Begum Rokeya University, Rangpur

Faculty of Science

Department of Statistics

Curriculum and Syllabus

B.Sc. Honours Program in Statistics

Effective from Session: 2023-2024

https://brur.ac.bd/faculty-of-science/department-of-statistics/

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Contents

1 Department of Statistics

1.1 Introduction

The Department of Statistics is one of the pioneer departments of Begum Rokeya University, Rangpur foster at specializing and training in statistical methodology in its theoretical, practical/applied, and scientific research aspects of the modern age, particularly with computer intensiveness in offering Bachelor of Science (B.Sc.), Master of Science (M.Sc.) degrees, Master of Philosophy (M.Phil) and Doctor of Philosophy (Ph.D.) degrees in Statistics.

The Department of Statistics started its academic journey in 2009 and committed to advancing knowledge and learning through teaching and research in Statistics.

The course curriculum is designed to develop a class of analytic and inferential aptitude among the students through rigorous practical and lab assignments along with exposure to applying statistics in many fields including sciences, social sciences, medicine, engineering, management science, finance, commerce and many more areas. There are flourishing research groups in Bioinformatics, Data Science, Epidemiology and Biostatistics, Health informatics, Demography, Public health, Multivariate analysis, Econometrics and Time series analysis, etc. The students are trained in various statistical languages and packages like C/C++, SPSS, STATA, SAS, MINITAB, RStudio, Python, MATLAB and MATHEMATICA using a well-equipped computer laboratory with nearly 60 computers having state of the art computer facilities. The Department also encourages its students to engage in extra-curricular and co-curricular activities, essential for the development, and nurturing of team spirit and the development of organizational skills.

1.2 Vision and Mission of the Department

Vision

The vision of the Department is to take a leading position globally in providing quality education in Statistics and Data Science, conducting leading-edge research and creating innovative industrial partnerships.

Mission

The mission of the department is to produce competent graduates in Statistics equipped with the skills necessary for success in a technological society and competitive global environment to serve the needs of the University, and local and national bodies in research, government, business, and industry.

Objectives

To fulfil the vision and missions, Department aims to

1. Strengthen and update various teaching and training programs at undergraduate, post-graduate, and doctoral levels to produce graduates with strong theoretical and practical knowledge of statistics in line with the labour market requirements.
2. Create an environment conducive to high quality research.
3. Contribute to the advancement of science and technology through interdisciplinary research in collaboration with scientists and scholars at the Begum Rokeya University, Rangpur, and other research institutions at home and abroad.
4. Contribute to the statistics profession and the larger scientific community by running quality statistical journals and serving on editorial boards, review panels, and administrative and advisory committees.
5. Employ high quality faculty members with diverse research interests.
6. Promote the exchange of knowledge and ideas by arranging invited talks regularly, in addition to workshops and international conferences.
7. Disseminate statistical knowledge by offering training programs to students of other departments and professionals of various government and private organizations.
8. Serve the statistical needs of the University and national bodies by providing consulting services in research, government, business, and industry.
9. Produce graduates with strong moral and ethical values and respect for local norms and culture while promoting global competencies and inclusivity.
10. Contribute substantially to the central roles through its graduate research, its support for programs in other disciplines, its enthusiastic implementation of the land-grant concept of a balanced program of teaching, research, extension, and public service, its recognition and adaptation to the rapidly changing global environment, and its commitment to excellence in international education and collaboration.

1.3 **FACULTY MEMBERS**

Department of Statistics

Begum Rokeya University, Rangpur

HEAD OF THE DEPARTMENT

Md. Siddikur Rahman, PhD
Associate Professor

ASSOCIATE PROFESSOR

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ASSISTANT PROFESSOR

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2 B.Sc. Honours Program in Statistics

2.1 Introduction

The Bachelor of Science (B.Sc.) Honors program in Statistics aims at teaching modern statistical techniques in theoretical, practical and research sectors, particularly with computer intensiveness.This program is extended over a period of four academic years. Each academic year is divided into two Semesters to be called as 1st Semester and 2nd Semester. The courses offered in this program are theoretical and practical. For assessment, each theoretical and practical course offered should be composed of either 50 or 100 marks. The total credits of courses are 153, which is composed of a total of 5100 marks.

2.2 Structure of the Program

2.2.1 Assessment system

60% marks are allotted for the final examination and the remaining 40% is allotted for continuous assessment. There will be two mid-semester examinations carrying 15 marks each, and 5 marks are allotted for the class performances/quiz/viva/presentation and 5 marks are allotted for the class attendance. In the final examination, students must answer 5 questions out of 7 questions. The sum of the marks of the final examination and continuous assessment are added, and final marks are converted into grades. The proportion of the total marks for each theoretical course shall be distributed as follows:

Marks (%) allocation for theoretical and Lab courses			
	Theoretical		**Lab**
Items	3.00 Credit	1.5 Credit	1.5 Credit
Class attendance	5%	2.5%	2.5%
Cass performances/quiz/ Viva-Voce /presentation	5%	2.5%	2.5%
Mid-semester Examination (minimum two)	15*2 = 30%	7.5*2=15%	7.5*2=15%
Semester Final Examination	60%	30%	30%

Marks distribution for attendance	
Attendance (%)	Marks (%)
90 and above	5
85 to 89	4
80 to 84	3
75 to 79	2
60 to 74	1
< 60	0

2.2.2 Grading and Grade Point

Total pass marks obtained in each theoretical course, oral (viva-voce) examination and practical courses shall be converted into LG (Letter Grade) and GP (Grade Point) as follows:

Numerical Grade	**Letter Grade**		**Grade Point**	**Interpretation**
80% and above	A+	(A plus)	4.00	Outstanding
75% to less than 80%	A	(A regular)	3.75	Excellent
70% to less than 75%	A-	(A minus)	3.50	Very Good
65% to less than 70%	B+	(B plus)	3.25	Good
60% to less than 65%	B	(B regular)	3.00	Satisfactory
55% to less than 60%	B-	(B minus)	2.75	Below Satisfactory
50% to less than 55%	C+	(C plus)	2.50	Average
45% to less than 50%	C	(C regular)	2.25	Poor
40% to less than 45%	D	----	2.00	Pass
Less than 40%	F	----	0.00	Fail
	I	Incomplete	-	Didn't complete the degree
	W	Withdrawn	-	Withdrawn

2.2.3 Name of the Program: Bachelor's Degree (Semester System)

Detail Course Outline

Level	Course Code	Course Title	Marks	Credit Points
1st year 1st Semester	STAT 1101	Introductory Statistics	100	3
	STAT 1102	Elementary Probability	100	3
	STAT 1103	Linear Algebra	100	3
	STAT 1104	Analytical Geometry and Calculus	100	3
	STAT 1105	Principles of Economics	100	3
	STAT 1106	Introductory Statistics Lab	50	1.5
		Total	**550**	**16.5**
1st year 2nd semester	STAT 1201	Bivariate Analysis	100	3
	STAT 1202	Probability Distributions	100	3
	STAT 1203	Introductory Data Base Management System	100	3
	STAT 1204	Algebra and Numerical Analysis	100	3
	STAT 1205	Stata and SPSS	100	3
	STAT 1206	Bivariate Analysis Lab	50	1.5
	STAT 1207	Viva-Voce	50	1.5
		Total	**600**	**18**
2nd year 1st semester	STAT 2101	Sampling Distributions	100	3
	STAT 2102	Statistical Estimation	100	3
	STAT 2103	Test of Hypothesis	100	3
	STAT 2104	Differential Equations and Complex Variables	100	3
	STAT 2105	Programming with C++ and SQL	50	1.5
	STAT 2106	Statistical Estimation Lab	50	1.5
	STAT 2107	Test of Hypothesis Lab	50	1.5
	STAT 2108	Programming with C++ and SQL Lab	50	1.5
		Total	**600**	**18**
2nd year 2nd semester	STAT 2201	Regression Analysis	100	3
	STAT 2202	Demography	100	3
	STAT 2203	Real Analysis	100	3
	STAT 2204	Operations Research	100	3
	STAT 2205	Programming with R and Python	100	3
	STAT 2206	Regression Analysis Lab	50	1.5
	STAT 2207	Demography Lab	50	1.5
	STAT 2208	Programming with R and Python Lab	50	1.5
	STAT 2209	Viva-Voce	50	1.5
		Total	**700**	**21**
3rd year 1st semester	STAT 3101	Design of Experiments	100	3
	STAT 3102	Stochastic Processes	100	3
	STAT 3103	Generalized Linear Model	100	3
	STAT 3104	Sampling Techniques	100	3
	STAT 3105	Introduction to Data Science	100	3
	STAT 3106	Design of Experiments Lab	50	1.5
	STAT 3107	Stochastic Processes Lab	50	1.5
	STAT 3108	Generalized Linear Model Lab	50	1.5
		Total	**650**	**19.5**

3rd year 2nd semester	STAT 3201	Time Series Analysis	100	3
	STAT 3202	Non-Parametric and Robust Statistics	100	3
	STAT 3203	Statistical Simulation and Modeling	100	3
	STAT 3204	Statistical Quality Control	100	3
	STAT 3205	Econometrics	100	3
	STAT 3206	Time Series Analysis Lab	50	1.5
	STAT 3207	Statistical Simulation and Modeling Lab	50	1.5
	STAT 3208	Econometrics Lab	50	1.5
	STAT 3209	Viva-Voce	50	1.5
		Total	**700**	**21**
4th year 1st semester	STAT 4101	Multivariate Distribution	100	3
	STAT 4102	Advanced Sampling Techniques	100	3
	STAT 4103	Spatial Statistics	100	3
	STAT 4104	Health Informatics	100	3
	STAT 4105	Research Methodology	100	3
	STAT 4106	Advanced Sampling Techniques Lab	50	1.5
	STAT 4107	Spatial Statistics Lab	50	1.5
	STAT 4108	Health Informatics Lab	50	1.5
		Total	**650**	**19.5**
4th year 2nd semester	STAT 4201	Multivariate Analysis	100	3
	STAT 4202	Survival Analysis	100	3
	STAT 4203	Statistical Machine Learning and Data Mining	100	3
	STAT 4204	Bioinformatics	100	3
	STAT 4205	Multivariate Analysis Lab	50	1.5
	STAT 4206	Survival Analysis Lab	50	1.5
	STAT 4207	Statistical Machine Learning and Data Mining Lab	50	1.5
	STAT 4208	Project Report	50	1.5
	STAT 4209	Viva-Voce	50	1.5
		Total	**650**	**19.5**
		Grand Total	**5100**	**153**

3 Detailed Syllabus
3.1 First Year

STAT 1101: Introductory Statistics

Title of the Course	**Introduction to Statistics**				
Course Code	STAT 1101				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course will provide appropriate statistical tools and techniques to analyze data for effective decisions.

Course Objectives (CO): The main objective of this course is to acquaint the students with the methods of obtaining and analyzing data in order to make better decisions in an uncertain and dynamic phenomenon. Emphasis will be given mainly on basic statistical methods and techniques.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: familiar with the origin of Statistics and related concepts.
CLO2: develop knowledge of using statistical data.
CLO3: familiar with a variety of methods for processing and presentation of statistical data.
CLO4: develops knowledge of methods for exploratory data analysis.
CLO5: derive and work with statistical methods including measures of central tendency & location.
CLO6: derive and work with statistical methods including measures of dispersion.
CLO7: develop working knowledge of statistical models for data analysis.

S.N.	Course Contents	Hrs	CLOs
1	**Statistics and Its Origin:** History, Definitions, Characteristics, Classification, Uses, Importance and Limitations of Statistics, Relation with other Disciplines.	6	CLO1
2	**Producing and Sources of Statistical Data:** population, sample, parameter, statistic,variables,Types of variables: qualitative, quantitative, discrete and continuous, graphical presentation for qualitative and quantitative data, Scales of Measurement : nominal, ordinal, interval and ratio.Data: primary data and secondary data, methods of collecting data, preparation of questionnaire and schedule, pre-testing of questionnaire, Concept of data cleaning and checking before statistical analysis.	6	CLO2
3	**Processing and Presentation of Statistical Data:** Sorting data, grouping qualitative and quantitative data: construction of frequency distribution and relative frequency distribution; graphical presentation of frequency distribution-histogram, frequency polygon, ogive. Details of different types of graphs and charts with their relative merits and demerits.	6	CLO2 CLO3
4	**Exploratory data analysis:** Stem-and-leaf plot, Box plots, Outliers and 5-number summaries.	6	CLO3 CLO4
5	**Measures of Central Tendency & Measures of Location:** Meaning of Central Tendency, Mean, Median and Mode with their Properties, Application of the Measures of Central Tendency, Meaning of Measures of Location, Quartiles, Deciles and Percentiles, Geometric Mean and Harmonic Mean with their Properties, Comparing the Averages, Box and Whisker Plots with their Uses.	6	CLO5
6	**Measures of Dispersion:** Meaning of Dispersion, Absolute and Relative Measures of Dispersion, Empirical Relations among Measures of Dispersions.	6	CLO6
7	**Shape Characteristics of Distribution**: Moments of a distribution, Sheppard's Correction for Moments, Shape Characteristics of a Distribution:Skewness and Kurtosis.	4	CLO7

Textbooks:

1. Weiss N (2007). Introductory Statistics, 7th edition. Addison Wesley.

Reference Books:

1. Douglas A. Lind ,William G. Marchal, Samuel A.Wathen (2022): Statistical Techniques in Business and Economics, 18th ed. Irwin.
2. Mann PS (2020). Introduction to Statistics, 10th edition. John Wiley & Sons Inc.
3. Newbold P (2004). Statistics for Business and Economics, 3rd edition. Prentice-Hall.

STAT 1102: Elementary Probability

Title of the Course	**Elementary Probability**				
Course Code	STAT 1102				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is heavily oriented towards formulating mathematical concepts based on the basics of sets and probability theory, including probability, conditional probability, random variables, mathematical expectation and variance, probability generating function, and special discrete probability distributions with practical applications.

Course Objectives (CO):
This course explores the basic concept of modern probability theory and its applications for decision-making in economics, business, and other fields of social and natural sciences.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the meaning of probability and probability experiment.
CLO2: to use and manipulate the axioms of probability comfortably to derive the results other set operations and use Venn diagrams to represents the results of set operations.
CLO3: understand the basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables.
CLO4: understand the behavior of the random variable and mathematical Expectation.
CLO5: know how to derive different basic probability distributions.

S.N.	Course Contents	Hrs	CLOs
1	**Set Theory:** Sets and Set Operations, Description and Notations, Universal Set. Venn Diagram, Empty Set, Subsets, Proper Subset, Equal Set, Unit Set, Finite and Infinite Sets, Operations with Sets-Intersection, Union, Complementation, Class of Sets, Power Set, Cartesian Product Set and Differences of Sets, Algebra of Sets-Commutative Laws, Associative Laws, Distributive Laws, Identity Laws, Idempotent Laws, Complement Laws and De Morgan's Laws.	8	CLO1
2	**Probability:** Probability and Possibility, Experiment or Random Experiment, Basic Requirements of Probability, Sample Space, Events, Probability of an Event, Mutually Exclusive Events, Addition Law, Counting Rules, Methods of Assigning Probabilities: The Classical, Empirical, Geometric, Relative Frequency, Axiomatic and Subjective methods, Total and Compound Probability, Probability and Odds, Odds Ratio, Tree Diagrams, Conditional Probability, Independence and Non-Independence of Events, Bayes' Theorem and Applications, Other Aspects of Probability.	8	CLO2
3	**Random Variables**: Basic Concepts, Discrete and continuous Random Variables, Probability Distribution, Probability Mass and Density Functions, Distribution Functions, Function of a Random Variable, Joint, Marginal and Conditional Distribution, Independence of Random Variable.	8	CLO1 CLO3
4	**Mathematical Expectation**: Meaning of Mathematical Expectation, Expected Value of a Function of a Random Variable, Expected Value of a Function of Two Random Variables, Conditional Expectation, Variance of a Random Variable, Conditional variance, Moments and Moment Generating Function, Cumulants and Cumulant Generating Function, Relations Between Moments and Cumulants, Characteristic Function, Special Mathematical Expectation, Chebyshev's inequality .	6	CLO3 CLO4
5	**Probability Enequality:** Chebyshev's inequality, Cauchy-Schwarz inequality.	6	CLO5

Textbooks:

1. Ross SM (2009). A First Course in Probability, *8th edition*. Prentice-Hall.

Reference Books:

1. Lipschutz, S. and J. Schiller (2011). *Introduction to Probability and Statistics*, McGraw-Hill, N.Y.
2. Stirzaker D (2003). Elementary Probability, *2nd edition*. Cambridge.
3. Blitzstein JK and Hwang J (2019). Introduction to Probability, *2nd edition*. Springer.

STAT 1103: Linear Algebra

Title of the Course	**Linear Algebra**				
Course Code	STAT 1103				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
The aim of this course is to provide an overview of the relevant aspects with basic algebraic properties of matrices and to accustomed with the fundamentals of vectors.

Course Objectives (CO):
1. To use mathematically correct language and notation for Linear Algebra.
2. To become computationally proficient in involving procedures in Linear Algebra.
3. To understand the axiomatic structure of a modern mathematical subject and learn to construct simple proofs.
4. able to apply matrix algebra in statistics and any other field.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: learn the fundamental concepts and properties of finite dimensional real vector spaces.
CLO2: familiar with algebra of real matrices and perform basic operations with vectors and matrices.
CLO3: know the concepts of determinants of matrices and compute determinants.
CLO4: solve homogenous and non-homogenous linear systems.
CLO5: understand the meaning of least square solution of a linear system and be able to find it.
CLO6: compute eigen values and eigen vectors and to solve linear systems.

S.N.	Course Contents	Hrs	CLOs
1	**Vectors:** Definition**,** Types of Vectors (Unit vector, Null vector etc.) Addition and Scalar Multiplication, Vector product, Geometrical Interpretation of Vector, Linear Dependence and Independence, Vector Space, Basis and Dimension, Sub-space, Cauchy-Schwartz inequality, Orthogonal Basis of Vectors, Gram-Schmidt Orthogonalization of Vectors.	8	CLO1 CLO2
2	**Matrices :** Definition of matrices, Matrix Operations and their Properties, Different types of Matrices, Identity matrix, Scalar, Diagonal, Null, Symmetric, Skew-Symmetric, Orthogonal, Unitary, Hermitian and Skew-Hermitian, Idempotent, Nilpotent and Involuntary matrices, Variance-covariance and Correlation matrices, Trace of a matrix, Definition of determinant, properties of determinant , Ideas of Minors, cofactors, Solution of equation with the help of Determinants, Rank of matrices and their properties and related theorem, Partitioning of matrices, Ad joint, Inverse and generalized inverse of a matrix and their properties, The Kronecker Sum, The Kronecker Product.	12	CLO3
3	**Simultaneous Equations**: Introduction, Solution of systems of homogeneous and non-homogeneous equations, Cramer's rule.	8	CLO4
4	**Characteristic values problems and quadratic forms:** Characteristic Roots and Vectors of a matrix, related theorem of Characteristics Roots and vectors, Caley-Hamilton theorem, Quadratic form and their Classifications, Their identification, Diagonalization of quadratic form, Related theorem of Quadratic forms, Gram Schmidt, Orthogonalization, Diagonalization of General Symmetric Matrices, Spectral Decomposition and Singular Value Decomposition of Matrices.	8	CLO5 CL06

Textbooks:
1. Anton H and Rorres C (2013). Elementary Linear Algebra, 11th edition. Wiley.

Reference Books:
1. Banerjee S and Roy A (2014). Linear Algebra and Matrix Analysis for Statistics. Chapman and Hall/CRC
2. Hadley, G. (1993): Linear Algebra, Addison Wesley Company, N.Y.

STAT 1104: Analytical Geometry and Calculus

Title of the Course	**Analytical Geometry and Calculus**				
Course Code	STAT 1104				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
The aim of this course to study the general knowledge of real number theory, differential and integration of the function of one variable, the theory and means of the definite integrals and indefinite integrals, basic ideas of sequence and series and so on.

Course Objectives (CO):
This is a fast-paced course emphasizing computational ability and geometric understanding of calculus. The objective is to provide students with practical mathematical skills necessary for advanced studies in all areas of statistics.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: know and demonstrate understanding of the concept's analytical geometry.
CLO2: familiar with algebra of real matrices and perform basic operations with vectors and matrices and functions.
CLO3: know the concepts of ordinary differentiation.
CLO4: familiar with basic concepts and properties of partial differentiation
CLO5: solve indefinite integrals.
CLO6: solve definite Integrals.

S.N.	Course Contents	Hrs	CLOs
1	**Analytical Geometry:** Basic concepts of Cartesian and Polar Co-ordinates, Pythagorean distance formula, Conic section.	8	CLO1
2	**Functions:** Function and Relation, Domain, Range, Inverse Function and Graphs of functions like exponential, logarithmic, sine, tangent etc. limits, continuity, and indeterminate form, Rolle's Theorem, Mean Value Theorem, Taylor's and Maclaurin's Formulae, Maxima and Minima of Functions.	8	CLO2
3	**Ordinary Differentiation:** Differentiability, Differentiation and Successive Differentiation, Leibniz theorem.	8	CLO2 CLO3
4	**Partial Differentiation:** Euler's theorem, Tangents and Normal. Asymptotes. L' Hospitals rule.	8	CLO4
5	**Indefinite Integrals**: Method of substitution, Integration by parts, Special trigonometric functions, and rational fractions.	8	CLO5
6	**Definite Integrals:** Fundamental theorem, General Properties. Evaluations of Definite Integrals and Reduction Formulae, Ideas of Double Integral, Triple Integral, Gamma function, Beta function, Incomplete Gamma function, Incomplete Beta function.	8	CLO6

Textbooks:

1. Anton H (1995). Calculus with Analytic Geometry, 5th edition. Wiley.

Reference Books:

1. Stewart J (2015). Calculus: Early Transcendentals, 9th edition. Cengage Learning.
2. Chris McMullen (2018). Essential Calculus Skills Practice Workbook with Full Solutions. Zishka Publishing

STAT 1105: Principles of Economics

Title of the Course	**Principles of Economics**				
Course Code	STAT 1205				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is designed to acquire the necessary skills and ability to work on the mathematical structures of a wide range of economic models. Students can also learn core economic principles and their applications in decision making process.

Course Objectives (CO):
This course will be helpful for appropriate statistical methods for analyzing and interpreting economic and business data.

Course Learning Outcomes (CLOs):
At the end of the course the students will be able to:

CLO1: learn the fundamental concepts and basic terminologies of economics and its world-wide applications.
CLO2: understand consumer demand and supply with their relevant problems.
CLO3: understand the principles of elasticity with the help of mathematics.
CLO4: understand the theory of consumer choice.
CLO5: derive and calculate indifference curve and related concepts.
CLO6: derive the production function, cost of production, revenue and profit.
CLO7: concepts of utility function and relevant terms
CLO8: gather the special market structures: monopoly and oligopoly and solve the relevant problems with the help of mathematical models.

S.N.	Course Contents	Hrs	CLOs
1	**Basics of Economics:** Meaning of Economics, Macroeconomics and Microeconomics, Goals of Microeconomics and Macroeconomics, Positive and Normative economics, common Fallacy of Economics, Methodology of economics, the economic Problem, and the Circular Flow of Economic Activity.	6	CLO1
2	**Demand and Supply:** Concept of demand and supply, Ceteris Paribus Theory, Market Price Determination under Pure Competition, Equilibrium Theory, Shits in Demand and Supply, Effects of Sales Tax and Specific Tax on Purely Competitive Equilibrium, Demand and Supply as Functions of More than One Variable, Complementary Product and Substitute Product.	10	CLO1 CLO2
3	**Elasticity:** Demand and Supply Elasticity, Demand and Total Revenue, Elasticity and Marginal Revenue, Elasticity Properties, Elasticity of Market Demand, elasticities for Functions of Several Variables.	6	CLO2 CLO3
4	**Theory of Consumer Choice:** Total and Marginal Utility, Law of Diminishing Marginal Utility, Maximizing Utility, Marshallian Cardinal Utility Approach, Hicksian Ordinal Utility Approach, Consumer Equilibrium, Substitution and Income Effects and Slutskey Equation Revealed Preference Theory.	5	CLO4 CLO5 CLO7
5	**Indifference Curve Approach**: Indifference Curve, Indifference Map, Properties of Indifference Curve, Marginal Rate of Substitution, Budget Constraint, Substitute and Income Effect.	2	CLO5 CLO6
6	**Theory of Production:** Production with One Variable Input: Total, Average and Marginal Product, Stages of Production Law of Return to Scale, Production with Two Variables Inputs: Isoquant Curve, Characteristics of Isoquant Curves, Marginal Rate of Technical Substitution, Producer's Equilibrium.	5	CLO6 CLO7 CLO8
8	**Market Structure:** Perfect Competition: Concept of Competitive Market, Profit Maximization and Competitive Firm's Supply Curve, Supply Curve in Competitive Market and Monopoly and related concepts	2	CLO6 CLO8
9	**Index number:** characteristics and uses, problems in the construction, classification; methods: unweighted, weighted: Laspeyre's, Paasche's, Dorbish and Bowley's, Fisher's, Marshall and Edgeworth's, Kelly's and the chain index numbers; test of accuracy, base shifting, splicing, deflating of index numbers; application of consumer price index number.	8	CLO9

Textbooks:

1. Samuelson PA and Nordhaus WD (2009). Economics, 19th edition. McGraw Hill. Reference Books

Reference Books:

1. Mankiw NG (2015). Principles of Economics, 7th edition. Cengage Learning.
2. Dowling ET (2011). Introduction to Mathematical Economics, 3rd edition. McGraw- Hill Education.
3. Newbold P, Carlson W and Thorne B (2012). Statistics for Business and Economics, 8th edition. Pearson

STAT 1106: Introductory Statistics Lab

Title of the Course	**Introductory Statistics Lab**				
Course Code	STAT 1105				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical use of different methods and gives extensive training to the students so that they learn how to manage and analyze statistical data.

Course Objectives (CO): This course provides extensive learning for statistical data analysis.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data.
CLO2: know estimate summary statistics from data and summarize statistical findings using graphs.
CLO3: know forecasting tools and techniques.

S.N.	Course Contents	Hrs	CLOs
1	Construction of frequency distribution tables with equal and unequal class intervals, Graphical Representation, steam and leaf plots, box, and whisker plots.	8	CLO1
2	Computation and interpretation of various measures of central tendency and dispersion from ungrouped and grouped data, calculation of moments, Sheppard's Corrections for Grouping Error, calculation of Skewness and Kurtosis.	8	CLO2
3	Problems related to correlation and regression.	8	CLO3

Textbooks:

1. Dalgaard, Peter. *Introductory statistics with R*. springer publication, 2008.

Reference Books:

1. Ware, William B., John M. Ferron, and Barbara M. Miller. *Introductory statistics: A conceptual approach using R*. Taylor & Francis, 2013.

STAT 1201: Bivariate Analysis

Title of the Course	**Bivariate Analysis**				
Course Code	STAT 1201				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
The main objective of this course is to introduce students to the knowledge of bivariate analysis, which covers correlation analysis, regression analysis, association of attributes and bivariate distribution.

Course Objectives (CO):
To provide knowledge and skills related to statistical and modern data science concepts.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:

CLO1: demonstrate a solid understanding of bivariate data.

CLO2: gain knowledge and technical competence, the ability to use fundamental statistical knowledge, methodologies, and modern computational tools in a suitable and pertinent way.

CLO3: Develop an understanding of the theoretical basis for correlation and regression analysis.

CLO4: develops knowledge about analyzing attributes, bivariate probability distribution and its properties.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to bivariate data**: Bivariate data, scatter diagram, Bivariate table, Conditional means and variances, Marginal distributions.	10	CLO1 CLO2
2	**Correlation**: Preparation of Bivariate frequency distribution, Correlation Ratio, Rank Correlation, Spearman Rank correlation, Kendall's Tau Correlation and Coefficient of Concordance, Fourfold and Tetra Choric Correlation, Intra-Class Correlation, Serial and Biserial Correlation, Partial and Multiple Correlation, Spurious Correlation, Non-sense Correlation.	6	CLO2 CLO3
4	**Regression**: Review of Regression, Standard error of estimates, Properties, Confidence interval & Hypothesis test in simple Regression, Lines of Best Fit, Residual Analysis and Linearity of Regression.	6	CLO2 CLO3
5	**Analysis of Attributes:** Basic Ideas, Classification, Order of Classes and Class Frequencies, Ultimate Class Frequencies, Positive Attributes, Consistency, Incomplete Data, Association of Attributes, Independence, complete association and disassociation, Measures of association, Coefficient of association, Coefficient of colligation, Partial association, Contingency Table, Coefficient of Contingency, Pearson's Coefficient of Mean Square Contingency, Analysis of $r \times c$ Contingency Table, Analysis of 2×2 Contingency Table by Yate's Correction.	6	CL04
6	**Bivariate Distributions:** Concept of Bivariate Probability Distribution, Marginal and Conditional Distribution, Expected Values and Variances, Moments and Cumulants, Moment and Cumulant Generating Functions, Derivation of Bivariate Normal Distribution and Study of its Properties, Normal Regression.	6	CL04

Textbooks:

1. Weiss N (2007). Introductory Statistics, 7th edition. Addison Wesley.

Reference Books:

1. Mann PS (2020). Introduction to Statistics, 10th edition. John Wiley & Sons Inc.
2. Newbold P (2004). Statistics for Business and Economics, 3rd edition. Prentice-Hall.
3. Witten IH, Frank E, and Hall MA (2016). Data Science: An Introduction. John Wiley & Sons Inc.

STAT 1202: Probability Distributions

Title of the Course	**Probability Distributions**				
Course Code	STAT 1202				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
The course explores the basic concepts of modern probability theory and its applications for decision-making in economics, business, and other fields of social sciences. The course is heavily oriented towards the formulation of mathematical concepts on probability and probability distributions and densities with practical applications.

Course Objectives (CO):
The course aims to provide students with a formal treatment of probability theory, essential tools for statistical analyses, and fostering understanding through real-world statistical applications.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:

1. develop problem-solving techniques needed to calculate probabilities accurately.
2. apply problem-solving techniques to solving real-world events.
3. apply selected probability distributions to solve problems.
4. Present the analysis of derived statistics.

S.N.	Course Contents	Hrs	CLOs
1	**Probability basics:** Probability Space, Probability Calculus, Measure Theoretical Approach to Probability.	8	CLO1
2	**Univariate Discrete Distributions:** Detailed Study of Bernoulli, Binomial, Poisson, Rectangular, Geometric, Hypergeometric, Negative Binomial, Multinomial, Truncated distributions of Bionomial and Poisson.	12	CLO2 CLO3 CL04
3	**Univariate Continuous Distributions:** Detailed Study of Uniform, Normal, Beta, Gamma, Exponential, Half Normal, Log Normal, Cauchy, Weibull, Inverse Gaussian, Laplace, Gumbell, Maxwell, Erlang, Pareto and other Exponential Family, Pearsonian System of Curves. Relationship between Incomplete beta function and binomial distribution, Relationship between Incomplete gamma function and Poission distribution.	12	CLO2 CLO3 CL04
4	**Bivariate Distribution:** Binomial, Poisson, Hypergeometric, Normal, Gamma, Beta.	6	CLO4

Textbooks:

1. Devore, J. L. (2002): *Probability and Statistics for Engineering and Sciences*, 5th edition, Thomson Books/Cole, USA.
2. Evans, M., Hasting, N. and Peacock, B. (2000): *Statistical Distributions*, 3rd edition, Wiley, New York.

Reference books:

1. Hogg, R. V. and Craig, A. T. (2002): *Introduction of Mathematical Statistics*, 5th edition, Pearson Education, Asia.
2. Kotz, S., Balakrishnan, N. and Johnson, N. L. (2000): *Continuous Multivariate Distributions*: Models and Applications, Vol. 1, 2nd edition, Wiley, New York.

STAT 1203: Introductory Data Base Management System

Title of the Course	Introductory Data Base Management System				
Course Code	STAT 1203				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides ideas for presenting an introduction to database management systems, with an emphasis on organizing, maintaining, and retrieving information efficiently and effectively from a DBMS.

Course Objectives (CO):
This course aims to develop the basic concepts and the applications of database systems.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Describe the fundamental elements of relational database management systems
CLO2: Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
CLO3: Design ER models to represent simple database application scenarios.
CLO4: Familiar with basic database storage structures and access techniques

S.N.	Course Contents	Hrs	CLOs
1	**Introduction:** Database-System Applications, Purpose of Database Systems, Database Languages, Database Design, Database and Application Architecture, Database Users and Administrators, History of Database Systems.	6	CLO1
2	**Introduction to the Relational Model**: Database Schema, Schema Diagrams, Relational Query Languages, The Relational Algebra.	8	CLO2
3	**Introduction to SQL:** Overview of the SQL Query Language, SQL Data Definition, Basic Structure of SQL Queries, SQL Data Types and Schemas, Index Definition in SQL, Accessing SQL from a Programming Language.	8	CLO1 CLO2
4	**Database Design Using the E-R Model:** Overview of the Design Process, The Entity-Relationship Model, Mapping Cardinalities, Primary Key, Extended E-R Features, Entity-Relationship Design Issues, Reducing E-R Diagrams to Relational Schemas	8	CLO3
5	**Relational Database Design:** Features of Good Relational Designs, Decomposition Using Functional Dependencies, Functional-Dependency Theory, Algorithms for Decomposition Using Functional Dependencies, Decomposition Using Multivalued Dependencies, Database-Design Process, Modeling Temporal Data.	8	CLO2 CLO3
6	**Application design and development :** Complex Data Types (Semi-structured Data, Object Orientation, Textual Data, Spatial Data), Application Development. **Stoarage manageemnt and indexing:** Physical Storage Systems, Data Storage Structures, Indexing, **Query processing and optimization:** Query Processing, Query Optimization, Transaction management:	6	CLO4

Textbooks:

1. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2011). Database system concepts. 7th EditionMcGraw-Hil.
2. Ramez Elmasri and Shamkant B. Navathe, Fundamentals of Database Systems, Pearson Education, 2008

Reference Books:

1. Teate RM (2021). SQL for data scientists: A beginner's guide for building datasets for analysis. Wiley.

STAT 1204: Algebra and Numerical Analysis

Title of the Course	Algebra and Numerical Analysis				
Course Code	STAT 1204				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is designed to acquire the necessary skills and ability to work further develop and apply problem solving skills in numerical methods by giving emphasize on non-linear equations, interpolation, differentiation, and integration.

Course Objectives (CO):
This course will improve the student's skills in numerical methods by using the numerical analysis with the help of statistical software.

Course Learning Outcomes (CLOs):
At the end of the course, the students will be able to:
CLO1: improve the student's skills in numerical methods by using numerical analysis with the help of statistical software.
CLO2: Know how to implement numerical methods on the specific problem.
CLO3: Know the flexible use of numerical methods in application to real problems.

S.N.	Course Contents	Hrs	CLOs
1	**Basic Concepts of Algebra:** Concepts of Equation, Binary Relation, Operation, Equivalence Relation, Properties of Real Numbers and complex numbers, Definition of Group and Field.	8	CLO1
2	**Central Difference Formula:** Gauss Formula, Stirling's Formula and Bessel's Formula with Equal and Unequal Interval of the Argument.	8	CLO2
3	**Divided Difference Formula:** Newton's General Interpolation Formula, Lagrange's Formula.	6	CLO3
4	**Inverse interpolation:** Lagrange's Formula, Newton's Divided Interpolation Formula, Successive Approximations and Reversion of Series.	6	CLO3
5	**Extrapolation:** Different methods of extrapolation.	6	CLO3
6	**Numerical differentiation and Integration:** General Quadrature Formula, Simpson's Rule, Weddle's Rule, Trapezoidal Rule. **Solution of Equations:** Numerical Solution of Equations by Various Methods (Method of False Position, Newton-Rapson	6	CLO3
7	Method and Method of Iteration, Convergence of these Methods and Their Inherent Errors, Numerical Solution of Simultaneous Linear Equations by Different Methods, Numerical Solution of Ordinary Differential Equations of First Order and of Second Order.	6	CLO3

Textbooks:

1. Stoer, J., &R. Bulirsch (2002).*Introduction to numerical analysis* (Vol. 12).Springer.

Reference Books:

1. Kuo, S. S. (1972): *Computer Applications of Numerical Methods Reading,* Addision-Wiley.
2. Scarborough, J. B. (1966): *Numerical Mathematical Analysis,* 6th ed. Johns Hopkins Press, Baltimore.
3. Scheld, F. (1988): *Schaum's Outline of Theory of Problems and Numerical Analysis,* McGraw Hill, Singapore.
4. Sastry, S. S. (1995): *Introductory Methods of Numerical Analysis,* 2nd ed. New Delhi, Prentice-Hall.
5. Hildeerbrand (1984): *Introduction to Numerical Analysis.*

STAT 1205: Stata and SPSS

Title of the Course	**Stata for Data Science**				
Course Code	STAT 1203				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This is an introductory course on the two popular statistical packages and students will learn to implement different statistical techniques using these packages.

Course Objectives (CO):
This course will help develop students' computing skills. In-depth knowledge of the course will enable students to analyse data from various sources.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: achieve basic skills in Stata/SPSS codes.
CLO2: learn how to analyse data from a survey/experimental study.
CLO3: to manage primary/secondary data to answer a specific query and learn implementation of a wide range of statistical techniques using SPSS and Stata.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Stata:** different windows and files, help file and searching for information; data entry, reading both Stata and and other format of data file, combining Stata files.	8	CLO1
2	**Exploring data:** example commands-browse, edit, list, sort, describe, assert, codebook; data management: creating a new data set specifying subsets of data with in and if qualifiers, generating and replacing variables, using functions based on egen command, converting numeric and string formats, creating new categorical and ordinal variables, reshaping or collapsing data, weighting observations, creating random data and random samples.	8	CLO2
3	**Graphs:** example commands- histograms, scatterplots, line plots, connected-line plots, two-way plots, box plots, combining graphs; exploratory data analysis: summary statistics and tables: example commands - summarize, tabstat, table; frequency tables and two-way cross tabulations, multiple tables and multi-way cross tabulations, tables of means, medians and other summary statistics.	8	CLO2 CLO3
4	**SPSS** Introduction to SPSS; data entry, reading SPSS and other data sets, import; defining the variable with labels and value labels; working with date and time variable; data matching across cases and variables; basic data management: transformation of data using different (numeric, arithmetic, statistical, and logical) expressions, operations, and functions; different commands in SPSS: get, save, save output, split files, sort cases, compute, recode, if, select if, do if, end if, list, aggregate, sample selection, report; graphical presentation: simple bar graphs, line graphs, graphs for cumulating frequency and pie graphs; exploratory analysis: frequencies, descriptive statistics, multiple response, bivariate analysis - crosstabs.	12	CLO2 CLO3

Textbooks:

1. Hamilton LC (2006). Statistics with Stata, Thomson Brooks/Cole.
2. Morgan GA, Barrett KC, Leech NL, and Gloeckner GW (2019). IBM SPSS for Introductory Statistics: Use and Interpretation, emph6th edition. Routledge.

Reference Books:

1. Acock AC (2010). A Gentle Introduction to Stata, *6th edition*. Stata Press.

STAT 1206: Bivariate Analysis Lab

Title of the Course	Bivariate Analysis Lab				
Course Code	STAT 1206				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical use of different methods and gives extensive training to the students so that they learn how to manage and analyze statistical data.

Course Objectives (CO): This course will help analyze statistical data.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data.
CLO2: know estimate summary statistics and forecasting from data and summarize statistical findings using graphs.

S.N.	Course Contents	Hrs	CLOs
1	Collection of simple data on at least two continuous and two qualitative variables by individual student, Preparation of scatter diagram showing all types of relationship between two variables, Preparation of Bivariate frequency table and computation of conditional means and conditional variances and drawing their graphs, Analysis of marginal distributions.	8	CLO1
2	Computation of all types of Correlation coefficients, Association, Independency, Consistency and Contingency analysis of attributes, Obtaining normal equations from a system of linear equations and their most plausible solution,	6	CLO2
3	Fitting of two and three variables regression models by the method of Least squares, Computation of partial and multiple correlation and regression coefficients and their interpretation-Three Variable Case, Residual analysis.	6	CLO2

Textbooks:

1. Dalgaard, Peter. *Introductory statistics with R*. springer publication, 2008.

Reference Books:

1. Ware, William B., John M. Ferron, and Barbara M. Miller. *Introductory statistics: A conceptual approach using R*. Taylor & Francis, 2013.

STAT 1207: Viva-Voce

Title of the Course	Viva-Voce
Course Code	STAT 1207
Credit Hours	**1.5**
Total Marks	**50**

3.2 Second Year

STAT 2101: Sampling Distributions

Title of the Course	**Sampling Distributions**				
Course Code	STAT 2101				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is designed to afford basic concepts and the application of transformation, sampling distribution and order statistics.

Course Objectives (CO):
The objective of this course is to familiar various probability distributions and sampling distributions. It includes deriving the properties of distributions, and interrelationship between them and focusing on their applications for exploratory analysis regarding the selection of appropriate distributions for explaining the random behaviour based on data and statistical inference. It also explores the application area of order statistics in real life and statistical theory.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the meaning of transformation of variables and sampling distribution.
CLO2: estimate the sampling distribution of mean, variance, correlation and regression coefficients.
CLO3: know the shape of sampling distribution to interpret the nature of statistical data.
CLO4: establish the interrelationship among $\chi^2, t \text{ and } F$.
CLO5: apply the sampling distributions in inferential statistics.
CLO6: Derive order statistics and related distribution.

S.N.	Course Contents	Hrs	CLOs
1	**Transformation of Variables:** Introduction, Distribution of function of random variable(s), Probability integral transformation, Transformation of variables-using Jacobian, Distribution function and moment generating function techniques, Problem on transformation of variables related to Binomial, Poisson, Uniform, Normal, Exponential, Gamma, Beta, Weibull and Extreme value distributions, Delta methods for finding mean and variance of function of random variable(s).	16	CLO1
2	**Introduction to Sampling distribution:** Meaning of parent and sampling distributions, statistic, population, sample. Exact sampling distribution related to normal population.	8	CLO2 CLO3
3	**Derivation of Sampling Distributions:** Methods of deriving sampling distribution (Fisher's lemma, $\chi^2, t \text{ and } F$ distributions) with their properties and applications. Relationship among $\chi^2, t \text{ and } F$ distributions	8	CLO3 CLO4
4	**Sampling Distributions in inferential statistics**: Distribution of sample mean, variance, Distribution of proportion and difference between two proportions, Distribution of Regression and correlation coefficients for null case.	16	CLO5
5	**Distribution of Order Statistics:** Introduction, Joint and marginal distributions of order statistics, Distribution of functions of order statistics, Illustrations from different parent distributions, Expected values and moments of order statistics, Applications.	8	CLO6

Textbooks:

1. Hogg, R. V. and A. T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson, Education, Asia.
2. Evans, M., N. Hasting and B. Peacock (2000): *Statistical Distributions*, 3rd ed., Wiley, New York.

Reference Books:

1. Robinson EA (2011). Probability Theory and Applications. Springer.

STAT 2102: Statistical Estimation

Title of the Course	**Statistical Estimation**				
Course Code	STAT 2102				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course describes estimation theory's main concepts and algorithms for practical application and research.

Course Objectives (CO):
This course aims to determine parameter values through measured and observed empirical data.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Understand all properties of a good estimator with application.
CLO2: Understand various methods of point estimators and their characteristics.
CLO3: Know how to detect the best estimates using nonparametric estimation.
CLO4: Understand interval estimators, confidence intervals and confidence limits of point and interval estimators.

S.N.	Course Contents	Hrs	CLOs
1	**Point Estimation:** Principle of point estimation, Unbiasedness, Consistency, Efficiency, Sufficiency, Factorization Criterion, Asymptotic efficiency, Minimum variance bound estimate, Cramer-Rao lower bound, Sufficiency and Completeness.	8	CLO1
2	**Methods of Point Estimation:** Introduction, Estimation methods– moments, maximum likelihood, minimum chi-square, least squares and Bayesian, with their properties, Minimax estimators, Point estimators concerning Bernoulli, binomial, Poisson, geometric, uniform, normal, exponential, gamma, beta and Weibull distributions.	10	CLO1 CLO2
3	**Nonparametric Estimation:** Basic ideas and methods of nonparametric estimation.	6	CLO3
4	**Interval Estimation:** Concepts of central and non-central confidence intervals, Estimation methods– Neyman classical, pivotal quantity, large sample, Bayesian and Fiducial, Confidence intervals for parameters of Bernoulli, binomial, Poisson, geometric, uniform, normal, exponential, gamma, beta and Weibull distributions.	6	CLO4

Textbooks:

1. Casella, G., & R. L. Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.
2. Hogg RV, McKean J and Craig AT (2019). Introduction to Mathematical Statistics, 8th Edition. Pearson.

Reference Books:

1. Lehmann, E.L. and G. Cassela (1998). *Theory of Point estimation*, Springer Verlag, NY.
2. Rao, C. R. (2009). *Linear statistical inference and its applications*. John Wiley & Sons.
3. Kendall & Stuart (2010): *Advanced Theory of Statistics*, Vol.1, 14th ed., Edward Arnold, N.Y. [Volume 01].

STAT 2103: Test of Hypothesis

Title of the Course	Test of Hypothesis				
Course Code	STAT 2103				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:

The course aims to provide the basics of hypothesis testing, with emphasis on some commonly encountered hypothesis tests in statistical data analysis, such as comparisons of averages, testing for variability, proportions, and significance.

Course Objectives (CO):

This course will also introduce parametric and nonparametric tests, including simple and composite hypotheses. Various test methods are introduced to test the hypothesis of statistical data.

Course Learning Outcomes (CLOs):

After successful completion of this course, students will be able to:

CLO1: Validate parametric and non-parametric tests for simple and composite hypothesis for large and small sample and interpret an applied problem, selecting the correct hypothesis test.

CLO2: Draw valid conclusions about hypotheses from the results of different statistical tests. Derive Neyman-Pearson Lemma and elucidate its applications to find BCR.

CLO3: Explain the LRT, their properties and applications and justify conclusions even when no scientific theory exists.

CLO4: Derive SPRT test for unknown sample size and explain its appropriate application.

CLO5: Understand the concept of nonparametric tests and explain their applications for small and large sample cases.

CLO6: Interpret the Bayesian predictive approach for testing the simple and composite null hypothesis.

S.N.	Course Contents	Hrs	CLOs
1	Basic concept, Idea of null and alternative hypotheses, Standard error, Test procedures, Probability value, Test of single proportion, mean and variance, Comparison of two and more proportions, means and variances, Test for correlation and regression coefficients, Contingency table, Test for independence and association of attributes in r x c contingency tables, Analysis of 2 x 2 contingency table by Yate's correction, Fisher's exact test in 2 x 2 contingency table, Test for association in three-way contingency tables, Small sample tests of significance, Large sample tests.	8	CLO1
2	Basic concept of parametric test, Simple and composite hypotheses, Errors in hypothesis testing, Test statistic, Critical region, Size of the test, Power, P-value,Best critical region (BCR), Power function, Power curve, Neyman- Pearson fundamental lemma, Most powerful critical region and test, Uniformly most powerful test, Two-sided BCR.	8	CLO2
3	Single mean test, equality of two means test, single variance test, equaity of two variances test, Correlation test, equality of two correlations test. Test of simple regression coefficients.proportion test, equality of two proportions test.	6	CLO2
3	Principles of likelihood ratio (LR) test, Distribution of LR statistic, Asymptotic distribution of LR statistic, Application of LR test, LR test in linear model.	6	CLO3
4	Introduction of sequential test, SPRT, OC and ASN functions. Exercise on Binomial, Poisson, Normal and Exponential distributions.	6	CLO4
5	Basic concept of Non-parametric Test, Comparison with parametric test, Sign, Run, Rank Sum, Randomization, Kolmogorov-Smirnov one and two samples, Kruskal-Wallis, Wilcoxon matched-pairs signed rank, Median, Mann- Whitney U, Rank correlation and goodness of fit tests.	6	CLO1 CLO5
6	Bayesian Hypothesis Testing, Introduction, Test of hypothesis concerning Normal and Exponential distributions in predictive approach.	4	CLO6

Textbooks:

1. Hogg RV, McKean J and Craig AT (2019). Introduction to Mathematical Statistics, 8th Edition. Pearson.
2. Casella, G., & R. L. Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.

Reference Books:

1. Rao, C. R. (2009). *Linear statistical inference and its applications*. John Wiley & Sons.
2. Kendall & Stuart (2010): *Advanced Theory of Statistics*, Vol.1, 14th ed., Edward Arnold,

STAT 2104: Differential Equations and Complex Variables

Title of the Course	Differential Equations and Complex Variables				
Course Code	STAT 2104				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course will illustrate the basic concept of differential equations and complex variables. It will also describe the solution procedure of differential equations and discuss the application of differential equations and complex variables in real-life data or any branch of science.

Course Objectives (CO):
This course aims to help students understand the origin and use of differential equations, the Laplace transform, linear algebra, and numerical methods for solving differential equations.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: enhance knowledge and understanding of differential equations and complex numbers.
CLO2: solve the functions of complex variables and continuity, differentiability and analyticity of such functions.
CLO3: solve complex integration problems.
CLO4: use differential equation models to solve practical problems including complex functions.
CLO5: Solve first-order differential equations using standard methods, such as separation of variables, integrating factors, exact equations, and substitution methods.
CLO6: Solve second and higher-order equations using reduction of order, undetermined coefficients, and variation of parameters.

S.N.	Course Contents	Hrs	CLOs
1	**Complex number:** Introduction, Properties of complex numbers, Differences with real number.	6	CLO1
2	**Complex functions:** Different functions, limit and continuity, Complex differentiation and Cauchy Riemann equations.	6	CLO2
3	**Complex integration:** Cauchy's integral, Morera's, Liouville's, Rouches's. Taylor's, Laurant's and Residue theorems. Evaluation of integrals, Elementary conformal transformations, Characteristic functions.	6	CLO3
4	**Differential Equation:** Basic concept, classification, origin and application of differential equation (DE), Nature and methods of solution, Initial and boundary value problems, Existence of solutions.	6	CLO4
5	**First-Order Differential Equation (DE):** Standard forms of first-order and exact DEs, Integrating factors, Separable and homogeneous equations, Linear DE, Bernoulli equations, Applications of first order DE- orthogonal and oblique trajectories.	6	CLO5
6	**Higher-Order Differential Equation:** Definition and basic existence theorem, Homogeneous equations, Reduction of order, Non-homogeneous equations, Homogeneous linear equation with constant coefficients, Method of undetermined coefficients, Variation of parameters, Cauchy- Euler equation, Application of DE in statistics.	6	CLO6

Textbooks:

1. Boelkins, M. R., J. L., Goldberg & M. C. Potter (2009). Differential equations with linear algebra. Oxford University Press USA.
2. Ross, S.L. (1989). Differential Equations, 4th ed., Wiley, N.Y.

Reference Books:

1. Arendt, W., C. J. Batty, M. Hieber, & F. Neubrander (2011). Vector-valued Laplace transforms and Cauchy problems. Springer.
2. Ayres, F. (1997). Differential Equations, Schaum's Outline Series, McGraw-Hill, NY.
3. Goodge, S.M. (2000). Differential Equations and Linear Algebra, Prentice Hall, N.J., USA.

STAT 2105: Programming with C++ and SQL

Title of the Course	Programming with C++ and SQL				
Course Code	STAT 2105				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides ideas on how to connect C++ programming with statistics through flowcharts and programming code execution using compilation, link, and run. It also teaches students how to analyse descriptive statistics and data analysis using C programming. This course is also designed to introduce students to SQL and its application in data science.

Course Objectives (CO):
This course aims to develop the basic concept of the C++ programming language and a comprehensive understanding of SQL and its pivotal role in data science.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: connect C programming with statistics through flowchart and programing code execution using compilation, link and run.
CLO2: how to analyse descriptive statistics and data analysis using C programming.
CLO3: understand the basic concepts of SQL and its application.

S.N.	Course Contents	Hrs	CLOs
1	**An overview of C:** the origins and importance of the C language, compilers versus interpreters; variables, constants, operators, and data types, declaration of variables, assignment statements, constants, operators, expressions.	6	CLO1
2	**Program control statements**: If-else statements, Nested of if-else statements, conditional statements, conditional operator, loop statements, break, continue and goto statement.	6	CLO1 CLO2
3	**Functions:** Definition of functions, Function declaration, Category of functions, the return statement, function arguments, arguments to main (), returning pointers, pointers to functions.	6	CLO1 CLO2
4	**Arrays**: single dimension arrays, passing single dimension arrays to functions, two and multi-dimensional arrays, arrays and pointers, allocated arrays, array initialization.	8	CLO1 CLO2
5	**Applications of C programming in data analysis:** Exploratory data analysis (EDA), data summary, e.g., mean, median, maximum, minimum, matrix operations, and calculation of different rates, correlation, and simple linear regression.	8	CLO1 CLO2
6	**SQL :** Introduction to Databases, SQL and MySQL, Creating a MySQL Database, MySQL Data Types, Table Creation, Populating and Modifying Tables, When Good Statements Go Bad, Query Mechanics, Query Clauses, The from Clause, The where Clause, The group by and having Clauses, The order by Clause.	8	CLO3

Textbooks:

1. Dietel PJ and Deitel HM (2010). C How to Program, 7th edition. Pearson.
2. Beaulieu A (2009). Learning SQL, 2nd edition. O'Reilly.

Reference Books:

1. Nell Dale, Chip Weems and Mark Headington (1998). Programming in C++, Narosa. London
2. Perry G and Miller D (2014). C Programming Absolute Beginner's Guide, 3rd Edition. Que.

STAT 2107: Test of Hypothesis Lab

Title of the Course	Test of Hypothesis Lab				
Course Code	STAT 2107				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for hypothesis testing.
Course Objectives (CO): This course introduces the practical application of parametric and nonparametric tests including simple and composite hypothesis. Various test methods are introduced for testing hypothesis of statistical data.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding Hypothesis testing.

S.N.	Course Contents	Hrs	CLOs
1	Large sample test of significance, small sample test of significance based on χ^2, t and F distributions, tests for several means and variances, test for independence and association in contingency table, exact test in a 2 x 2 contingency table, Parametric test, Likelihood ratio tests, SPRT, OC and ASN function and Bayesian hypothesis testing.	24	CLO1

Textbooks:
1. Hogg RV, McKean J and Craig AT (2019). Introduction to Mathematical Statistics, 8th Edition. Pearson.

Reference Books:
1. Casella, G., & R. L. Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.

STAT 2108: Programming with C++ and SQL Lab

Title of the Course	Programming with C++ and SQL Lab				
Course Code	STAT 2108				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course provides ideas on how to hands-on knowledge of C++ programming and SQL and their application in Statistics
Course Objectives (CO):
This course is aimed at developing real-life applications of C++ programming language and SQL
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Practical uses of C++ programming using various well-known statistical methods.
CLO2: Under

S.N.	Course Contents	Hrs	CLOs
1	Calculate descriptive statistics using C++ programming, Exploratory data analysis (EDA), data summary, e.g., mean, median, maximum, minimum, matrix operations, and calculation of different rates, correlation, and simple linear regression.	6	CLO1
2	SQL and MySQL, Creating a MySQL Database, MySQL Data Types, Table Creation, Populating and Modifying Tables,	8	CLO2

Textbooks:
1. Dietel PJ and Deitel HM (2010). C How to Program, 7th edition. Pearson.
2. Beaulieu A (2009). Learning SQL, 2nd edition. O'Reilly.

Reference Books:
1. Nell Dale, Chip Weems and Mark Headington (1998). Programming in C++, Narosa. London
2. Perry G and Miller D (2014). C Programming Absolute Beginner's Guide, 3rd Edition. Que.

STAT 2201: Regression Analysis

Title of the Course	**Regression Analysis**				
Course Code	STAT 2201				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is designed to provide an overview of the most common techniques used to quantify regression analysis and enlighten people on establishing relationships and model-building techniques.

Course Objectives (CO):
This course provides all the features of regression analysis, including how to apply and fit an appropriate regression model according to the nature of the data, critically analyze results obtained from fitting a regression model, and develop the capability of model-building strategies.

Course Learning Outcomes (CLOs):
Upon completion of the course, students are expected to know:
CLO1: learn about the concept of linear regression and correlation.
CLO2: learn about model formulation and fitting the model using least squares method.
CLO3: learn about polynomial regression model.
CLO4: model diagnosis and interpret the results.
CLO5: how to identify the best regression model.
CLO6: learn about non linear regression model.

S.N.	Course Contents	Hrs	CLOs
1	**Simple Linear Model:** Linear and Non-Linear Model, Regression Function and Model Building, Linear Regression, Least Square Estimators and Their Properties, Precision of the Estimated Regression Model, Lack of Fit and Pure Error, Inverse Linear Regression.	8	CLO1
2	**Multiple Regression Model:** Repeated Observations, Test of Linearity, Non-Linear Relations, Transformation of Variables, Three Variable Regression and Its Parameters' Estimation, Multiple Correlation Coefficient, Correlation Ratio, Inter and Intra-Class Correlation, Confidence Interval, Testing Hypothesis in Three Variable Regression Situation, General Linear Regression Model and Its Parameters' Estimation Using Ordinary Least Square Method (OLS), Properties of OLS Estimators, Orthogonal Columns in $X-$Matrix, Families of Transformations, Use of Dummy Variables in Multiple Regression, Confidence Interval, Testing Hypothesis in General Regression Situation, Weighted Least Squares, Restricted Least Squares, Errors in Predictors (as well as in Response), Inverse Regression (Multiple Predictors Case).	8	CLO2
3	**Polynomial Regression:** Polynomial Regression, Estimation and Interpretation of Coefficients.	12	CLO3
4	**Examination of Residuals:** Overall Plot, Time Sequence Plot, Plot against Regression Equation, Plot against Predictor Variables, Other Residual Plots, Statistics for Examination of Residuals, Correlations among Residuals, Outliers, Serial Correlation in Residuals, ExaMining Runs in Time Sequence Plot of Residuals, Durbin-Watson Test for a Certain Type of Serial Correlation, Detection of Influential Observations.	6	CLO4
5	**Selection of Best Regression Equation:** All Possible Regression, Best Set of Regression, Backward Elimination Procedure, Stepwise Regression Procedure, Ridge Regression, Predictor Sum of Squares, Principal Component Regression, Latent Root Regression, Stage-Wise Regression Procedure, Robust Regression.		CLO5
6	**Non-linear Estimation:** Least Squares in Non-linear Case, Estimating Parameters of Non-linear System, Re-parameterization of Model, Geometry of Linear Least Squares and Non-linear Least Squares, Non-linear Growth Models.		CLO6

Textbooks:

1. Weisberg S (2013). Applied Linear Regression, 4th edition. Wiley. Reference Books

Reference Books:

1. Montogomery DC, Peck EA, and Vining GG (2012). Introduction to Linear Regression Analysis, 5th edition. Wiley and Sons.
2. Draper NR and Smith H (1999). Applied Regression Analysis, 3rd edition. Wiley.

STAT 2202: Demography

Title of the Course	Demography				
Course Code	STAT 2102				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides valuable information about a country's socio-economic development, population growth and trends, and overall public health scenario.

Course Objectives (CO):
This course is planned to introduce the concepts of demography and demonstrate different demographic techniques for measuring population characteristics.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to
CLO1: unfold the fundamental concepts of demography.
CLO2: know the demographic data sources and collection procedure.
CLO3: assemble information about causes of errors in age data and their detection techniques
CLO4: identify essential thoughts about demographic measures and their consequences
CLO5: compute different measures and interpret different types of fertility, mortality, and migration data
CLO6: know the nuptiality measures, migration statistics and effect on population growth
CLO7: familiar with life tables, its construction, and analysis
CLO8: know the demographic transition theory and population projection

S.N.	Course Contents	Hrs	CLOs
1	**Basic concept of Demography:** Definition, role and importance of demographic/population studies; sources of demographic data: census, vital registration system, sample surveys, population registers and other sources especially in Bangladesh. Methods of Demographic Data Collection, Concept of De Facto and De Jure Population, Assessment of Quality of Demographic Data, Characteristics of Adequate Population Census, Vital Registration Method and Sample Surveys and their Advantages and Disadvantages, Characteristics of Demography, Age and Sex Composition structure, Population aging, Evaluation of Age and Sex data, Myer's index, Whipple's index, UN Age-Sex Accuracy index.	8	CLO1 CLO2 CLO3
2	**Errors in Demographic Data:** Sources of Type of Errors in Demographic Data and their Correlations, Age Heaping, Age Misstatement, Under Enumeration, Over Count etc., Application of Different Methods in Detecting Errors/Digital Preferences, Estimation Method of Under Count and Over Count.	6	CLO4
3	**Analysis of Demographic Events:** Nature of Demographic Events, Analysis of Fertility, Fecundity, Fecundabality and Reproduction, Various Measures of Fertility, Important Determinants of Fertility, Estimation of Mean Age at Childbearing, Concept of Mortality and Morbidity, Important Determinants of Mortality, Various Measures of Mortality and Morbidity, Force of mortality, Adjusted Measures of Morbidity, IMR and Its Components (Neonatal and Post-Neonatal Infant Mortality), Marriage, Divorce and Nuptiality, Migration.	8	CLO5 CLO6 CLO7
4	**Standardization:** Concept of Standardization in Demographic Measurements, Role of Standardization, Different Methods of Standardization with their Merits and Demerits, Stable Population and Its Properties, Lotke's and Derivation of Stable Population Model.	6	CLO5 CLO6 CLO7
5	**Life Table Analysis:** Life Table and Its Uses, Current and Cohort Life Table, Construction of Life Table, Life span and Life Expectancy, Applications of Life Tables in Population Studies, Model Life Tables, Study of Stationary, Stable and Quasi Stable Population Models, Graduation of Fertility and Mortality.	6	CLO8
6	**Population Projection and Estimation:** Nature and Methodology of Population Projection and Estimation, Evaluation of the Methods, Projection of Households and Families. Demographic Transition Theory.	4	CLO8

Textbooks:

1. Siegel JS and Swanson DA (2004). The Methods and Materials of Demography, 2nd edition. Emerald.
2. Swanson, D., & J. S. Siegel (2004). The methods and materials of demography. Elsevier Academic Press.

Reference Books:

1. Poston Jri. DL, and Bouvier LF (2016). Population and Society: An Introduction to Demography, 2nd edition. Cambridge University Press.
2. BBS and NIPORT, All Demographic Reports.
3. Goldmann, G. (2010). Principles of Demography.

STAT 2203: Real Analysis

Title of the Course	Real Analysis				
Course Code	STAT 2203				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction: To provide a continuation of the study of Real Analysis with emphasis on the transition from one to several variables and from real-valued to vector-valued functions.

Course Objectives (CO):
The course is designed to fill the gaps left in the development of calculus as it is usually presented in and elementary course and provide the background required for insight into more advanced level in pure and applied mathematics.

Course Learning Outcomes (CLOs):
On successful completion of the course, a student should be able to understand.
CL01: real-valued functions of several variables, with boundedness, limits, continuity, uniform continuity, directional and partial derivatives of a real-valued function of n variables,
CL02-03: differential calculus of vector-valued functions of several variables' differential of a vector-valued function as a linear transformation.
CL04-06: integral calculus of real-valued functions of several variables and multiple integrals, differentiation of functions matrices and quadratic forms and metric spaces, properties of a metric space and continuous on metric spaces.

S.N.	Course Contents	Hrs	CLOs
1	**Sets:** Function, relation, equivalence relation, Real valued function, Open set, Dense Set, Countability, Compact and connected sets, Monotonic class of sets, Additive class of sets.	4	CLO1
2	**Sequences and Series:** Introduction, Convergence principle, Convergence and absolute convergence of series, Comparison test, ratio test, Root test, Integral test, Rearrangement of absolute convergent series, Cauchy's convergence, Multiplication of absolutely convergent series, Abel's Lemma, Dirichlet's test, Abel's test for conditional convergent power series.	4	CLO2
3	**Real Functions:** Continuity, Properties of continuous functions, Uniform continuity, The Exponential, Logarithmic and Trigonometric functions, Derivatives, Rolle's theorem, Mean value theorems, Cauchy's mean value theorem, Taylor's theorem with Lagrange's and Cauchy's form of the remainder.	4	CLO3
4	**Riemann Integral:** The existence of the Riemann integral of a continuous function, Simple properties. First and second mean value theorem, Convergence and absolutely convergence of improper and infinite integrals, Sequences and series of functions, Uniform convergence, comparison test, Term by term integration and differentiation.	4	CLO4
5	**Differentiation:** Partial differentiation, Jacobians and its properties, Taylor's theorem for several variables, Principles of maxima and minima for several variables, Lagrange's multipliers, Local maxima and minima.	4	CLO5
6	**Multiple Integral:** Double integral, Triple integral, Line and surface integral.	4	CLO6

Textbooks:

1. Trench, W. F. (2012): Introduction to Real Analysis, Free Hyperlinked Edition 2.01.

Reference Books:

1. Goldberger, S (2012).: *Method of Real Analysis*, McGraw Hill, N.Y.
2. Gupta, S. L., Nissha Rani (1993): *Fundamental Real Analysis*, 3rd rev. ed. Vikas
3. Hardy, G.H. (1983): *A First Course in Pure Mathematics*. CUP, London
4. Hobson E. *The Theory of functions of a Real Variable and Theory of Fourier Series*

STAT 2204: Operation Research

Title of the Course	Operation Research				
Course Code	STAT 2204				
Credit Hours	3.0				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course aims to emphasize the application of operations research to solving business problems and introduce various statistical quality control tools and techniques, which are necessary skills for a quality professional.

Course Objectives (CO):
This course provides fundamental concepts for solving quality-related problems using operations research and statistical quality control tools.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the basic concepts and principles of operation research.
CLO2: formulate and solve various optimization problems using appropriate methods and software.
CLO3: analyze and interpret the solutions to optimization problems regarding their feasibility, optimality, sensitivity, and implications.

SL No.	Course Contents	Hrs	CLOs
1	**Operation Research:** Meaning and scope of operation research and basic elements of Linear Programming (LP). Mathematical concept of LP, Formulation of LP problems (LPP). Solution of LPP, Graphical and Simplex methods, Fundamental theorem of LP, Duality theorem, Sensitivity analysis, Parametric programming, Integer LP, Solution of mixed integer, Integer programming problem of cutting plane method, Transportation problem.	8	CLO1
2	**Linear programming:** formulation, graphical solution, simplex method, duality, and sensitivity analysis.	8	CLO2 CLO3
3	**Nonlinear Programming:** Introduction, Graphic solution method, General non-LPP, Mathematical background, Lagrange multipliers method, Kuhn- Tucker conditions, Quadratic programming (QP), Wolfe's modified simplex method, Beale's QPP algorithm.	8	CLO3
4	**Game Theory:** Basic concept, Two and n-persons zero-sum game, Game without saddle points, Graphic methods for 2 × n and m × 2 games, Minimax of saddle point theorems, Fundamental theorems of matrix games, Principle of dominance, Connection between games and LP.	8	CLO3

Textbooks:
1. Srinivasan, G. (2012). Operations Research: Principles and Applications, PHI Private Limited.

Reference Books:
1. Taha H. A. (2009). Operations Research: An Introduction, 10th ed., Prentice Hall, N.Y.

STAT 2205: Programming with R and Python

Title of the Course	Programming with R and Python				
Course Code	STAT 2205				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course briefly introduces programming in R and Python and its applications in data science and analytics.

Course Objectives (CO):
This course covers the practical applications of statistical data analysis using R and Python programming. It covers the basics of R and Python programming, creating objects, writing functions, reading/creating data sets, basic programming, creating plots, and statistical data analysis.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the fundamentals of R and Python programming.
CLO2: produce insights from data through exploratory data analysis.
CLO3: create effective data visualizations using R and Python.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to R**: History and overview of R programming language, R objects, data structure (e.g., lists, data frames, etc.), reading and writing data files, subsetting R objects, vectorized operations, control structures, functions (both in-built and custom), simulation, and calling C function from R.	6	CLO1
2	**Exploratory data analysis with R:** managing data with different tidyverse packages (e.g., dplyr, ggplot2, etc.), exploratory graphs (grammar of graphics), and generating summary statistics.	8	CLO2 CLO3
3	**Application of R**: optimizing non-linear functions using Newton-Raphson iterative procedure, numerical integration and differentiation.	8	CLO2
4	**Fundamentals of Python:** Installing Python and Jupyter Notebook; the basic syntax of a Python program, Python data types; expressions and variables; lists, tuples, sets, and dictionaries; writing conditions, loops, and functions.	8	CLO1
5	**Studying python Packages:** Numpy, Scipy, scikit-learn, Pandas, Matplotlib, Seabon etc. with image analysis tools. **Numeric Python:** Basic concept of numpy, array with its operations, vectorized operations, matrix operations, example with univariate and multivariate statistics. **Data analysis with NumPy and pandas:** installing NumPy and pandas, NumPy arrays; indexing, slicing, and iterating NumPy arrays; arithmetic and matrix operations with NumPy; pandas objects– DataFrame, Series, and Index; data indexing and selection; handling missing data; combining and joining datasets, aggregation and grouping, exploratory data analysis. **Data visualization with matplotlib and seaborn:** Bar plots, histograms, density plots. Boxplots and scatterplots	8	CLO2 CLO3
6	**Conditional Execution and Iteration:** Boolean expressions, ehe if and if/else statements, compound Boolean expressions, nested conditionals, multi-way decision statements, conditional expressions, the while statement, definite loops vs. indefinite loops, for statement, nested loops, abnormal loop termination.	8	CLO2 CLO3

Textbooks:

1. Wickham H and Grolemund G (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly.
2. McKinney W. (2022). Python for data analysis: Data wrangling with Pandas, NumPy, and Jupyter, *3rd edition*. O'Reilly.

Reference Books:

1. Wickham H (2019). Advanced R, Second Edition. Chapman & Hall/CRC.
2. Grus, J. (2019). Data science from scratch: First principles with python. O'Reilly.

STAT 2206: Regression Analysis Lab

Title of the Course	Regression Analysis Lab				
Course Code	STAT 2206				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical use of different regression methods for forecasting purposes.
Course Objectives (CO): This course aims to provide data analysis skills with regression techniques.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding regression problem.
CLO2: know regression diagnostics tools and techniques.

S.N.	Course Contents	Hrs	CLOs
1	OLS estimation of general linear regression model, fitting of polynomial regression model and orthogonal polynomial, fitting of two and three variables regression models by the method of Least squares when the models are linear in parameters and linear in variables, Computation of partial and multiple correlation and regression coefficients and their interpretation-Three Variable Case, Residual analysis.	12	CLO1
2	Regression with dummy independent variables, Detection of heteroscedasticity and GLS estimation of the model, Detection of autocorrelation and remedial measures, Variable selection and model building.	12	CLO2

Textbooks:
1. Dalgaard, Peter. *Introductory statistics with R*. springer publication, 2008.

Reference Books:
1. Ware, William B., John M. Ferron, and Barbara M. Miller. *Introductory statistics: A conceptual approach using R*. Taylor & Francis, 2013.

STAT 2207: Demography Lab

Title of the Course	Demography Lab				
Course Code	STAT 2208				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical use of different statistical methods to manage and analyze demographic data.
Course Objectives (CO): This course aims to provide skills for demographic data analysis.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from demographic data.

S.N.	Course Contents	Hrs	CLOs
1	Presentation of Population and Demographic Data by Graphs and Charts, Computations of Population Change and Growth rates, Computation of Aging Indices, Evaluation of Age and Sex Data by Whipple's, Myer's and UN Age Sex Accuracy Indices.	12	CLO1
2	Analysis of Marriage and Divorce Rates, Computation of different Measures of Fertility and Reproduction from vital registration and census data (such as CWR, CBR, ASFR, ASMFR, TFR, GFR, GRR, NRR and PPR), Computation of Different measures of Mortality CDR,ASMR, IMR, Neonatal, Perinatal death rates Standardization of Birth, Death, Marriage and Divorce Rates, Construction of Complete and Abridged life Tables, Estimates of Migration by survival methods, Population Estimates & Projection using Mathematical Methods.	12	CLO1

Textbooks:
1. Poston Jri. DL, and Bouvier LF (2016). Population and Society: An Introduction to Demography, 2nd edition. Cambridge University Press.

Reference Books:
1. BBS and NIPORT, All Demographic Reports.

STAT 2208: Programming with R and Python Lab

Title of the Course	Programming with R and Python				
Course Code	STAT 2207				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course provides practical applications of programming in R and Python

Course Objectives (CO):
This course covers the practical applications of statistical data analysis using R and Python programming. It covers apply the basics of R and Python programming, creating objects, writing functions, reading/creating data sets, basic programming and create plots and statistical data analysis.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the fundamentals of R and Python programming.
CLO2: produce insights from data through exploratory data analysis.
CLO3: create effective data visualizations using R and Python.

S.N.	Course Contents	Hrs	CLOs
1	Managing data with different tidyverse packages (e.g., dplyr, ggplot2, etc.), exploratory graphs (grammar of graphics), and generating summary statistics. optimizing non-linear functions using Newton-Raphson iterative procedure, numerical integration and differentiation.	**8**	CLO1 CLO2
2	Installing NumPy and pandas, NumPy arrays; indexing, slicing, and iterating NumPy arrays; arithmetic and matrix operations with NumPy; pandas objects– DataFrame, Series, and Index; data indexing and selection; handling missing data; combining and joining datasets, aggregation and grouping, exploratory data analysis. Bar plots, histograms, density plots. Boxplots and scatterplots	**8**	CLO2 CLO3

Textbooks:

3. Wickham H and Grolemund G (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly.
4. McKinney W. (2022). Python for data analysis: Data wrangling with Pandas, NumPy, and Jupyter, *3rd edition*. O'Reilly.

Reference Books:

3. Wickham H (2019). Advanced R, Second Edition. Chapman & Hall/CRC.
4. Grus, J. (2019). Data science from scratch: First principles with Python. O'Reilly.

STAT 2209: Viva-Voce

Title of the Course	**STAT 2209: Viva-Voce**
Course Code	STAT 2209
Credit Hours	**1.5**
Total Marks	**50**

3.3 Third Year

STAT 3101: Design of Experiments

Title of the Course	Design of Experiments				
Course Code	STAT 3101				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course introduces the concept of response variables, factors, variability, and the process of partitioning variances due to group memberships and compares those to total variability. Students will learn basic concepts of design, the requirements of a good experimental design, analyze real data with standard experimental designs, and check their statistical properties.

Course Objectives (CO):
This course is aimed at providing the basic requirements of experimental design and how to construct an experimental design model. It also aims to develop a strong and competent knowledge of analyzing data using CRD, RBD, LSD, and analysis of covariance (ANCOVA) and to gain knowledge about the tools and techniques for analyzing real data and testing their significance.

Course Learning Outcomes (CLOs):
After completing the course, the students are expected to
CLO1: understand design and Analysis of Variance and analyze the data from such experiments and interpret the results.
CLO2: understand the concept of Analysis of Covariance
CLO3: design the experiments involving up to two and three factors with k levels.
CLO4: understand the concept of Orthogonal Design
CLO5: understand design and analysis the fractional factorial experiments for k factors each with two levels and the experiments involving random factors.

S.N.	Course Contents	Hrs	CLOs
1	**Analysis of Variance:** Definition, Assumptions, Analysis of variance (ANOVA) corresponding to one-way, two-way and three-way classifications, fixed, random and mixed effect models, Parametric function and contrasts, Variance components analysis.	8	CLO1
2	**Analysis of Covariance:** Introduction, Concomitant variable, Analysis of covariance in one-way, two-way and three-way classifications with one concomitant variable.	6	CLO2
3	**Experimental Design:** Basic concept, Principles of experimental design, Requirements of a good experiment.	8	CLO3
4	**Orthogonal Design:** Completely randomized design, Randomized block design, Analysis including interaction effects, Latin square design, Efficiency of a design, Missing plot technique in RBD and LSD.	8	CLO4
5	**Factorial Experiment:** Basic ideas, description and analysis of 2^p, 3^p , p×q factorial experiments, Confounding, Split plot design.	6	CLO5

Textbooks:

1. Montgomery DC (2019). Design and Analysis of Experiments, 10th edition. Wiley.
2. Cohran and Cox (2000): *Experimental Design*, 2nd ed., John Wiley, N.Y.

Reference Books:

1. Dean AM, Voss AM, and Dragulji´c (2017). Design and Analysis of Experiments, 2nd edition. Springer.
2. Gerber, A. S., & D. P. Green (2012). *Field experiments: Design, analysis, and interpretation*. New York: WW Norton.
3. Ryan, T. P., & Morgan, J. P. (2007). *Modern experimental design*. John Wiley & Sons, Inc., Hoboken, New Jersey.

STAT 3102: Stochastic Processes

Title of the Course	Stochastic Processes				
Course Code	STAT 3102				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course introduction:
This course bridges and accommodates the methods and applications of stochastic processes.

Course Objectives (CO):
This course is designed to give a basic idea about stochastic processes, which include generating functions, Limit Theorems, Recurrent Events, the Random Walk and Rust Problem, Markov Chains, Homogeneous Markov Processes, Point Processes, and Branching Processes.

Course Learning Outcomes (CLOs):
At the end of the course, the students will be able to
CLO1: Know when it is appropriate to use probability generating function.
CLO2: Know the concept of stochastic process and related concepts.
CLO3: understand the concept of Markov chain and statistical inference about Markov chains.
CLO4: Elements of stochastic processes with applications to the natural sciences.
CLO5: understand the concept and application of point and branching process.

Course Content

S.N.	Course Contents	Hrs	CLOs
1	**Generating Functions:** Characteristic function, Probability generating function (p.g.f), Convolution, Inversion Theorem.	4	CLO1
2	**Limit Theorems:** Mutual independence of random variables, Convergence of sequence of random variables, Laws of large numbers, Central limit theorem.	6	CLO2
3	**Stochastic Processes:** Definition, Classifications, Renewal equation, Delayed recurrent events, Number of occurrences of a recurrent event. Application to the theory of success runs.	6	CLO3
4	**Random Walk and Ruin Problem:** The classical ruin problem, Expected duration of the game. Generating functions for the duration of the game and for the first- passage times.	6	CLO2
5	**Markov Chains:** Transition matrix. Higher transition probabilities, Classification of states and chains, Ergodic properties, Evaluation of P^n. Finite Markov Chains: General Theory of random walk with reflecting barriers, transient states, Absorption probabilities, Application to recurrence times.	6	CLO3
6	**Homogeneous Markov processes:** Poisson process, Simple birth process, Simple death process, Simple birth-death process, Effect of immigration, Queuing process, Single server queues, Equilibrium theory, Queues with many servers, Limiting properties of queues.	6	CLO4
7	**Point process:** Stationary point process, Renewal process, doubly stochastic process. Branching process: Structure of the process, Branching process, Age dependent branching process, Branching renewal process.	6	CLO5
8	**Branching Process:** Structure of process, Age dependent branching process, Branching renewal process.	6	CLO5

Textbooks:

1. Ross, S.M. (2003): *Introduction to Probability Models*, 8th ed. Academic Press

Reference Books:

1. Ross, S. M. (2001). *Stochastic Processes*, Academic Press, N.Y.
2. Gikhman, I. I., &A. V. Skorokhod (2004).*The Theory of Stochastic Processes*.Springer.

STAT 3103: Generalized Linear Model

Title of the Course	**Generalized Linear Model**				
Course Code	STAT 3103				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course deals with different statistical models for analyzing quantitative and qualitative data, which are usually encountered in research.

Course Objectives (CO):
The course aims to generate a strong and effective theoretical background to understand the underlying methodologies of statistical methods including the general linear model.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: derive and work with sampling distributions of binary or categorical measures.
CLO3: develop knowledge of mixed effects models.
CLO4: familiar with a variety of methods for analyzing Binary Data
CLO5: familiar with a variety of methods for analyzing Ordered Data
CLO6: familiar with a variety of methods for analyzing categorical or count data.

S.N.	Course Contents	Hrs	CLOs
1	**Probability Distributions and Statistical Inference for Categorical Data:** Categorical response data, Distributions for categorical data (Bernoulli distribution, multinomial distribution), Statistical inference for categorical data, Statistical inference for a proportion, Contingency Tables, Comparing proportions, Chi-squared tests, Exact tests for small samples, Correlation for categorical data.	8	CLO1 CLO2
2	**Linear mixed effects models:** Introduction, random effects covariance structure, prediction of random effects, residual analysis, and diagnostics.	6	CLO3
3	**Generalized linear model (GLMs) for Binary Data: Binary Logistic Regression** Components of generalized linear model, GLMs for binary data, fitting generalized linear models, Logistic Regression, Probit, Odds and Odds ratios, Logistic regression for classification, Inference for logistic regression, Categorical predictors, Summarizing effects, Strategies in model selection, Model checking.	6	CLO4
4	**GLMs for Ordered Data: Ordered Logit** A latent variable model for ordinal variables, Identification, Estimation, Maximum Likelihood Estimation, The parallel regression assumption.	6	CLO5
5	**GLMs for Nominal Responses: Multinomial Logit** Logit models for nominal responses, The multinomial logit model, Maximum Likelihood Estimation, The Independence of Irrelevant Alternatives, The conditional logit model.	6	CLO6
6	**GLMs for Count Data:** The Poisson distribution. The Poisson model. The Negative Binomial model. Beta Regression. Gamma Regression. Models for truncated counts. Zero-inflated models. Poisson-Beta model, Gamma-Poisson model.	7	CLO6

Textbooks:

1. Dobson AJ and Barnett AG (2008). An Introduction to Generalized Linear Models, 3rd edition. Chapman & Hall.
2. McCullagh P and Nelder JA (1989). Generalized Linear Models, 2nd edition. CRC Press.

Reference Books:

1. Agresti, A. (2012): Categorical Data Analysis, 3nd Edition, John Wiley and Sons, New York.

STAT 3104: Sampling Techniques

Title of the Course	Sampling Techniques				
Course Code	STAT 3104				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides an overview of survey methods, aiming to introduce students to the principles and practices of designing, conducting, and analyzing surveys.

Course Objectives (CO):
This course covers sampling design and analysis methods useful for research and management in many fields.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: know about the necessity of sample survey, steps of conducting a survey, and explain the basic concepts and terminology of survey research.
CLO2: learn different approaches to design a survey.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction:** concept of sampling, and definition of related terms; role of sampling theory, requirements of a good sampling design, steps in a sample survey, probability and nonprobibility sampling, selection (draw-to-draw) and inclusion probability, sampling weight, with and without replacement sampling, characteristics of estimate: bias, mean square error and variance (precision), errors in sample survey and census, sample size determination: basics and complex scenarios.	6	CLO1
2	**Simple random sampling (SRS):** sample selection, estimation: mean, total, proportion, ratio of two quantities, unbiasedness, and variances/standard errors (SEs) of the estimators, estimators of the SEs, confidence interval (normal approximation); finite population correction, estimation over subpopulation, computation: inclusion probabilities and sampling weights, Ratio and regression methods of estimation.	6	CLO1 CLO2
3	**Systematic sampling:** motivation, use and challenges, sample selection, different estimators and their unbiasedness and variances, estimator of the variances, comparison with SRS, sampling from population with linear trend, Circular systematic sampling.	6	CLO1 CLO2
4	**Stratified random sampling:** concept, reasoning and needs in heterogeneous population, number and formation of strata, sample selection, estimators (total, mean, proportion), variances of the estimators, estimators for the variances, different allocation techniques, comparison with SRS, design effect and its uses, poststratification, quota sampling.	6	CLO1 CLO2
5	**Cluster sampling:** motivation and reasoning, formation, and size of clusters; cluster sampling with equal sized clusters: estimators and their various properties (unbiasedness, variance and estimated variance), comparison with SRS and systematic sampling, optimum cluster size, stratification in cluster sampling: estimation and comparison with simpler sampling designs.	6	CLO1 CLO2
6	**Non-probability sampling:** Purposive/Judgement sampling, Quota sampling, Convenience sampling.		CLO1 CLO2
6.	**Special sampling designs:** capture-recapture sampling: implementation, Peterson and Chap- man estimators for population size and their variances, Hypergeometric and Multinomial models for estimating population abundance; ranked set sampling: sample selection and estimation, different kinds of non-probability sampling design.	6	CLO1 CLO2

Textbooks:

1. Thompson SK (2002). Smapling. 2nd edition. Wiley.
2. Cochran WG (1977). Sampling Techniques, 3rd edition. Wiley.

Reference Books:

1. Lohr SL (1998). Sampling: Design and Analysis. Duxbury.
2. Levy PS and and Lemeshow S (2008). Sampling of Populations: Methods and Applications, 4th edition. Wiley.
3. Rao PSRS (2000). Sampling Methodologies with Applications, 1st edition. Chapman & Hall/CRC.

STAT 3105: Introduction to Data Science

Title of the Course	**Introduction to Data Science**				
Course Code	STAT 3105				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:

This course provides a broad but thorough introduction to the methods and practice of basic data science and its core methods, models, and algorithms.

Course Objectives (CO):

The course aims to provide applied statistics students with detailed knowledge of analyzing large, high-dimensional, and big data sets and to let computers perform tasks that traditional computer science methods are unable to address.

Course Learning Outcomes (CLOs):

After successful completion of this course, students will have the knowledge and skills to:

CLO1: concept of Artificial Intelligence, Big Data, and their areas.

CLO2: design and implement various statistical machine-learning algorithms in real-world applications.

CLO3: evaluate the performance of various statistical machine learning algorithms and identify and implement advanced computational methods in machine learning.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to data science**: Data science concept and its life cycle; big data and its sources; explain and demonstrate the value of data in assessing problems and supporting scientific, commercial, social, and artistic problem-solving; distinguish between different types of data that are generated in science, engineering, and design; identify the types of questions that can be asked of data in satisfaction of a particular information goal; Employ strategies for ensuring data quality. Identify aspects of data governance to judge whether and how data can be used in analyses.	8	CLO1
2	**Artificial Intelligence and Big Data:** Overview of basic concepts and techniques of Artificial Intelligence (AI), including its history and applications, and statistical machine learning. Data science concepts and their application areas. Overview of supervised and unsupervised learning.	8	CLO1 CLO2
3	**Big data:** Overview of Big Data, including its definition, sources, characteristics, and the challenges associated with processing and analyzing large datasets. Big data applications: examples and use cases. The Hadoop framework and its various components include HDFS, MapReduce, YARN, and Hive.	8	CLO3
4	**Statistical learning:** Statistical learning and regression, the curse of dimensionality and parametric models, assessing model accuracy and bias-variance trade-off, classification problems, and K-nearest neighbors.	8	CLO3
5	**Dimension reduction and unsupervised machine learning techniques:** Techniques to reduce the dimension of data, principal components and principal components regression and partial least squares. Clustering (K-means, Fuzzy C-means, Hierarchical Clustering). Introduction to Decision trees and Classification trees. Statistical machine learning case studies in R.	8	CL03

Textbooks:

1. Witten IH, Frank E, and Hall MA (2016). Data Science: An Introduction. John Wiley & Sons Inc.

Reference Books:

1. Bart Baesens, (2014), *Analytics in a Big Data World: The Essential Guide to Data Science and its Applications,* Wiley
2. Hrushikesha Mohanty, Prachet Bhuyan and Deepak Chenthati, (2015), *Big Data a Primer*, Springer.

STAT 3106: Design of Experiments Lab

Title of the Course	**Design of Experiments Lab**				
Course Code	STAT 3106				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for the analysis of variance.
Course Objectives (CO):
This course aims to enhance the basics of designing experiments and performing statistical data analysis.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding analysis of variance and design of experiment-related problems.

S.N.	Course Contents	Hrs	CLOs
1	Analysis of variance of one way, two way and three-way classified data, Analysis of variance of CRD, RBD and LSD, Estimates of one missing value in RBD and LSD and ANOVA of these designs, Analysis of factorial experiments and total and partial confounding, Covariance analysis of one way and two-way classified data with one concomitant variable.	12	CLO1

Textbooks:
1. Montgomery DC (2019). Design and Analysis of Experiments, 10th edition. Wiley.

Reference Books:
1. Dean AM, Voss AM, and Dragulji´c (2017). Design and Analysis of Experiments, 2nd edition. Springer.
2. Bailey R (2008). Design of Comparative Experiments. Cambridge.

STAT 3107: Stochastic Processes Lab

Title of the Course	**Stochastic Processess Lab**				
Course Code	STAT 3107				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for stochastic processes.
Course Objectives (CO):
This course covers the practical applications of stochastic processes.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding stochastic process-related problems.

S.N.	Course Contents	Hrs	CLOs
1	Markov-Chain, Closed Sets, Classification of States, Properties of States, Chapman-Kolmogorov Equations, First Entrance Decomposition Formula. Ergodic Properties of Irreducible Chains, Higher Order and Secondary Probability, Recurrent Events, Delayed Recurrent Events, Periodic Chains, Transient and Recurrent States, Gambler's Ruin Problem, Estimating Transition Probabilities of Markov Chain, Asymptotic Behavior of $P_1 p$, Determination of Different Properties of Transition Probability Matrix, Homogeneous and Non-Homogeneous Poisson Process, Determination of Steady State Probabilities for Different Queuing Systems.	24	CLO1

Textbooks:
1. Jones PW and Smith P (2018). Stochastic Processes: An Introduction, 3rd Edition. Routledge.

Reference Books:
1. Grimmett G and Stirzaker D (2001). Probability and Random Processes, 3rd edition. Oxford.

STAT 3108: Generalized Linear Model Lab

Title of the Course	**Generalized Linear Model Lab**				
Course Code	STAT 3108				
Credit Hours	1.5				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course deals with using different statistical models to analyze quantitative and qualitative data.

Course Objectives (CO):
The course aims to generate a strong and effective real-life applications background to understand the underlying methodologies of statistical methods, including the generalized linear model.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: derive and work with probability distributions of binary or categorical measures.
CLO2: develop knowledge of mixed effects models.

S.N.	Course Contents	Hrs	CLOs
1	Practical knowledge about Probability Distributions and Statistical Inference for Categorical Data for categorical data, Statistical inference for a proportion, Contingency Tables, Comparing proportions, Chi-squared tests, Exact tests for small samples, Correlation for categorical data., random effects covariance structure, prediction of random effects, residual analysis, and diagnostics.	8	CLO1 CLO2
2	Research based knowledge about Binary Logistic Regression, Multinomial Logistic Regression, Probit, Odds and Odds ratios, Logistic regression for classification, Inference for logistic regression, Categorical predictors, Summarizing effects, Strategies in model selection, Model checking.	6	CLO2

Textbooks:

1. Dobson AJ and Barnett AG (2008). An Introduction to Generalized Linear Models, 3rd edition. Chapman & Hall.
2. McCullagh P and Nelder JA (1989). Generalized Linear Models, 2nd edition. CRC Press.

Reference Books:

1. Agresti, A. (2012): Categorical Data Analysis, 3nd Edition, John Wiley and Sons, New York.

STAT 3201: Time Series Analysis

Title of the Course	**Time Series Analysis**				
Course Code	STAT 3201				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course introduces the basic concepts and methods of time series analysis which is widely used in various fields, such as economics, finance, engineering, biology, and social sciences, to model and forecast trends, cycles, seasonality, and other patterns in the data.

Course Objectives (CO):
The course covers stationarity, autocorrelation, autoregressive and moving average models, ARIMA models, trend and seasonality decomposition, exponential smoothing methods, and forecasting evaluation. The course also introduces some advanced topics, such as spectral analysis, state-space models, and multivariate time series analysis. The course emphasizes both theoretical understanding and practical applications of the methods using real-world data sets and software tools.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Understand the basic concepts and properties of time series data.
CLO2: Apply appropriate methods to model and forecast time series data**.**
CLO3: Evaluate the performance and validity of time series models**.**
CLO4: Interpret and communicate the results of time series analysis.
CLO5: Conduct independent research on a topic related to time series analysis**.**

S.N.	Course Contents	Hrs	CLOs
1	**Introduction and examples of time series:** simple descriptive techniques: time series plots, trend, seasonal effects, sample autocorrelation, correlogram, filtering.	8	CLO1
2	**Probability models:** stochastic processes, stationarity, second-order stationarity, white noise model, random walks, moving average (MA) processes, autoregressive (AR) processes, ARMA processes, seasonal ARMA processes, the general linear process; properties, estimation and model building, diagnostic checking.	8	CLO2 CLO3 CLO4
3	**Forecasting:** naive procedures, exponential smoothing, Holt-Winters, Box-Jenkins forecasting, linear prediction, forecasting from probability models.	8	CLO2 CL04
	Non-stationary time series: non-stationarity in variance-logarithmic and power transformations; non-stationarity in mean; deterministic trends; integrated time series; ARIMA and seasonal ARIMA models; modelling seasonality and trend with ARIMA models. **Stationary processes in the frequency domain:** the spectral density function, the periodogram, spectral analysis.	12	CLO2 CL04 CL05
4	**Advanced Topics in Time Series Analysis:** Spectral analysis and frequency domain methods, State-space models and Kalman filter, Multivariate time series analysis, Vector autoregressive (VAR) models, Cointegration and error correction models.	8	CLO2 CLO3 CLO4 CLO5

Textbooks:

1. Jonathan DC and Kung-Sik C (2008). Time Series Analysis - With Applications in R. Springer.
2. Spyros M, Steven W and Rob H (1997). Forecasting – Methods and Applications, 3rd edition. Wiley.

Reference Books:

1. Chatfield C (2003). The Analysis of Time Series, 6th edition. Chapman & Hall.
2. Shumway RH and Stoffer DS (2011). Time Series Analysis and Its Applications: With R Examples. Springer.
3. Brockwell PJ and Davis RA (2002). Introduction to Time Series and Forecasting. 3rd edition. Springer.

STAT 3202: Non-Parametric and Robust Statistics

Title of the Course	Non-Parametric and Robust Statistics				
Course Code	STAT 3202				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course is designed to help learners acquire knowledge of Non-parametric and Robust Statistics, which will help them apply robust estimation techniques for outlying data.

Course Objectives (COs):
- Help to make the learners able to learn robust methods that deal with all types of statistical data
- Answer the issue of outliers in experimental data
- Robust statistics as a tool helps in identifying the right parameter estimate which describes the majority of the data
- help to identify the effect of individual points, and hence the outliers

Course Learning Outcomes (CLOs):
By the end of this course, you should be able to:
CLO1 - explain why robust statistical methods are used
CLO2 - measure robustness and use robust estimators.
CLO3 - select appropriate algorithms for robust estimators
CLO4 – learn how the robustness of the estimators can be measured
CLO5 – measure and apply robust regressions for bivariate data

S.N.	Course Contents	Hrs	CLOs
1	**Introduction:** Definition and aims of non-parametric and robust statistics, classical versus robust approaches to statistics, outliers, detection of outliers, the three-sigma edit rule	8	CLO1
2	**Location:** Robust location and dispersion estimates, M-estimates of location with known scale, Trimmed means.	8	CLO2
3	**Scale:** Dispersion estimates, M-estimates of scale, M-estimates of location with unknown scale	8	CLO2 CLO3
4	**Location and Scale**: Simultaneous M-estimates of location and scale, numerical computation of M-estimates	12	CLO3 CLO4
5	**Measuring robustness:** Influence function, breakdown point, maximum asymptotic bias, balancing robustness and efficiency.	8	CLO4
6	**Correlation and regression:** Robust correlation estimates, linear regression models with fixed predictors: regression M-estimates; model with random predictors: MM-estimate, LMS estimate, S-estimate, LTS estimate, tau-estimate.	8	CLO5

Textsbooks
1. Maronna, R.A., Martin, R. D. and Yohai, V. J. (2006), *Robust Statistics: Theory and Methods*, John Wiley & Sons.

References
1 Hampel, F.R., Ronchetti, E.M., Rousseeuw, P.J. and Stahel, W.A. (1986), *Robust Statistics: The Approach Based on Influence Functions*, John Wiley & Sons.
2 Huber, P.J. (1981), *Robust Statistics*, John Wiley & Sons.

STAT 3203: Simulation and Modeling

Title of the Course	**Simulation and Modeling**				
Course Code	STAT 3203				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course introduces basic simulation methods and tools for modeling and simulation of continuous, discrete and combined systems.

Course Objectives (CO):
This course provides the foundations for the students to understand computer simulation needs, and to implement simulations for a variety of real-world problems by choosing a model that is realistic replica of the actual situation and choosing one whose mathematical analysis is tractable.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to
CLO1: Understand the basic concepts of systems, models, and simulation.
CLO2: Introduce to simulation and its nature with advantages and disadvantages.
CLO3: Apply simulation in queuing and inventory system.
CLO4: Generate random numbers by different generators with its validity test.
CLO5: Generate continuous and discrete random variates from different probability distributions.
CLO6: Generate random numbers using Monte Carlo simulation method.
CLO7: Create various types of simulation models. Apply different simulation model Verification and Validation technique for accuracy.
CLO8: Develop simulation model, algorithm, and computer programs for performing statistical analysis of outputs from intended simulations.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Simulation:** Basic concepts of systems, models, and simulation, discrete and continuous systems simulation, purposes of simulation, advantages and disadvantages of simulation, steps in a simulation study, simulation application examples - queuing system, inventory system, Monte Carlo simulation.	8	CLO1 CLO2 CLO3
2	**Random number generator:** Introduction, linear congruential generator: Mixed and multiplicative generator. Tests for random numbers: Frequency test (Chi-Square test, Kolmogorov-Smirnov test), Runs test, Autocorrelation test, Gap test, Poker test, etc.	6	CLO4
3	**Methods for generating random variates**: Inverse transformation, composition, convolution, acceptance-rejection, comparison of the methods.	6	CLO5
4	**Applications of probability distributions in simulation:** Uniform, Weibull, Gamma, Normal, Lognormal, Exponential, Beta, Binomial, Poisson, Geometric, Negative Binomial etc. Monte Carlo Simulation Method. Monte Carlo integration. MCMC method.	8	CLO5 CLO6
5	**Verification and Validation of Simulation Models:** Model building, verifications, and validations, techniques for verification and validation of simulation models, statistical methods for comparing real-word observations and simulation output data.	6	CLO7
6	**Analysis of Simulation Data:** Identifying the distribution with data, Parameter estimation, Goodness-of-fit tests for both discrete and continuous data, Output analysis for terminating and steady-state simulations. MCMC methods: Introduction, Markov chain, Hastings-Metropolis Algorithm, Gibbs Sampler, Simulated Annealing.	6	CLO8

Textbooks:

1. Robert, C. and G. Casella (2010). Introducing Monte Carlo Methods with R. Springer-Verlag New York.
2. Rubinstein, R.Y. and D. P. Kroese (2017). Simulation and the Monte Carlo method. John Wiley & Sons.
3. Lazic, S. E., & H. L. Roche (2012). Introducing Monte Carlo Methods with R.

Reference Books:

1. Ross, B. M. (2012): Simulation, 5th Edition, Academic Press, USA.
2. Law, A. M., & W. Kelton (2000). Simulation modeling and analysis. Mac Graw Hill, Boston, Burr Ridge, USA.
3. Suess, E.A. and B.E. Trumbo (2010). Introduction to Probability Simulation and Gibbs Sampling with R, Springer.

STAT 3204: Statistical Quality Control

Title of the Course	**Statistical Quality Control**				
Course Code	STAT 3204				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course aims to introduce various statistical quality control tools and techniques, which are necessary skills for a quality professional.

Course Objectives (CO):
This course will cover the underlying statistical techniques for modern quality control. These important methodologies have a broad scope of application in manufacturing, health care, pharmaceuticals, service industries, and other domains.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to
CLO1: Understand the philosophy and basic concepts of quality improvement.
CLO2: Demonstrate the ability to use statistical process control methods.
CLO3: Demonstrate the ability to design, use, and interpret control charts for variables.
CLO4: Demonstrate the ability to design, use, and interpret control charts for attributes.
CLO5: Demonstrate the ability to design, use, and interpret acceptance sampling meyhods.

S.N.	Course Contents	Hrs	CLOs
1	**Quality Basics and History**: Meaning of quality, Factors effecting quality, Quality Principles, Quality function, Quality control, Aims and objectives of quality control, Characteristics, Cost of quality, Value of quality, Seven QC tools, Need of management of product quality, Historical perspective of quality control.	8	CLO1 CLO2
2	**Statistical Quality Control:** Introduction, Concept of variability , Common vs. Special Causes, Types of Control charts, Measurement of control limits, **Control charts for variables:** large sample data, Warning limits, Revised control limits, Group control chart, Control chart with line trend.	8	CLO2 CLO3
3	**Control Charts for Attributes:** Control charts for non-confirming Models, control charts for fraction non- conforming. Process and Measurement System Capability Analysis: Using Probability plot, process capability ratios, specification limits and Tolerances.	8	CLO3 CLO4
4	**Acceptance Sampling:** Introduction, Advantages and Disadvantages of Sampling methods, Sampling techniques, Sampling Risks and indices, Operating characteristic curves, Average outgoing quality Limit. Sampling plans Single, Double, Multiple and Sequential Sampling Plans Tightened Inspection, Dodge-Rooming system, Sequential plans.	8	CLO5

Textbooks:

1. E. L. Grant Richard, R.S. Leavenworth, Design Statistical Quality Control, 7th Edition, McGrawHill Pvt Ltd New Delhi, 2011.
2. D. C. Montgomery, Statistical Quality Control,7th Edition, John Wiley Sons, 2012

Reference Books:

1. Banks, J. (1989): *Principles of Quality Control*, John Wiley and Sons, New York.
2. Burr, J. (2002): *Elementary Statistical Quality Control*, Marcel Dekkar, USA.
3. Grant, E. L. (1996): *Statistical Quality Control*, 7th edition, McGraw-Hill, New York.
4. Montgomery, D. C. (2002): *Introduction to Statistical Quality Control*, 4th edition, John Wiley and Sons, New York.
5. Mukhopadhyaya, P. (1999): *Applied Statistics*, Books and Allied (P) Ltd., India.

STAT 3205: Econometrics

Title of the Course	Econometrics				
Course Code	STAT 3205				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides an overview of the course content for Econometrics, a branch of economics that applies statistical methods to analyze economic data and test economic theories.

Course Objectives (CO):
The course aims to equip students with the skills and knowledge to conduct empirical research in economics using various econometric techniques and software tools.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Explain the role of econometrics in empirical economic analysis.
CLO2: Demonstrate a solid understanding of basic statistical concepts relevant to econometrics, such as probability, hypothesis testing, and estimation methods.
CLO3: Apply econometric techniques to real-world economic data using statistical software.
CLO4: Evaluate the validity of econometric models and interpret their results.
CLO5: Recognize and address common econometric problems, such as endogeneity, heteroscedasticity, and autocorrelation.
CLO6: Conduct independent research projects that involve collecting, analyzing, and interpreting economic data.
CLO7: Communicate econometric findings effectively through written reports and presentations.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Econometrics:** Definition, scope, and importance of econometrics, The data generation process, Causal inference and econometric modeling. **Review of Statistical Concepts:** Probability distributions and statistical inference, Hypothesis testing and confidence intervals, Simple and multiple regression analysis.	7	CLO1 CLO2
2	**Simple Linear Regression:** Assumptions and interpretation, Estimation methods (OLS), Hypothesis testing and model diagnostics. **Multiple Linear Regression:** Model specification and estimation, Inference and hypothesis testing, Multicollinearity and model diagnostics.	10	CLO3 CLO4
3	**Violations of Classical Assumptions:** Heteroscedasticity and robust standard errors, Autocorrelation and panel data analysis, Endogeneity and instrumental variables	10	CLO5
4	**Time Series Econometrics:** Stationarity and unit roots, ARMA models and forecasting, Cointegration and error correction models. **Advanced Topics in Econometrics:** Limited dependent variable models (logit, probit), Simultaneous equation models, Panel data analysis, Interpretation and communication of results.	8	CLO6 CLO7

Textbooks:

1. Greene WH (2011). Econometric Analysis, 7th edition. Prentice Hall. Reference Books

Reference Books:

1. Gujarati DN (2010). Basic Econometrics, 5th edition. McGraw-Hill.
2. Wooldridge JM (2010). Introductory Econometrics: A Modern Approach, 5th edition. Cengage Learning.

STAT 3206: Time Series Analysis Lab

Title of the Course	**Time Series Analysis Lab**				
Course Code	STAT 3206				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for the analysis of time series data.
Course Objectives (CO):
It provides practical knowledge for time series data analysis.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from time series data.

S.N.	Course Contents	Hrs	CLOs
1	Measurement of Secular Trend, Seasonal Variation, Cyclical Movement and Irregular Components, Spencer's 15 and 21-Points Formula, Correlogram Analysis, Diagnostic Checking, Forecasting, Spectral Analysis.	12	CLO1

Textbooks:
1. Jonathan DC and Kung-Sik C (2008). Time Series Analysis - With Applications in R. Springer.

Reference Books:
1. Shumway RH and Stoffer DS (2011). Time Series Analysis and Its Applications: With R Examples. Springer.

STAT 3207: Statistical Simulation and Modeling Lab

Title of the Course	**Statistical Simulation and Modeling Lab**				
Course Code	STAT 3208				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for statistical simulation and data processing.

Course Objectives (CO):
It provides simulation programming concepts for modern data science.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding statistical simulation and data processing.

S.N.	Course Contents	Hrs	CLOs
1	**Simulation Problem Solving Though SPSS, SAS and R:** Generating Random Number from Uniform, Binomial, Poisson, Normal, Exponential, and Gamma by Different Monte-Carlo Methods and Using Standard Software and Computer Program; Testing Uniform Random Numbers using chi-square Test, Kolmogorov-Smirnov Test and Graphical Methods, Assess Different Statistical Properties of Generated Data, Integration by Monte-Carlo Simulation.	24	CLO1

Textbooks:
1. Robert, C. and G. Casella (2010). Introducing Monte Carlo Methods with R. Springer-Verlag New York.

Reference Books:
1. Lazic, S. E., & H. L. Roche (2012). Introducing Monte Carlo Methods with R.

STAT 3208: Econometrics Lab

Title of the Course	**STAT 3207: Econometrics Lab**				
Course Code	STAT 3207				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for econometrics.

Course Objectives (CO):
It provides practical knowledge for econometric data analysis.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: produce statistical results from data regarding survey design.

S.N.	Course Contents	Hrs	CLOs
1	Tests for Autocorrelation, Multicollinearity, Heteroscedasticity, Estimation of Parameters and Analysis of Data in Presence of Autocorrelation, Multicollinearity and Heteroscedasticity; Estimation of Parameters in Presence of Lagged Dependent Variable, Dummy Variable.	24	CLO1

Textbooks:
1. Greene WH (2011). Econometric Analysis, 7th edition. Prentice Hall. Reference Books

Reference Books:
1. Gujarati DN (2010). Basic Econometrics, 5th edition. McGraw-Hill.

STAT 3209: Viva-Voce

Title of the Course	**Viva-Voce**
Course Code	STAT 3209
Credit Hours	**1.5**
Total Marks	**50**

3.4 Fourth Year

STAT 4101: Multivariate Distribution

Title of the Course	**Multivariate Distribution**				
Course Code	STAT 4101				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course introduces the fundamental concepts and techniques of multivariate distributions in statistics and probability theory.

Course Objectives (CO):
This course aims to understand various multivariate probability distributions and their properties, including joint distributions, conditional distributions, and marginal distributions. The course will also cover topics such as covariance, correlation, and multivariate transformations. Practical applications of multivariate distributions in data analysis and statistical modeling will be emphasized throughout the course.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: Explain the fundamental concepts and properties of multivariate distributions.
CLO2: Apply multivariate distributions to analyze and model complex datasets.
CLO3: Perform multivariate transformations to obtain new variables with desired properties.
CLO4: Conduct hypothesis testing and interval estimation for multivariate data.
CLO5: Interpret and communicate statistical results from multivariate analyses effectively.
CLO6: Apply multivariate distributions in various fields, such as finance, biology, and social sciences.

S.N.	Course Contents	Hrs	CLOs
1	**Aspects of multivariate Analysis:** Meaning and Applications of Multivariate Analysis, Meaning and Interpretation of Euclidian and Statistical Distances, Spectral Decomposition, Cholesky Decomposition of Positive Definite Matrix, DeterMining Square Root of Matrices, Partition of Covariance Matrices, Generalized Variance.	6	CLO1
2	**The multivariate normal distribution:** Meaning, Derivation and Properties of multivariate Normal Distribution, Contour, Maximum Likelihood Estimator of Mean Vector and Variance Covariance Matrix, Large Sample Behavior of Mean Vector and Variance Covariance Matrix. Evaluating Normality of Univariate Marginal Distributions, Bivariate and Multivariate Distributions by P-P and Q-Q Plot, Steps in Detecting Outliers and Cleaning Data, Transformation to Near Normality by Square Root, Logit, Fisher's and Box-Cox Transformation, Sampling Distribution of Sample Mean and Sample Covariance Matrix, Wishart Distribution, Demerits of Multivariate Normal Likelihood and Estimation of MV and CV by MLE Information of Sufficient Statistics for MNP.	6	CLO2
3	**Inferences about Mean Vector:** Hoteling's Statistic, Derivation of Test, Defining Critical Region of Multivariate Normal Mean Vector, Relation with Statistic and Wishart Random Matrix, LR Statistics, Derivation of the Distribution of LR Statistics to Test Mean Vector and DeterMining Confidence Region of Mean Vector. Multivariate Quality Control Charts: Charts for Individual Multivariate Observation, Ellipse Format Chart, Chart, Control Region for Future Individual Observation, Control Ellipse and Chart for Future Observation, Comparing Several Multivariate Means, Paired Comparison, Repeated Measures Designs for Comparing Treatments, One-Way ANOVA, MANOVA, Profile Analysis.	6	CLO3
4	**Multivariate Multiple Regression:** Meaning, Functional Form and Underlying Assumptions, Likelihood Ratio Test for Regression Parameters, Predicting Multivariate Multiple Regression, Confidence Ellipse and Prediction Ellipse from Bivariate Responses.	6	CLO4

Textbooks:
1. Hair, J. F., R. L. Tatham, R. E., Anderson &W. Black (2006).*Multivariate data analysis*. Upper Saddle River, NJ: Pearson Prentice Hall.

Reference Books:
1. Johnson, R. A. and Wichern, D. W. (2002): *Applied Multivariate Statistical Analysis,* 5th edition, Pearson Education, Asia.

STAT 4102: Advanced Sampling Techniques

Title of the Course	**Advanced Sampling Techniques**				
Course Code	STAT 4102				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course introduces the basic concepts and methods of advanced sampling techniques for statistical analysis.

Course Objectives (CO):
This course aims to cover sampling design and analysis methods that are useful for research and management in many fields.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: understand the necessity of multi-stage sampling.
CLO2: formulate the multi-stage design.
CLO3: know methods for estimating variance in complex multi-stage design,
CLO4: implement methods for designing a survey, particularly a national-level large-scale survey.

S.N.	Course Contents	Hrs	CLOs
1	**Probability proportional to size (PPS) sampling:** motivating examples, with replacement (WR) sampling: cumulative measure of size method and Lahiri's method, Hansen-Hurwitz (H-H) estimator (unbiasedness, variances, estimated variance), comparison with SRS, optimum measure of size, PPS without replacement (WOR) sampling: challenges and solutions, initial probabilities, normalizing probabilities, inclusion probabilities and their relation with the sample size, Horvitz-Thompson (H-T) estimator (unbiasedness, variance, estimated variance), different methods of PPSWOR: Brewer's method, Durbin's method, Des Raj method, Murthy's method, Rao- Hartley-Cochran method, Multinomial distribution for PPSWR sampling, H-T estimator in case of PPSWR sampling.	8	CLO1 CLO2 CLO3 CLO4
2	**Sub-sampling, sub-sampling of unequal sized clusters:** different estimators and their variances, two-stage sampling: design, estimators (total, mean), variances and their unbiased estimators, three stage sampling: design, estimators (total, mean), variances and their estimators, general framework (two-stage and three-stage) for estimating population total, different sampling designs at different stages, determination of sample sizes in two and three-stage sampling, optimum sampling and sub-sampling fractions, use of information from pilot survey.	8	CLO1 CLO2 CLO3 CLO4
3	**Double sampling:** Concept of double sampling and its necessity, application in stratified sampling, and in Ratio and Regression estimators, repeated sampling from the same population: sampling on two and more than two occasions.	8	CLO4
4	**Complex survey:** definition and challenges involved in complex surveys, approaches of variance estimation (VE), replication methods for VE: random group method, balanced repeated replication (balanced half-sample replication) method, Jackknife method and Bootstrap method, implementation of replication methods in complex sampling designs, post-stratification.	8	CLO4
5	**Non-sampling errors:** sources of the errors, effects of nonresponse, inference on population proportion in presence of nonresponse, types of nonresponses, Call-backs and its effects, Hansen and Hurwitz approach for nonresponse, Politz-Simmons adjustment for bias reduction, mathematical model for errors of measurement, mechanism of nonresponse, imputation, and its different techniques.	8	CLO4
6	**Special sampling designs:** multiplicity, network sampling: design and estimation (multiplicity and Horvitz-Thompson estimators for population total, and their different properties), adaptive sampling: adaptive cluster sampling (ACS) and related concepts used in ACS, Hansen- Hurwitz and Horvitz-Thompson estimators for population total, and their different properties.	8	CLO4

Textbooks:

1. Cochran WG (1977). Sampling Techniques, 3rd edition. Wiley.

Reference Books:

1. Lohr SL (1998). Sampling: Design and Analysis. Duxbury.
2. Thompson SK (2012). Sampling, 3rd edition. Wiley.
3. Kirk MW (2007). Introduction to Variance Estimation, 2nd edition.Wiley.

STAT 4103: Spatial Statistics

Title of the Course	**Spatial Statistics**				
Course Code	STAT 4103				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course will introduce the theory and methods of spatial and spatiotemporal statistics. It will present spatial and spatiotemporal statistical models and discuss methods for inferring spatial processes within a geostatistical and hierarchical Bayesian framework.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: distinguish between three different types of spatial data and apply basic statistical tools required to conduct inference from such data.
CLO2: demonstrate skill in using some of the measures of dependence in spatial processes in analyzing and modeling spatial data.
CLO3: demonstrate in-depth knowledge of some of the important topics in spatial statistics.
CLO4: demonstrate knowledge in determining spatial models for some spatial data.
CLO5: show skill in simulating some spatial models using the package R.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Spatio-Temporal Statistics:** Introducing Spatial Data **,** Goals of Spatio-Temporal Statistics, Spatial Regression Analysis, Descriptive and Dynamic Modeling, Hierarchical Statistical Models, Modeling spatially correlated data, quantifying spatial association and autocorrelation, interpolation methods, variograms, kriging, and spatial point patterns.	8	CLO1
2	**Exploring Spatio-Temporal Data:** Spatio-Temporal Data, Representation of Spatio-Temporal Data in R, Visualization of Spatio-Temporal Data (Spatial Plots, Time-Series Plots, Hovmöller Plots, Interactive Plots, Animations), Exploratory Analysis of Spatio-Temporal Data.	8	CLO2
3	**Spatio-Temporal Statistical Models:** Spatio-Temporal Prediction, Regression (Trend-Surface) Estimation, Model Diagnostics: Dependent Errors, Parameter Inference for Spatio-Temporal Data , Spatio-Temporal Forecasting, Generalized Linear Models and Generalized Additive Models, Hierarchical Spatio-Temporal Statistical Models	8	CLO3
4	**Dynamic Spatio-Temporal Models:** General Dynamic Spatio-Temporal Models, Latent Linear Gaussian DSTMs, Process and Parameter Dimension Reduction.	8	CLO4
5	**Evaluating Spatio-Temporal Statistical Models:** comparing model output to data: what do we compare (Comparison to a Simulated "True" Process, Predictive Distributions of the Data,Validation and Cross-Validation), model checking (extensions of regression diagnostics, graphical diagnostics, sensitivity analysis), model validation (predictive model validation, spatio-temporal validation statistics, spatio-temporal cross-validation measures, scoring rules , field comparison, model selection (model averaging, Model Comparison via Bayes Factors , Model Comparison via Validation , Information Criteria).	8	CLO5

Textbooks:

1. Wikle, C. K., Zammit-Mangion, A., and Cressie, N. (2019), Spatio-Temporal Statistics with R, Boca Raton, FL: Chapman & Hall/CRC.

Reference Books:

1. Roger S. (2021): Applied Spatial Data Analysis with R, 1st edition. WILEY, Springer.

STAT 4104: Health Informatics

Title of the Course	**Health Informatics**				
Course Code	STAT 4104				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides an overview of population health informatics.

Course Objectives (CO):
This course will present a practical, step-by-step approach on how to implement evidence-based, data-driven informatics solutions to enhance population health.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: familiar with overview of population health informatics.
CLO2: develop knowledge of using statistical data for population health informatics.
CLO3: familiar with various methods for health data analysis and visualization.
CLO4: develops knowledge of innovations and sustainability in population health technologies.

S.N.	Course Contents	Hrs	CLOs
1	**Overview of Health Informatics:** Emerging Need for Population Health Informatics, Medical and Population Health Informatics, The Emerging Role of Population Health Informatics, Public Health Informatics Workforce, Privacy, Design, Development, and System Evaluation of Population Health Informatics, Applications, Confidentiality, Security, and Ethics, Statistical Issues in Population Health Informatics.	8	CLO1
2	**Role of Health Informatics in Understanding Data, Information, and Knowledge:** Overview of Data, Information, and Knowledge, Data and Data Types, Information and Information Systems, Knowledge and Knowledge Management, Challenges Managing Data, Information, and Knowledge, Personal Health Records, Electronic Health Records and Telehealth Applications Mobile Health Interventions: Opportunities, Challenges, and Applications, Role of Statistics in Population Health Informatics.	8	CLO2
3	**Big Data, Cloud Computing, and Visual Analytics in Population Health:** Introduction to Big Data, Big Data Classification and Tools, Big Data in Health Care, Leveraging Big Data for Disease Prevention, Challenges Related to Big Data in Health Care, Introduction to Cloud Computing, Leveraging Cloud Computing in Population Health, Cloud Computing Challenges and Opportunities, Introduction to Health Data Visualization, Concepts of Geographic Information Science, Information Visualization with Examples, Geovisualization with Example.	12	CLO3 -05
4	**Innovations and Sustainability in Population Health Technologies:** The Growth of the Internet and Social Media, The Intersection of ICTs and Health Care, Innovations in Population Health, Health Technology Innovations, Implementation of Health Technology Innovations, Examples of Health Technology, Innovations in Global Settings, Sustainability.	6	CLO4

Textbooks:

1. Joshi A (2017). Population Health Informatics: Driving Evidence-Based Solutions Into Practice, 2nd edition. Jones & Bartlett Learning.

Reference Books:

1. Prakash J (2021): Computational Intelligence and Healthcare Informatics, 1st edition. WILEY.
2. Edward H. Shortliffe (2021): Biomedical Informatics: Computer Applications in Health Care and Biomedicine, 5th Edition, Springer.
3. Magnuson J.A. (2020): Public Health Informatics and Information Systems, 3rd Edition, Springer.

STAT 4105: Research Methodology

Title of the Course	**Research Methodology**				
Course Code	STAT 4105				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:

This course introduces students to the fundamental principles of research design, data collection, data analysis, and report writing.

Course Objectives (CO):

It will cover a range of research approaches, including quantitative, qualitative, and mixed methods.

Course Learning Outcomes (CLOs):

After successful completion of this course, students will be able to:

CLO1: to formulate research questions, develop hypotheses, choose appropriate research methods, and collect and analyze data.

CLO2: learn about the various data collection techniques, such as surveys, interviews, observations, and statistical techniques for analyzing data.

CLO3: familiar with a variety of methods for planning, conducting, evaluating, and presenting a research project.

S.N.	Course Contents	Hrs	CLOs
1	**Foundations of Research:** Meaning, concept, motivation, and objectives of the research; Types of research – descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical, concept of the applied and basic research process. Criteria and steps of good research. **Language of research:** Variables and attributes; concepts and constructs; theory and models; proposition and hypotheses: relational terminologies: independent and dependent variables, intervening variables, extraneous variables, moderating variables confounder variables.	8	CLO1
2	**Problem Identification and Formulation:** Defining and formulating the research problem, the importance of literature review in defining a problem, identifying gap areas from literature and research database, research question, and formulation of research hypothesis.	8	CLO2
3	**Research Design and Methods:** Research methods vs. methodology; features of a good research design, concept, types, and uses of exploratory, descriptive, and experimental research designs. Qualitative and quantitative research approach, mixed methods design. Concept of measurement, problems in measurement in research - validity, and reliability. **Sampling:** use of sampling techniques in research design; brief review of sampling and sample size determination. **Techniques of data collection:** Qualitative approaches – focus group discussion (FGD), in depth interview (IDI), key informant interview (KII) and their guidelines and checklist; concepts of ethnography, content analysis, and discourse analysis, Quantitative approach – the concept of a survey, mode of a survey – face-to-face interview, telephone interview, online/email, etc. Survey tools – Questionnaire, schedule, structured, semi-structured, open-ended, and close-ended questions. Data collection apps: survey CTO, Kobo Toolbox, etc.; Field Implementation – a pilot study, monitoring the data collection, quality control, and data validity.	12	CLO3
4	**Data Analysis:** Steps of data preparation and analysis; Guidelines for using secondary data for research: when, how, and why, Dissemination of Research findings: Different Steps in Writing Report, Layout of the Research Report; Effective presentation, preparing articles for peer review. **Research Ethics and Scholarly Publishing:** Ethics-ethical issues, ethical committees (human and animal); IPR- intellectual property rights and patent law, commercialization, copyright, royalty; scholarly publishing concept and research paper design, citation, acknowledgment, plagiarism, reproducibility, and accountability. **Experiential Learning Project:** Group project and field work – writing a research proposal, developing, and implementing field data collection, data analysis, and report writing and presentation.	12	CLO3

Textbooks:

1. Kothari CR and Garg G (2019). Research Methodology: Methods & Techniques. New Age.

Reference Books:

1. Gertler PJ, Martinez S, Premand P, Rawlings LB and Vermeersch CMJ (2017) . Impact Evaluation in Practice, *2nd edition*. World Bank Group, Washinngton DC.
2. Coninck JD, Chaturvedi K, Haagsma B, Griffioen H and Glas MVD (2008). Planning, monitoring and evaluation in development organizations: sharing training and facilitation experiences. Sage.

STAT 4106: Advanced Sampling Techniques Lab

Title of the Course	**Advanced Sampling Techniques Lab**				
Course Code	STAT 4106				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces practical sampling design and analysis methods.
Course Objectives (CO):
This course is aimed at designing sample survey.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1 implement methods for designing a survey, particularly a national-level large-scale survey.

S.N.	Course Contents	Hrs	CLOs
1	Drawing Probability Samples, Sampling with and without Replacement, Estimation of Population Characteristics and Variance of Estimators for Cluster Sampling, Double Sampling and Two Stage Sampling Methods, Allocation of Sample Sizes for Optimum Cost and Variance Function for Different Sampling Procedures, Drawing of Stratified Two-Stage Sampling and Estimation of Parameters, Report Writing based on Practical Problem.	24	CLO1 04

Textbooks:
1. Cochran WG (1977). Sampling Techniques, 3rd edition. Wiley.

Reference Books:
1. Thompson SK (2012). Sampling, 3rd edition. Wiley.

STAT 4107: Spatial Statistics Lab

Title of the Course	**Spatial Statistics Lab)**				
Course Code	STAT 4107				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course is designed to provide real-life applications of Spatial statistics using different software.
Course Objectives (CO): This course is aimed at solving different problems of spatial statistics.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to
CLO1: learn statistical and mathematical models used in Spatio-Temporal Data in various real-life problems.
CLO2: Analyze Spatio-Temporal Data by applying Spatial Statistical methods using R.

S.N.	Course Contents	Hrs	CLOs
1	Representation of Spatio-Temporal Data in R, Visualization of Spatio-Temporal Data (Spatial Plots, Time-Series Plots, Hovmöller Plots, Interactive Plots, Animations), Exploratory Analysis of Spatio-Temporal Data.	24	CLO1 CLO2

Textbooks:
1. Wikle, C. K., Zammit-Mangion, A., and Cressie, N. (2019), Spatio-Temporal Statistics with R, Boca Raton, FL: Chapman & Hall/CRC.

Reference Books:
2. Roger S. (2021): Applied Spatial Data Analysis with R, 1st edition. WILEY, Springer.

STAT 4108: Health Informatics Lab

Title of the Course	**Health Informatics Lab**				
Course Code	STAT 4108				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for population health informatics.

Course Objectives (CO):
This course is aimed at solving the problems of health and big data.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: develop knowledge of using statistical data for population health informatics.
CLO2: familiar with various methods for health data analysis and visualization.

S.N.	Course Contents	Hrs	CLOs
1	Solving Problems related Big Data, Cloud Computing, and Visual Analytics in Population Health and Innovations and Sustainability in Population Health Technologies.	24	CLO1 CL02

Textbooks:
1. Joshi A (2017). Population Health Informatics: Driving Evidence-Based Solutions Into Practice, 2nd edition. Jones & Bartlett Learning.

Reference Books:
1. Edward H. Shortliffe (2021): Biomedical Informatics: Computer Applications in Health Care and Biomedicine, 5th Edition, Springer.
2. Magnuson J.A. (2020): Public Health Informatics and Information Systems, 3rd Edition, Springer.

STAT 4201: Multivariate Analysis

Title of the Course	Multivariate Analysis				
Course Code	STAT 4201				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15×2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
This course provides a comprehensive introduction to the theory and application of multivariate analysis techniques.

Course Objectives (CO):
This course aims to analyze and interpret complex datasets using various multivariate techniques, such as multivariate regression, factor analysis, discriminant analysis, and principal component analysis. Emphasis will be placed on understanding the underlying assumptions, conducting appropriate analyses, and interpreting the results meaningfully.

Course Learning Outcomes (CLOs):
Upon successful completion of this course, students will be able to:
CLO1: know about the basics of multivariate analysis techniques.
CLO2: Identify the appropriate multivariate technique for a given research question or problem.
CLO3: Conduct factor analysis, PCA, ICA to identify underlying dimensions and reduce data dimensionality.
CLO4: Apply discriminant analysis to classify observations into predefined groups.
CLO5: Perform principal component analysis to extract the most important information from a dataset.
CLO6: Interpret and evaluate results of multivariate analyses effectively.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Multivariate Analysis:** Overview of multivariate analysis, Importance and applications of multivariate analysis, Types of variables in multivariate analysis. Multivariate Data Exploration: Descriptive statistics for multivariate data, Data visualization techniques for multivariate data, Data screening and cleaning.	8	CLO1
2	**Dimension reduction:** Principal components: Definition and Objective of Principal Component Analysis (PCA), Distribution of i-th Principal Component, Proportion of Total Population Variance due to k-th PC, PC for Standardized Variable, Graphing PC, Test for Equal Correlation Structure. Independent Component Analysis (ICA): Basic Concept on ICA: Definition, Identifiability of the ICA Model, Ambiguities of ICA, Preprocessing of ICA: Centering, Whitening, Principles of ICA Estimation: Maximization of non-Gaussianity using kurtosis and Negentropy, Minimization of Mutual Information, Maximum Likelihood Estimation. Factor Analysis: Definition and Purposes of Factor Analysis, Its Relation with PCA and MR Model, Meaning of Orthogonal Factor Model, Cumulative Factor, Specific Factor, Loading Covariance Structure for Orthogonal Factor Model, Principal Component, and Principal Factor, ML Method of Parameter Estimate of PC Model, Large Sample Test for Number of Common Factors, Oblique, Variance and Oblique Rotation. Definition and Elements of Factor Scores, Estimating Factor Scores by WLS and Regression Methods. Best Strategy from FA.	8	CLO3 CLO5
3	**Cluster Analysis:** Meaning and Objectives of Clustering, Different Similarity Measures, Euclidean Distance, Statistical Distance, Minkowski, Canberra, Hierarchical Clustering Method, Non-Hierarchical Method.	10	CLO2 CLO5 CLO6
4	**Discrimination and Classification Analysis:** Meaning and Goals of Discrimination and Classification, Method of Discrimination and Classification, Problems of Classification, Expected Caused and Total Probability of Misclassification, Minimum Cost Region, Classification with Two-Multivariate Normal Population, Fisher Discrimination Function.	8	CLO4
5	**Nonparametric Multivariate Techniques:** Nonparametric analogs of multivariate techniques, Permutation tests, Interpreting nonparametric multivariate results.	8	CLO6

Textbooks:

1. Anderson,T.W. (2003): *An Introduction to Multivariate Statistical Analysis*, 5th ed., Wiley, N.Y.
2. Johnson, R. A. and D. W Wichern (2002): *Applied Multivariate Statistical Analysis*, 5th ed., Prentice Hall, N.Y.

Reference Books:

1. Hyvarinen, A, J. Karhunen and E. Oja (2001): *Independent Component Analysis*, Wiley, New York.

STAT 4202: Survival Analysis

Title of the Course	**Survival Analysis**				
Course Code	STAT 4202				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction: This course covers the basic principles and methods of epidemiology and lifetime data analysis.
Course Objectives (CO): This course aims to familiarise with epidemiologic terminology and related topics.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to
CLO1: comprehend with the basic idea about epidemiology, health and disease, and its related topics.
CLO2: familiar with epidemiologic terminology, outcome measures, methods for estimating association measures.
CLO3: frame out different epidemiological study designs, choose an appropriate epidemiologic study design.
CLO4: conduct epidemiological or health-related medical study with appropriate epidemiological study design.
CLO5: apply proper statistical methods and models to analyze the data from epidemiological or medical study.
CLO6: know the basic features of censored life-time data, survival function, hazard functions.
CLO7: know both parametric and non-parametric estimation of survival and hazard functions.
CLO8: formulation, estimation and interpretation of the survival regression models.
CLO9: learn how to apply the survival analysis methods to solve the real-life problems.

S.N.	Course Contents	Hrs	CLOs
1	**Epidemiology:** Definition, Health and Disease, Sources of Health-Related Data, Scope of Epidemiology, Uses of Epidemiology.	4	CLO1 CLO2
2	**Types of Epidemiological Studies:** Cross Sectional, Cohort, Case-Control, Retrospective and Prospective, Clinical Trials, Community Intervention and Cluster Randomized Trials.	6	CLO3
3	**Measures of Disease Frequency:** Incidence and Prevalence Rates, Relation between Incidence and Prevalence, Case Fatality Rate, Risk Ratio, Rate Ratio, Risk Difference, Rate Difference, Mortality Measures, Standardized Mortality Ratio.	6	CLO2 CLO3
4	**Measures of Association between Disease and Risk Factor:** Risk, Relative Risk, Attributable Risk, Odds Ratio, Relative Hazard.	6	CLO2 CLO5
5	**Epidemiology and Prevention:** Scope of Prevention, Levels of Prevention: Primordial, Primary, Secondary and Tertiary.	4	CLO4 CLO5
6	**Screening, Properties of Screening Test:** Generalizability, Sensitivity, Specificity, Negative and Positive Predictive Values of a test and its related topics.	4	CLO4 CLO5
7	**Biostatistics:** Definition**,** Scope of Biostatistics, Probability Density Function, Survivor Function, Hazard Function, Their Inter Relationships; Censoring and Truncation; Type I, Type II and Random Censoring; Likelihood Functions Under Different Types of Censoring, Survival Distributions: Exponential, Weibull, Extreme Value, Gamma, Lognormal.	6	CLO6 CLO7
8	**Non-Parametric Methods of Estimating Survivor Functions:** Life Table Method, Product Limit Method, Variance Estimates, Cumulative Hazard Function, Plots Involving Estimated Survivor and Hazard Functions; Non-Parametric Methods for Comparing Survival Distributions: Gehan's Generalized Wilcoxon Test, Mantel-Haenszel Test.	6	CLO8
9	**Inference Procedures:** One Parameter Exponential Distribution with Type I and Type II Censored Data, Comparison of Exponential Distributions, Two Parameter Exponential Distribution with Type I and Type II Censored Data, Inference Procedures for Weibull and Extreme Value Distributions with Type I and Type II Censored Data.	6	CLO7 CLO8
10	**Parametric Regression:** Poisson Regression Model, Exponential Regression Model, Proportional Hazards model, Proportional odds model, Conditional likelihood, Partial likelihood, Marginal likelihood, Logistic Regression, Method of Estimation, Tests of Hypothesis.	6	CLO9

Textbooks:

1. Kenneth, J. Rothman, Timothy L Lash and Sander Green Land (2012): Modern Epidemiology, 3rd Edition, Lippin Catt.
2. Lawless, J. F. (2011). Statistical models and methods for lifetime data (Vol. 362).John Wiley & Sons.

Reference Books:

1. Daniel, W. W. (2000): Bio-Statistics: A Foundation for Analysis in the Health Science, 7th Edition, John Wiley and Sons, New York.
2. Collett D (2014). Modelling Survival Data in Medical Research, 3rd edition. Chapman & Hall/CR.
3. Lee, E. T. and Wang, J. W. (2013): Statistical Methods for Survival Data Analysis, 4th Edition, Wiley Series, New York.

STAT 4203: Statistical Machine Learning and Data Mining

Title of the Course	**Statistical Machine Learning and Data Mining**				
Course Code	STAT 4203				
Credit Hours	03				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:
The course introduces students to a new and actively evolving interdisciplinary field of modern data science and artificial Intelligence.

Course Objectives (CO):
This course provides hands-on practical analysis of real-world datasets using available software tools and modern programming languages and libraries.

Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1-2: familiarize with a new rapidly evolving field of machine learning and data mining (MLDM).
CLO3-6: understand fundamental principles and application of data mining techniques.
CLO7-8: understand fundamental principles of modern data analysis techniques.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Machine Learning (ML) and Data Mining:** Modern ML and Data Mining techniques, Artificial intelligence VS Machine Learning VS Deep Learning, Types of ML: Supervised Learning, Unsupervised Learning, and Reinforcement Learning, Supervised Learning and its Types, Unsupervised Learning and its Types, Deep Learning – Basics, Data Mining and Knowledge Discovery in Data Bases.	6	CLO1 CLO2
2	**Clustering and its basic techniques:** Clustering PAM Algorithm, Clustering with Genetic Algorithms, Clustering with Neural Networks, Clustering Large Databases, Clustering with Categorical Attributes, Ensemble methods of clusterization for k-means partitions' aggregation.	6	CLO3
3	**Classification and its basic techniques:** The task of classification, 1-Rules, K-Nearest Neighbours approach, Naïve Bayes, Decision Trees, Logistic Regression, Quality assessment: precision, recall, F - measure, loss-function, confusion-matrix, cross-validation and learning curves (ROC, lift, etc.), Ensemble methods of classification: Bagging, Boosting, and Random Forest.	6	CLO4
4	**Frequent Itemset Mining and Association Rules**: Frequent item sets, Apriori and FP-growth algorithms, Association rules, Interestingness measures: support and confidence, Closed item sets, Connection with Lattice Theory and Formal Concept Analysis.	8	CLO5
5	**Support Vector Machine:** Understanding of Support Vector Machine algorithm with different Kernels, Applications of SVM, Linear SVM, Nonlinear classification, Computing the SVM classifier, Support-vector clustering (SVC), Multiclass SVM, Support Vector Regression, Bayesian SVM.	6	CLO6
6	**Artificial Neural Networks:** Basic ideas of Deep Learning, (Stochastic) gradient descent, Statistical (Bayesian) view on Machine learning.	6	CLO6
7	**Text Mining & Web Mining**: Basics of Text Mining, Common Text Mining Visualizations, Sentiment Scoring, Hidden Structures, Text Vectors and Topic Modeling. Web Content Mining, Crawlers, Harvest System, Virtual Web View, Personalization, Web Structure Mining, Page Rank, Clever, Web Usage Mining, Preprocessing, Data Structures, Pattern Discovery, Pattern Analysis.	6	CLO7
8	**Machine Learning Tools for Big Data:** Orange, Weka, Scikit-learn and Apache Spark.	4	CLO8

Textbooks:

1. Gareth J, Daniela W, Trevor H, Robert T (2013). An introduction to statistical learning: with applications in R. Spinger; 2013.
2. Dunham, M. H. (2003): Data Mining: Introductory and Advanced Topics, 1st edition, Pearson.

Reference Books:

1. Hall, M., Witten, Ian H., Frank, E. (2011): Data Mining: practical machine learning tools and techniques.

STAT 4204: Bioinformatics

Title of the Course	**Bioinformatics**				
Course Code	STAT 4204				
Credit Hours	**3**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		15*2 = 30	05	05	**40**
	Semester Final Examination	**60**			
	Total Marks	**100**			

Course Introduction:

This course aims to provide an overview of the most common statistical methods for Bioinformatics and to provide the necessary information for solving complex biological problems and achieving the satisfactory score of sustainable development goals (SDGs) index from the health sectors.

Course Objectives:

The main objective of this course is to understand basic biology and application of statistical modeling in Bioinformatics

Learning Outcomes:

After completing this course successfully, the learners/students will be able to:

CLO1: learn basic biological terms that will be helpful to learn the discipline of bioinformatics

CLO2: acquire knowledge about biological databases, sequence alignments, data retrieval system, phylogenetic analysis, and comparative genome analysis.

CLO3: retrieve the DNA/Protein sequences from databases and analyze them using bioinformatics tools.

CLO4: perform multiple sequence alignment using bioinformatics tools.

CLO5: learn about the methods used for identification of DEGs from DNA microarray and RNA-Seq datasets

CLO6: know the databases to retrieve the DNA microarray and RNA-Seq datasets

CLO7: learn about the methods used for identification of DEGs from DNA microarray and RNA-Seq datasets

CLO8: gain knowledge about system biology including PPI and KEGG pathways.

S.N.	Course Contents	Hrs	CLOs
1	**Introduction to Bioinformatics:** Basic molecular biology: Cell, DNA, RNA, Chromosome, Gene, and Central dogma. Scope of Bioinformatics, Branches of Bioinformatics (Genomics, Transcriptomics, Proteomics, Metabolomics and so on).	6	CLO1
2	**Database and search tool**: Computational tools and biological databases National Centre for Biotechnology Information (NCBI), European Bioinformatics Institute (EBI), EMBL Nucleotide Sequence Database, DNA Data Bank of Japan (DDBJ), Swiss-Prot.	6	CLO2
3	**Sequence alignment, database searching and data ethics**: The evolutionary basis of sequence alignment, Database similarity searching, Sequence Similarity search tools: BLAST and FASTA, Concept of Alignment, Multiple Sequence Alignment (MSA), Percent Accepted Mutation (PAM), Blocks of Amino Acid and Substitution Matrix (BLOSUM), data bias.	8	CLO3 CLO4
4	**Statistical phylogenetic:** Motivation and background on phylogenetic, Distance and clustering approach, Likelihood methods, parsimony, RNA-based phylogenetic methods, phylogenetic Tree Estimation-UPGMA.	6	CLO2 CLO5
5	**Protein Classification and Structure prediction:** Introduction to protein structure prediction, Review of protein structure and terminology, protein classification. Methods of protein classification: Viewing protein structures, protein structure classification databases, Alignment of protein structures, structural prediction, structural modeling.	8	CLO4 CLO5
6	**DNA microarray:** database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases DNA microarray: understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches), Gene annotation such as Gene Set Enrichment Analysis (GSEA). **RNA-Seq Data:** Next generation sequencing (NGS), Methods of analyzing NGS, Identification of DEGs using Discrete distribution-based methods (edgeR, DESeq, DESeq2, Limma-Voom etc), definition of bulk RNA-Seq, Single cell RNA-Seq.	10	CLO6 CLO7
7	**System biology:** Introduction, Associated disciplines, Protein-protein interaction (PPI) network, Metabolic pathway database (KEGG pathway database), **Drug Discovery and design:** Target identification, Target Validation, Lead Identification, lead optimization, preclinical Pharmacology & Taxology.	6	CLO8

Textbooks:

1. Bioinformatics, Andreas D. Baxevanis, David S. Wishart, Gary D., Bade, Wiley, United Kingdom, 2019.

Reference Books:

1. Introduction to Bioinformatics, Lesk, Arthur M, Oxford University Press, USA, 2019.5th edition.

2. Bioinformatics: Sequence and Genome Analysis, Mount, D. W., CBS Publishers & Distributors, India, 2005.

STAT 4205: Multivariate Analysis Lab

Title of the Course	**Multivariate Analysis Lab**				
Course Code	STAT 4205				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for applied multivariate statistical analysis.
Course Objectives (CO):
This course is aimed at providing practical concepts on multivariate techniques.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: develop knowledge of applied multivariate statistical analysis.
CLO2: familiar with a variety of methods for multivariate data analysis and visualization.

S.N.	Course Contents	Hrs	CLOs
1	Solving Problems related as multivariate regression, factor analysis, discriminant analysis, principal component analysis, Cluster Analysis, Discrimination and Classification Analysis and Nonparametric Multivariate Techniques.	24	CLO1 CL02

Textbooks:
1. Anderson,T.W. (2003): *An Introduction to Multivariate Statistical Analysis*, 5th ed., Wiley, N.Y.

Reference Books:
1. Johnson, R. A. and D. W Wichern (2002): *Applied Multivariate Statistical Analysis*, 5th ed., Prentice Hall, N.Y.

STAT 4206: Survival Analysis Lab

Title of the Course	**Survival Analysis Lab**				
Course Code	STAT 4206				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction: This course introduces the practical skills and training for epidemiological data analysis.
Course Objectives (CO): This course aims to provide practical epidemiology and survival analysis concepts.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: develop knowledge of epidemiology.
CLO2: familiar with a variety of methods for epidemiological data analysis and visualization.

S.N.	Course Contents	Hrs	CLOs
1	Plots Involving Estimated Survivor and Hazard Functions, Probability Plots, Cross Product Ratio, Prevalence Rate, Incidence Rate, Non-parametric Estimation of survival probabilities and their Standard errors from ungrouped and grouped data, Construction of survival curves and their confidence belts, Graduation of life data (Censored and uncensored) by plotting procedures, Fitting of appropriate parametric model (one parameter exponential, two parameter exponential and Weibull) to observed data and testing goodness of fit of fitted models (Kolmogorov- Smirnov test, L.R. test), Construction of confidence limits for life parameters for the fitted models, Analysis of screening tests, Estimation of sensitivity and potency of test preparation, Computations of attributable and relative Risks - odds Ratio Analysis, Graphical Solutions of two variable problems, Report Writing based on Practical Problem.	24	CLO1 CLO2

Textbooks:
1. Lawless, J. F. (2011). Statistical models and methods for lifetime data (Vol. 362).John Wiley & Sons.

Reference Books:
1. Daniel, W. W. (2000): Bio-Statistics: A Foundation for Analysis in the Health Science, 7th Edition, John Wiley and Sons, New York.
2. Collett D (2014). Modelling Survival Data in Medical Research, 3rd edition. Chapman & Hall/CR

STAT 4207: Machine Learning and Data Mining Lab

Title of the Course	**Machine Learning and Data Mining Lab**				
Course Code	STAT 4207				
Credit Hours	**1.5**				
Evaluation (Marks Distribution)	**Continuous Assessment**	Two Mid Semester Exam	Assignment/ Presentation	Attendance	Subtotal
		7.5*2 = 15	2.5	2.5	**20**
	Semester Final Examination	**30**			
	Total Marks	**50**			

Course Introduction:
This course introduces the practical skills and training for data mining.
Course Objectives (CO): This course is aimed at providing practical concepts on data mining and applications.
Course Learning Outcomes (CLOs):
After successful completion of this course, students will be able to:
CLO1: develop knowledge of data mining-related practical problems.
CLO2: familiar with various methods for big data analysis and visualization.

S.N.	Course Contents	Hrs	CLOs
1	Problems regarding association rules, clustering, classification, machine learning, Supervised Learning, Unsupervised Learning, Decision trees, text Mining & web Mining.	24	CLO1 CLO2

Textbooks:

1. Gareth J, Daniela W, Trevor H, Robert T (2013). An introduction to statistical learning: with applications in R. Spinger; 2013.

Reference Books:

1. Hofmann M, Chisholm A (2015): Text Mining and Visualization: Case Studies Using Open-Source Tools, Chapman & Hall/CRC Data Mining and Knowledge Discovery Series, 1st Edition.
2. KwartlerT. (2017): Text Mining in Practice with R, Wiley.

STAT 4208: Project Report

Title of the Course	**Project Report**
Course Code	STAT 4208
Credit Hours	**1.5**
Total Marks	**50**

STAT 4209: Viva-Voce

Title of the Course	**Viva-Voce**
Course Code	STAT 4209
Credit Hours	**1.5**
Total Marks	**50**