Kolkata.

➤ Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory, Vol-1. World Press.

➤ Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint). John Wiley and Sons.

➤ Hogg, R.V., Tanis, E.A. and Zimmerman, D. L.: Probability and Statistical Inference. Pearson Education.

➤ Johnson, R.A. and Bhattacharya, G.K.: Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.

➤ Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata McGraw-Hill.

➤ Hogg, R.V., McKean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics, 8th Edition. Pearson.

➤ Gupta, S.C. and Kapoor, V.K. (2020): Fundamentals of Mathematical Statistics. Sultan Chand and Sons.

➤ Ramachandran, K.M. and Tsokos, C.P.: Mathematical Statistics with Applications. Academic Press.

➤ Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

<div align="center">**STATISTICS MINOR**</div>

STAT-MD-MC1-3-Th   **3 Credits**

(Descriptive Statistics I & Probability I)   **THEORY**

Statistics: Definition and scope. Concepts of statistical population and sample.

Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous.

Scales of measurement: nominal, ordinal, interval and ratio.

Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.   (10)

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Ginis Coefficient, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Box Plot. Outliers.   (15)

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability: classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.   (20)

STAT-MD-MC1-3-P   **1 Credit**

(Descriptive Statistics I & Probability I)   **PRACTICAL**

List of Suggested Practical

- Diagrammatic representation of data.
- Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation.
- Problems based on moments, skewness and kurtosis.
- Problems related to quantiles and measures based on them, construction of box plot.
- Application problems based on Classical Definition of Probability.
- Application problems based on Bayes' Theorem.

Reference Books:

- Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, World Press, Kolkata.
- Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.
- Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, Pearson Education, Asia.
- Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, Tata McGraw-Hill Pub. Co. Ltd.
- Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.
- Freedman, D., Pisani, R. and Purves, R.: Statistics, W. W. Norton & Company.
- Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.
- Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.
- Parzen, E.: Modern Probability Theory and its Applications, John Wiley.
- Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.
- Cacoullos, T.: Exercises in Probability, Narosa.
- Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.
- Ross, S.: A First Course in Probability, Prentice Hall.
- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.
- Gupta, S.C., Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons

STAT-MD-SEC3-3-Th   3 Credits
(An Introduction to R)   **THEORY**

Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open source philosophy.

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. (10)

The different types of numbers in R: Division by zero leading to Infor -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. Barplot, Pie chart and Histogram. Box plot. (15)

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. (8)

Numerical Integration in R: Trapezoidal and Simpson's 1/3rd rules.

Numerical solution of equations in R: Method of fixed-point iteration and Newton-Raphson method in one unknown.

Simulation in R: Simulating a coin toss, a die roll and a card shuffle. Finding probabilities of events related to such experiments using simulation. (12)

STAT-MD-SEC3-3-TU   1 Credit
(An Introduction to R)   **TUTORIAL**

Reference Books:

- Gardener, M.: Beginning R - The Statistical Programming Language, Wiley Publications.
- Braun W J, Murdoch D J: A First Course in Statistical Programming with R. Cambridge University Press. New York.
- A simple introduction to R by Arnab Chakraborty

  (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis

  (freely available at https://cran.r-project.org/doc/contrib/Paradisrdebuts_en.pdf)

STATISTICS INTERDISCIPLINARY

STAT-MD-IDC3-3-Th   **2 Credits**
(Statistics for Practitioners)   **THEORY**

Understanding univariate data: Variable, notion of population and sample, different types of data, methods of collecting primary and secondary data, presentation of data, summary measures on data with central tendency (arithmetic mean, median, mode), dispersion (range, quartile deviation, standard deviation, coefficient of variation), ideas of skewness and kurtosis (only through diagrams), Exploratory Data Analysis.   (8)

Understanding bivariate data: Paired data and ideas (without mathematical details) of different measures of associations, primarily Pearson's correlation coefficient, Spearman's Rank correlation (no tie), measures of association of attributes through contingency table, two-variable linear regression and multiple (three-variable only) linear regression (without derivation of the regression coefficients' formulae).   (8)

Statistical Inference (*testing of hypothesis*): Basic idea of binomial and normal populations (graphical idea only, derivation of the properties excluded). Concepts of hypotheses, knowledge on test statistic and decision making in terms of critical value and p-value for some standard testing problems like test for proportion/proportions, mean based on single (normal) sample, test on comparing means based on two-sample and paired sample data.   (7)

Miscellaneous discussion: Applications of one-way and two-way ANOVA with one observation per cell (without derivation and details) assuming normality, Kruskal-Wallis test (without derivation and details), sample size determination, estimation of population mean and variability for finite population, idea and application of logistic regression for binary response data.   (7)

STAT-MD-IDC3-3-P   **1 Credit**

(Statistics for Practitioners)   **PRACTICAL**

List of Suggested Practical

- Measures of mean, median, mode, range, QD, SD, CV for univariate data case.

- Fitting of linear regression on bivariate and on three-variable multivariate data, measures of Pearson's correlation coefficient, Spearman's Rank correlation, measures of association of attributes through contingency table.

- Tests for proportion/proportions, tests of means for single sample, two-sample, and paired sample data on normal response using p-value approach.

- Applications of ANOVA and Kruskal-Wallis test.

- Sample size determination, estimation of population mean and variability for finite population.

- Fitting of logistic regression for binary response data.

Reference Books:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. I, 9th Edition World Press, Kolkata.

- Das, N.G.: Statistical Methods, Vol I, Tata McGraw Hill Pub. Co. Ltd.

- Johnson, R.A. and Wichern, D.W.: Applied Multivariate Statistical Analysis, PHI.

- Hardle W. and Simar, L.: Applied Multivariate Statistical Analysis.

- Kutner, M.H. et.al.: Applied Linear Statistical Models.

- Belsley D.A. et.al.: Regression Diagnostics.

- Draper N.R. and Smith, H.: Applied Regression Analysis.

- Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

- Roychowdhury, S., Bhattacharya, D.: Probability and Statistical Inference Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

STAT-MD-CC4-4-Th / STAT-MD-MC5-6-Th   **3 Credits**
(Design of Experiments I and Sample Survey I)   **THEORY**

Design of Experiments I:

Analysis of Variance: Factors, types and effects; Fixed, random and mixed effects models; Analysis of one-way and two-way classified data with equal number of observations in each cell (Fixed Effects Models only). (10)

Experimental designs: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher). (2)

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model, Applications of the techniques of ANOVA to the analysis of the above designs. Missing plot techniques in RBD and LSD. Uniformity trial experiments and comparison of designs. (10)

Sample Survey I:

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, random numbers, procedure of selecting a sample, estimates of population mean, total and proportion, standard errors of these estimates, estimates of their standard errors. (15)

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. (4)

Two-stage sampling (with primary units of equal size and equal selection probability at each stage): unbiased estimation of population mean and total. Ideas of snowball sampling, purposive sampling. (4)

STAT-MD-CC4-4-P / STAT-MD-MC5-6-P   **1 Credit**
(Design of Experiments I and Sample Survey I)   **PRACTICAL**

List of Suggested Practical

- Analysis of Variance of a one-way classified data (fixed effects model).
- Analysis of Variance of a two-way classified data with one observation per cell (fixed effects model).
- Analysis of Variance of a two-way classified data with more than one observation per cell (fixed effects model).
- Analysis of a CRD.
- Analysis of an RBD.
- Analysis of an LSD.
- Analysis of an RBD with one missing observation.
- Analysis of an LSD with one missing observation.
- To select a simple random sample with and without replacement.
- Simple random sampling – estimation of population mean, total and proportion; estimation of related standard error.
- Estimate the sample size for SRSWOR.
- Stratified Sampling –estimation of population mean and total, allocation of sample to strata by proportional and Neyman's methods, Comparison of the efficiencies of the above two methods relative to SRS.
- Estimation of gain in precision in stratified sampling.
- Two-stage Sampling – estimation of population mean and total.

Reference Books:

- Renchner, A. C. And Schaalje, G. B.: Linear Models in Statistics (Second edition), John Wiley and Sons.
- Scheffe, H.: The Analysis of Variance, John Wiley.
- Cochran, W.G. and Cox, G.M.: Experimental Design. Asia Publishing House.
- Das, M.N. and Giri, N.C.: Design and Analysis of Experiments. Wiley Eastern Ltd.
- Kempthorne, O.: The Design and Analysis of Experiments. John Wiley.
- Montgomery, D. C.: Design and Analysis of Experiments, John Wiley.

- Wu, C. F. J. And Hamada, M.: Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
- Dean, A.M. and Voss, D.: Design and Analysis of Experiments. Springer Texts in Statistics.
- Goon, A.M., Gupta, M.K., Das Gupta, B.: An Outline of Statistical Theory, Vol-II, World Press, Calcutta.
- Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics, Vol-II, World Press.
- Cochran, W.G.: Sampling Techniques (3rd Ed.), Wiley Eastern.
- Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C.: Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics.
- Murthy, M.N.: Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- Des Raj and Chandhok P.: Sample Survey Theory, Narosa Publishing House.

STAT-MD-CC5-4-Th / STAT-MD-MC6-6-Th   **3 Credits**

(Descriptive Statistics III and Probability III)   **THEORY**

Descriptive Statistics III   (15)

Multivariate frequency distribution: multivariate data, multiple regression, multiple correlation, partial correlation coefficient, Particular case with three variates.

Probability III   (30)

Moments, Quantiles, Skewness and Kurtosis (including discussions of these measures for Binomial, Poisson and Univariate Normal Distributions). Generating functions – probability generating function and moment generating function.

Discrete probability distributions: Uniform, Geometric, negative binomial, hypergeometric. Limiting/approximation cases.

Continuous probability distributions: uniform, exponential, beta, gamma, lognormal distributions along with their properties.

Two dimensional random variables (*discrete and continuous cases*): Joint p.m.f. and p.d.f., marginal and conditional distributions, properties of c.d.f., independence of variables, Theorems on sum and product of expectations of random variables, Conditional Expectation, Correlation and Regression. Trinomial distribution and its properties. Bivariate Normal Distribution and its properties.

STAT-MD-CC5-4-P / STAT-MD-MC6-6-P   1 Credit
(Descriptive Statistics III and Probability III)   PRACTICAL

- Problems on trivariate data: regression line, multiple & partial correlation.
- Application problems based on discrete distributions.
- Application Problems based on continuous distributions.

Reference Books:

- Goon A.M., Gupta M.K. & Dasgupta B.: An Outline of Statistical Theory (Vol-1), World Press
- Johnson, N.I. & Kotz S.: Distributions in Statistics, John Wiley
- Ross S.M.: Introduction to Probability Models, Academic Press
- Mood A.M., Graybill F. & Boes D.C.: An Introduction to the Theory of Statistics (3rd ed), McGraw Hill
- Rao C.R.: Advanced Statistical Methods in Biometric Research, John Wiley
- Hogg R.V. & Craig A.T.: Introduction to Mathematical Statistics
- Rohatgi V.K.: An Introduction to Probability Theory & Mathematical Statistics, John Wiley
- Stuart G & Ord J.K.: Advanced Theory of Statistics (Vol 2), Charles Griffin
- Goon A. M., Gupta M. K. and Dasgupta B.: Fundamentals of Statistics (V-1), World Press.
- Bhattacharya, G.K. & Johnson R. A.: Concepts & Methods of Statistics, John Wiley
- Gupta, S.C., Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons

STATISTICS MINOR

STAT-MD-MC2-4-Th   **3 Credits**

(Descriptive Statistics II & Probability II)   **THEORY**

Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation.

Rank correlation: Spearman's and Kendall's measures.   (15)

Analysis of Categorical Data: Contingency table, independence & association of attributes.   (5)

Random Variables: Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (without proof), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Variance. Standard probability distributions: Discrete Uniform, Binomial, Poisson, and Normal.   (25)

STAT-MD-MC2-4-P   **1 Credit**

(Descriptive Statistics II & Probability II)   **PRACTICAL**

List of Suggested Practical

- Problems based on analysis of bivariate data.
- Problems based on measures of rank correlation.
- Problems based on analysis of categorical data.
- Finding expectation, variance from a given probability distribution.
- Fitting of binomial distributions for n and $p = q = 1/2$.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of mean.
- Fitting of Poisson distributions after computing mean.
- Application problems based on binomial distribution.
- Application problems based on Poisson distribution.
- Problems based on area property of normal distribution.
- To find the ordinate for a given area for normal distribution.
- Application based problems using normal distribution.

- Fitting of normal distribution when parameters are given.
- Fitting of normal distribution when parameters are not given.

Reference Books:

➢ Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics, Vol. I, The World Press, Kolkata.

➢ Goon, A.M., Gupta, M.K. & Dasgupta, B.: An Outline of Statistical Theory (Vol-1), World Press.

➢ Miller, Irwin and Miller, Marylees: John E. Freunds Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

➢ Mood, A.M., Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

➢ Tukey, J.W.: Exploratory Data Analysis, Addison-Wesley Publishing Co.

➢ Agresti, A.: Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

➢ Freedman, D., Pisani, R. and Purves, R.: Statistics, 4th Edition, W. W. Norton & Company.

➢ Chung, K.L.: Elementary Probability Theory with Stochastic Process, Springer / Narosa.

➢ Feller, W.: An Introduction to Probability Theory & its Applications, John Wiley.

➢ Parzen, E.: Modern Probability Theory and its Applications, John Wiley.

➢ Uspensky, J.V.: Introduction to Mathematical Probability, McGraw Hill.

➢ Cacoullos, T.: Exercises in Probability, Narosa.

➢ Rahman, N.A.: Practical Exercises in Probability and Statistics, Griffin.

➢ Ross, S.: A First Course in Probability, Prentice Hall.

➢ Hogg, R.V., Tanis, E.A. and Rao J.M.: Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

➢ Myer, P.L.: Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

➢ Rohatgi, V. K. and Saleh, A.K. Md. E.: An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

➢ Roychowdhury, S., Bhattacharya, D.: Statistics Theory and Practice, U.N. Dhur & Sons. Pvt. Ltd.

➢ Gupta, S.C., Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons

QUESTION PATTERN

Four-year B.Sc. (Honours and Honours with Research) Course
&
Three-year B.Sc. Multidisciplinary Course
(Under Curriculum & Credit Framework, 2022)

Theoretical

Full Marks: 75 (Applicable for all papers with 3 Credits)

(a) Objective type: 5 questions × 2 marks = 10 marks

(5 questions are to be attempted out of 8 choices carrying 2 marks each)

(b) Short answer type: 4 questions × 5 marks = 20 marks

(4 questions are to be attempted out of 6 choices carrying 5 marks each)

(c) Broad answer type: 3 questions × 15 marks = 45 marks

(3 questions are to be attempted out of 5 choices carrying 15 marks each)

Full Marks: 50 (Applicable for all papers with 2 Credits)

(a) Objective type: 5 questions × 2 marks = 10 marks

(5 questions are to be attempted out of 8 choices carrying 2 marks each)

(b) Short answer type: 4 questions × 5 marks = 20 marks

(4 questions are to be attempted out of 6 choices carrying 5 marks each)

(c) Broad answer type: 2 questions × 10 marks = 20 marks

(2 questions are to be attempted out of 3 choices carrying 10 marks each)

Practical

Full Marks: 25 (Applicable for all papers with 1 Credit)

Duration: *2 Hours*

(a) Problems: 16 marks

(b) Viva-voce: 5 marks

(c) Practical Note Book: 4 marks

Full Marks: 50 (Applicable for all papers with 2 Credits)

Duration: *4 Hours*

(a) Problems: 40 marks

(b) Viva-voce: 5 marks

(c) Practical Note Book: 5 marks

Full Marks: 100 (Applicable for all papers with 4 Credits)

Duration: *5 Hours*

(a) Problems: 80 marks

(b) Viva-voce: 10 marks

(c) Practical Note Book: 10 marks

Notes:

1. The candidates will be required to answer all the questions in the Practical Papers.
2. Practical Examination for B.Sc. Four-year Statistics Major to be conducted in away centres simultaneously on the basis of single question paper in presence of external examiners.
3. Practical Examination for B.Sc. Four-year Statistics Major in the papers STAT-H-SEC1-1 and STAT-H-SEC3-3 to be conducted in batches in away centres using Computers only.
4. Practical Examination for B.Sc. Four-year Statistics Minor and IDC to be conducted in home centres by internal examiners only.
5. Practical Examination for Three-year Statistics Major, Minor and IDC to be conducted in home centres by internal examiners only.