SCHOOL OF STATISTICS
&
SCHOOL OF DATA SCIENCE AND FORECASTING

PROGRAM CODE : ST4A

PROGRAM TITLE : BACHELOR OF SCIENCE (Hons.)

- APPLIED STATISTICS AND ANALYTICS

PROGRAM OUTCOMES :

- Apply statistical techniques to the solution of real - world business problems, communicate findings, and effectively present results using data visualization techniques.
- Demonstrate knowledge of statistical data analysis techniques utilized in business decision making.
- Apply principles of Data Science to the analysis of business problems.
- Use data mining software to solve real – world problems.
- Employ cutting edge tools and technologies to analyze Big Data.
- Apply algorithms to build machine intelligence.
- Demonstrate use of team work, leadership skills, decision making and organization theory.

PROGRAM STRUCTURE :

First Semester :

Code	Title	Credits (L T P)
CORE COURSES		
ST4A - 101	Descriptive Statistics	4 (2-1-2)
ST4A - 103	Introduction to Probability Theory	3 (2-0-2)
ST4A - 105	Fundamentals of Economics	3 (2-1-0)
ST4A - 107	Programming in C++	4 (2-1-2)
ABILITY ENHANCEMENT COURSE		
ST4A - 109	Communication Skills	3 (2-1-0)
ELECTIVE COURSES – DISCIPLINE CENTRIC (Any One)		
ST4A - 121	Discrete Mathematics	4 (3-1-0)
ST4A - 123	Mathematical Analysis	4 (3-1-0)
ELECTIVE GENERIC : The students can choose following course or any other UG level generic course being run in this campus.		
ST4A - 141	Computer Applications	3 (2-1-0)
Comprehensive Viva – Voce		

ST4A - 151	Comprehensive Viva – Voce	4
VALUE ADDED (ADD – ON COURSE) : It is an additional course. Its credits shall not be counted in calculating SGPA / CGPA.		
ST4A - 161	Business Ethics	3 (2-1-0)

DETAILED SYLLABUS :

First Semester :

ST4A – 101 : Descriptive Statistics   **Credits : 4 (2-1-2)**

COURSE DESCRIPTION :

Unit I : Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurements – nominal; ordinal; interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

Unit II : Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range; quartile deviation; mean deviation; standard deviation; coefficient of variation.

Unit III : Bivariate frequency distribution, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard`s corrections.

Unit IV : Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation, simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

PRACTICALS :

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman rank correlation with and without ties.
11. Partial and Multiple correlations.
12. Planes of regression and variances of residuals for given simple correlations.
13. Planes of regression and variances of residuals for raw data.

TEXT BOOKS :

I. Goon A.M. , Gupta M.K. and Dasgupta B. (2002) : Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

II. Miller, Irwin and Miller , Maryless (2006) : John E. Freund`s Mathematical Statistics with Applications, (7th Edn.) Pearson Education, Asia.

III. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007) : Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw – Hill Pub. Co. Ltd.

ST4A – 103 : Introduction to Probability Theory   **Credits : 4 (2-1-2)**

COURSE DESCRIPTION :

Unit I : Probability: Introduction, random experiments, sample space, events and algebra of events, Definition of probability – classical; statistical and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes theorem and its applications.

Unit II : Random variables: discrete and continuous random variables, p.m.f ; p.d.f and c.d.f , illustration and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint marginal and conditional p.m.f ; p.d.f and c.d.f , independence of variables, bivariate transformations with illustrations.

Unit III : Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Uniqueness and inversion theorems (without proof) along with applications, Conditional expectations.

Unit IV : Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Introduction of Discrete and Continuous Probability Distributions along with their characteristic properties and limiting/approximation cases.

PRACTICALS :

1. Fitting of binomial distributions for n and $p = q = \frac{1}{2}$.
2. Fitting of binomial distributions for n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on negative binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.

TEXT BOOKS :

I.   Hogg, R.V. , Tanis, E.A. and Rao J.M. (2009) : Probability and Statistical Inference, 7th Edn. , Pearson Education, New Delhi.
II. Miller, Irwin and Miller, Maryless (2006) : John E. Freund`s Mathematical Statistics with Applications, 7th Edn. , Pearson Education, Asia.
III. Myer, P.L. (1970) : Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

ST4A – 105 : Fundamentals of Economics   **Credits : 3 (2-1-0)**

COURSE OBJECTIVE :

- To introduce the first year students to the basic concepts of microeconomics and macroeconomics.
- To explain economic concepts and theories related to the behavior of economic agents, markets, industry and firm structures, legal institutions, social norms, and government policies.
- To gain an understanding of core economic principles and how they apply to a wide range of real – world issues.

COURSE OUTCOMES : Upon completing the course, students will be able to :

- Demonstrate knowledge of the laws of supply and demand and equilibrium; and apply the supply and demand model to analyze responses of markets to external events.
- Evaluate economic issues and public policy by using economic models or data analysis while identifying underlying assumptions of the model(s) and limitations.

COURSE DESCRIPTION :

Unit I : Introduction to Economics – Definition, Nature and Scope of Economics; The Economic Problems: Scarcity and Choice; Difference between Microeconomics and Macroeconomics; Significance in decision-making and fundamentals concepts; Production Possibility Frontier; Opportunity Cost; Positive and Normative Economics.
Supply and Demand - How Markets work; Determinants of Individual Demand and Supply; Demand/Supply Schedule; Demand/Supply Curve; Market versus Individual Demand/Supply; Shifts in the Demand/Supply; Elasticity of Demand and Supply; Market Equilibrium; Changes in Market Equilibrium; Application of Demand and Supply; Price Control and Rationing, Rent Control, Minimum Agriculture Support price, Incidence of Indirect Taxes.

Unit II : The Theory of Consumer Behavior - Rationality, Utility, Cardinal Utility Theory, Indifference Curve, Consumers Preferences, The Consumption Decision; Budget constraints, Consumption and Income/Price Changes, Consumer`s Surplus.

Unit III : The Theory of Firm – Theory of Production, Technology and Production Functions, The Law of Diminishing Marginal Returns, The Law of Returns to Scale; Theory of Cost; Concepts of Cost, Cost Functions, The Distinction between the Long Run and Short Run, Fixed and Variable costs, Behavior of the Firm in Short Run and Long Run.

Unit IV : Introduction to Macroeconomics and National Income Accounting – Introduction to Macroeconomics; Circular Flow of Income; Real versus Nominal Income; Meaning and Concepts of National Income : GNP/GNI , NNP/NNI, Personal Income and Disposable Income; Methods of Computing National Income – Production Method, Income Method, Expenditure Method.
Concept of Consumption and Investment – The Theory of Multiplier and Accelerator; Business Cycles; Inflation : Nature and Causes, Effects of Inflation, Measurement of Inflation.

TEXT BOOKS :

I. M.L. Jhingan, Principles of Economics
II. H.L. Ahuja, Principles of Microeconomics
III. D.N. Dwivedi, Macroeconomics : Theory and Policy, Tata McGraw – Hill

ST4A – 107 : Programming in C++   **Credits : 4 (2-1-2)**

COURSE OBJECTIVE :

COURSE OUTCOMES :

COURSE DESCRIPTION :

Unit I : Object Oriented Programming : Procedural Programming v/s Object – Oriented Programming, Terminology, Benefits, Languages, and Applications, Data Types, Variables, Operations, Expressions, Control Structures, Arrays, Strings, Pointers. Function : Introduction, Prototype, Passing Data by Value, Reference Variables, using Reference Variables as Parameters, Default Arguments, Overloading Functions, Passing Arrays to Functions.

Unit II : Introduction to C++ : Applications, Example Programs, Tokens. Classes : Introduction, Defining an Instance of a Class, Data Access Modifiers, Why have Private Members ? Separating Class Specification from Implementation, Inline Member Functions, Constructors, Passing Arguments to Constructors, Destructors, Overloading Constructors, Private Member Functions, Instance and Static Members, Friends of Classes, Member – wise Assignment, Copy Constructors, Operator Overloading.

Unit III : Inheritance : Introduction, Protected Members and Class Access, Base Class Access Specification, Constructors and Destructors in Base and Derived Classes, Redefining Base Class Functions, Polymorphism and Virtual Member Functions, Abstract Base Classes and Pure Virtual Functions, Multiple Inheritance. C++ Streams : Stream Classes, Unformatted I/O Operations, Formatted I/O Operations.

Unit IV : Exceptions : Introduction, Throwing an Exception, Handling an Exception, Object – Oriented Exception Handling with Classes, Multiple Exceptions, Extracting Data from the Exception Class, Re – throwing an Exception. Templates : Function Templates – Introduction, Function Templates with Multiple Type, Overloading with Function Templates, Class Templates – Introduction, Defining Objects of the Class Template, Class Templates and Inheritance.

PRACTICALS :

1. Write a program to print the sum of digits of a given number.
2. Write a program to check whether the given number is Armstrong or not.
3. Write a program to check whether the given string is Palindrome or not.
4. Write a program to read the student name, roll no. , marks and display the same using class and object.
5. Write a program to find area of a rectangle, circle, and square using class and object.
6. Write a program to implement inline function inside and outside of a class for a. Finding the area of a square b. Finding the area of a cube.
7. Write a program to implement friend function and friend class.
8. Write a program to implement constructor and destructor with in a class.
9. Write a program to demonstrate hierarchical inheritance.
10. Write a program to demonstrate multiple inheritance.
11. Write a program to demonstrate the constructor overloading.
12. Write a program to demonstrate static polymorphism.
13. Write a program to demonstrate dynamic polymorphism.

14. Write a program to implement polymorphism using Pure Virtual Functions.
15. Write a program to demonstrate the function templates and class templates.
16. Write a program to demonstrate exception handling using try, catch, and finally.

Note : Recommended to use Open Source Software : GCC on Linux ; DevC++ (or) CodeBlocks on Windows 10.

TEXT BOOKS :

   I.   Tony Gaddis, Starting out with C++ : From Control Structures through Objects (7e).

REFERENCES BOOKS :

   I.   B. Lippman, C++ Primer.
  II.   Bruce Eckel, Thinking in C++.
 III.   K.R. Venugopal, Mastering C++.
 IV.   Herbert Schildt, C++ : The Complete Refernce.
  V.   Bjarne Stroustrup, The C++ Programming Language.
 VI.   Sourav Sahay, Object Oriented Programming with C++.

ST4A – 109 : Communication Skills   **Credits : 3 (2-1-0)**

COURSE OBJECTIVE : To make use of the opportunities and meet the challenges of the modern world, students need to develop effective communication skills. This is a skill that is most often quoted as lacking in engineers and IT professionals. Proper communication skills are also extremely important in interpersonal relationships. This course will help students in becoming confident and effective communicators, who can project themselves positively to others.

COURSE OUTCOMES : At the end of the course the students will be able :
- To make communication with the parties concerned.
- To write memorandum, circulars, notices, business letters, and business reports.
- To write resume and job application.
- To participate in group discussion and interviews.

COURSE DESCRIPTION :

Unit I : Introduction to Communication - Need for Effective Communication, The Process of Communication : Levels of communication; Flow of communication; Use of language in communication; Communication networks; Significance of technical communication. Barriers to Communication : Types of barriers; miscommunication; noise; overcoming measures.

Unit II : Listening Skills – Listening as an active skill; Types of Listeners; Listening for general content; Listening to fill up information; Intensive Listening; Listening for specific information; Developing effective listening skills; Barriers to effective listening skills.
Reading Skills – Previewing techniques; Skimming; Scanning; Understanding the gist of an argument; Identifying the topic sentence; Inferring lexical and contextual meaning; recognizing coherence and sequencing of sentences; Improving comprehension skills.
Writing Skills - Sentence formation; Use of appropriate diction; Paragraph and essay writing; Coherence and Cohesion.

Unit III : Letter Writing - Formal, informal and demi – official letters; business letters. Job Application : Cover letter, Differences between Bio-Data, CV and Resume. Report Writing : Basics of Report Writing; Structure of a report; Types of reports. Non - verbal Communication and Body Language : Forms of non–verbal communication; Interpreting body – language cues; Kinesics; Proxemics; Chronemics; Effective use of body language.

Unit IV : Interview Skills – Types of Interviews; Ensuring success in job interviews; Appropriate use of non – verbal communication. Group Discussion : Differences between group discussion and debate; Ensuring success in group discussions. Presentation Skills : Oral presentation and public speaking skills; business presentations. Technology – based Communication : Netiquettes – effective e – mail messages; power – point presentation; enhancing editing skills using computer software.

TEXT BOOKS :
  I.   Spoken English & Effective Communication (With 2 CDs) : Mind Power Spoken English Institute by Prof. Sharad Shrivastava and Dr. Amita Singhvi ; Franklin International ; New edition (2015)
  II.   Communication Skills by Sanjay Kumar and Pushp Lata ; Oxford University Press India ; (2015)
  III. El Dorado : A Textbook of Communication Skills by R. Pushkala and P.A. Sarada ; Orient Blackswan ; (2013)

ST4A – 123 : Mathematical Analysis   **Credits : 4 (3-1-0)**

COURSE OBJECTIVE :

COURSE DESCRIPTION :

Unit I : Real Analysis – Representation of real numbers as points on the line and the set of real numbers as complete ordered field, Bounded and Unbounded sets, neighborhoods and limit points, Superimum and Infimum, Derived Sets, Open and Closed sets, sequences and their convergence, limits of some special sequences such as r^n , $\left(1 + \dfrac{1}{n}\right)^n$, and $n^{\frac{1}{n}}$ and Cauchy`s general principle of convergence,

Cauchy`s first theorem on limits, monotonic sequences, limit superior and limit inferior of a boundedsequences.

Unit II : Infinite series, positive termed series and their convergence, Comparison test, D`Alembert`s ratio test, Cauchy`s $n^{th}$ root test, Raabe`s test, Gauss test, Cauchy`s condensation test and integral test(Statements and Examples only). Absolute convergence of series, Leibnitz`s test for the convergence ofalternating series, Conditional convergence. Indeterminate from, L' Hospital`s rule.

Unit III : Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle`s and Lagrange`s Mean Value theorems. Taylor`s theorem with Lagrange`s and Cauchy`s form of remainder (without proof). Taylor`s and Maclaurin`s series expansions of sin x, cos x , e^x , $(1+x)^n$,log (1+x).

TEXT BOOKS :

I.   S.C. Malik and Savita Arora : Mathematical Analysis, Second Edition, Wiley Eastern Limited, NewAge International Limited, New Delhi, 1994.

II. Somasundram D. and Chaudhary B. : A First Course in Mathematical Analysis, Narosa PublishingHouse, New Delhi , 1987.

III. Gupta S.L. and Nisha Rani : Principles of Real Analysis, Vikas Publ. House Pvt. Ltd. , New Delhi,1995.

IV. Appostol T.M. : Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi,1987.

V.   Shanti Narayan : A course of Mathematical Analysis, 12th revised Edition, S. Chand & a. Co.(Pvt.) Ltd., New Delhi, 1987.

VI. Bartle, R. G. and Sherbert, D. R. (2002) : Introduction to Real Analysis (3rd Edition), John Wileyand Sons (Asia) Pte. Ltd., Singapore.

VII. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006) : A Course in Calculus and Real Analysis,Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

1-0)COURSE OBJECTIVE :

COURSE DESCRIPTION :

Unit I : Computer - What is Computer, Basic Applications of Computer; Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Using Mouse; Using right Button of the Mouseand Moving Icons on the screen, Use of Common Icons, Status Bar, Using Menu and Menu-selection, Running an Application, Viewing of File, Folders and Directories, Creating and Renaming of files and folders. Memory Concepts- Units: Byte, Kilo Byte, Mega Byte, Giga Byte, Tera Byte, Peta Byte, Exa Byte, Zetta Byte, Yotta Byte. Primary Memory: Cache, RAM, ROM Secondary Memory: Fixed and Removable Storage-Hard Disk Drive, CD/DVD Drive, Pen Drive, Blue Ray Disk Input Output Ports/Connections: Serial,Parallel and Universal Serial Bus, PS-2 port, Infrared port, Bluetooth, Firewire.

Unit II : Operating System - What is an Operating System; Need for operating system, Basics of Popular Operating Systems; The User Interface, Opening and closing of different Windows; Creating Short cuts, Basics of O.S Setup; Common utilities. Functions of Operating System (Processor Management, Memory Management, File Management and Device Management), Types of operating system-Interactive (GUI based), Commonly used operating systems: UNIX, LINUX, Windows, Mobile OS-Android, Symbian. Types of Software-System Software, Utility Software and Application Software. Utility Software: Anti-Virus, FileManagement tools, Compression tools and Disk Management tools (Disk Clean-up, Disk Defragmenter, Backup). Concept of Computing, Data and Information; Applications of IECT.

Unit III : Word Processing and Spread Sheet - Word Processing Basics; Opening and Closing of documents; Text creation and Manipulation; Formatting of text; Table handling; Spell check, language setting and thesaurus; Printing of word document. Basics of Spread sheet; Manipulation of cells; Formulas and Functions; Editing of Spread Sheet, printing of Spread Sheet. Basics of presentation software; Creating Presentation; Preparation and Presentation of Slides; Slide Show; Taking printouts of presentation / handouts.

Unit IV : Introduction to Internet, WWW and Web Browsers - Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; connecting to internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting, World Wide Web; Web Browsing software, Search Engines; Understanding URL; Domain name; IP Address; Using e-governance website, Basics of electronicmail; Getting an email account; Sending and receiving emails; Accessing sent emails; Using Emails; Document collaboration; Instant Messaging; Netiquettes.

PRACTICALS :

1. Study of Computer Components, Booting of Computer and its Shut Down.
2. Practicing WINDOWS Operating System – use of Mouse, Title Bar, Minimum, Maximum and CloseButtons, Scroll Bars, Menus and Tool Bars.
3. WINDOWS Explorer – Creating Folders, COPY and PASTE functions.
4. MS WORD – Creating a document, editing, saving ; use of options from tool bars – Format, Insertand Tools (Spelling & Grammar), alignment of paragraphs and text.
5. MS WORD – Creating a table, merging of cells, column and row width.
6. MS WORD – Referencing in MS – Word.
7. MS EXCEL – Creating a spreadsheet, alignment of rows, columns and cells using Format tool bar.

8. MS EXCEL – Entering formula expressions through the formula tool bar and use of in-builtfunctions – SUM, AVERAGE AND STDEV.
9. MS EXCEL – Creating and saving graphs with and without data.
10. Creating Mark sheet in MS EXCEL.
11. Graph and tables Hands – on.
12. MS Power Point – Preparation of slides on power point.
13. MS ACCESS – Creating database, structuring with different types of fields and use of query facilityfor accessing the information.
14. Internet Browsing – Use of Internet Explorer, browsing a Web Page through search engines.
15. E-mail – Creation of E-mail ID, attaching files and sending.
16. E-mail and Mail merge Hands – on.

TEXT BOOKS :

I. Computers Fundamentals and Architecture by B. Ram
II. Microsoft Windows XP Step by Step , PHI
III. William Stallings, Operating System, Pearson Education
IV. Norton, Introduction to Computers, McGraw Hill
V. Ron Mansdield, Microsoft Office, BPB Publication
VI. Fundamentals of Computers: P. K. Sinha
VII. System Analysis and Design by Elias M Awad.

REFRENCES BOOKS :

I. P C Software for Windows by R K Taxali
II. P C Software Bible by S.Jaiswal
III. Computers Today: Suresh K.Basandra
IV. Operating System: Achyut S. Godbole
V. Management Information systems by Gerald V. Post & David L. Anderson.
VI. Understanding Computer Fundamentals & Dos by G.K. Iyer
VII. MS-Office Interactive course by Greg Perry, Techmedia
VIII. MS Office Complete Reference TMH Publication.

SCHOOL OF STATISTICS
&
SCHOOL OF DATA SCIENCE AND FORECASTING

PROGRAM CODE : ST4A

PROGRAM TITLE : BACHELOR OF SCIENCE (Hons.)

- APPLIED STATISTICS AND ANALYTICS

PROGRAM STRUCTURE :

Second Semester :

Code	Title	Credits (L T P)
CORE COURSES		
ST4A - 102	Probability Distributions	4 (3-1-0)
ST4A - 104	Calculus	3 (2-1-0)
ST4A - 106	Microeconomics	3 (2-1-0)
ST4A - 108	Database Management Systems	4 (2-0-2)
ABILITY ENHANCEMENT COURSE		
ST4A - 110	Environmental Studies	3 (2-1-0)
ELECTIVE COURSES – DISCIPLINE CENTRIC		
ST4A - 122	Numerical Methods	4 (3-1-0)
ELECTIVE GENERIC : The students can choose following course or any other UG level generic course being run in this campus.		
ST4A - 142	Advanced Excel	3 (0-0-6)
Comprehensive Viva – Voce		
ST4A - 152	Comprehensive Viva – Voce	4

ST4A – 102 : Probability Distributions   **Credits : 4 (3-1-0)**

COURSE OBJECTIVE : Life is full of uncertainties and therefore probability distributions offer useful techniques for quantifying these uncertainties. Students apply the concepts of various probability distributions to find probabilities of the uncertainties. This particular course explores the basic concepts of probability theory and its application in different fields.

COURSE OUTCOMES : By completing this course the students shall learn the following :

- Collecting the desired information about the universe in minimum time and high degree of reliability.
- Understanding the concepts of a random variable and a probability distribution.
- Understanding the difference between discrete and continuous random variables.
- Computing probabilities using a Binomial and Poisson probability distribution.
- Understanding the difference between how probabilities are computed for discrete and continuous random variables.
- How to compute probability values for a continuous uniform probability distribution and be able to compute the expected value and variance for such a distribution
- Be able to compute probabilities using a normal probability distribution. Understand the role of the standard normal distribution in this process.
- Be able to compute probabilities using an exponential probability distribution.

COURSE DESCRIPTION :

Unit I : Discrete Probability Distributions : Uniform, Binomial, Poisson, Geometric, Negative Binomial and Hyper – geometric distributions along with their characteristics properties and limiting / approximation cases.

Unit II : Continuous Probability Distributions : Normal, Exponential, Uniform, Beta, Gamma, Cauchy, Log–normal and Laplace distributions along with their characteristics properties and limiting / approximation cases.

Unit III : Exact sampling distributions : Definition and derivations of p.d.f of χ^2 with n degrees of freedom (d..f.) using m.g.f. , nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f. , cumulant generating function, mode, additive property and limiting form of χ^2 distribution. Tests of significance and confidence intervals based on χ^2 distribution.

Unit IV : Exact sampling distributions : Student`s and Fishers` t-distribution, Derivations of its p.d.f. , nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t-distribution.
Snedecore`s F – distribution : Derivation of p.d.f. , nature of p.d.f curve with different degrees of freedom, mean, variance and mode. Test of significance and confidence intervals based on t and F distributions.

PRACTICALS :

1. Fitting of Binomial distributions for n and p = q = ½.

2. Fitting of Binomial distributions for given n and p.
3. Fitting of Binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on Binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on Negative Binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.
16. Exact Sample Tests based on Chi – Square Distribution.
17. Testing of goodness of fit.
18. Testing of independence of attributes.
19. Testing based on 2 X 2 contingency table without and with Yates` corrections.
20. Testing of significance and confidence intervals of an observed sample correction coefficient.
21. Testing and confidence intervals of equality of two population variances.

TEXT BOOKS :

I. Goon A.M. , Gupta M.K. and Dasgupta B. (2003) : An Outline of Statistical Theory, Vol. I , 4th Edn., World Press, Kolkata.
II. Rohatgi V.K. and Saleh, A.K. Md. E. (2009) : An Introduction to Probability and Statistics, 2nd Edn. (Reprint), John Wiley and Sons.
III. Hogg, R.V. and Tanis, E.A. (2009) : A Brief Course in Mathematical Statistics, Pearson Education.
IV. Johnson, R.A. and Bhattacharya, G.K. (2001) : Statistics – Principles and Methods, 4th Edn. , John Wiley and Sons.
V. Mood, A.M. , Graybill, F.A. and Boes D.C. (2007) : Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw – Hill Pub. Co. Ltd.
VI. Myer, P.L. (1970) : Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

COURSE

OUTCOMES :

COURSE

DESCRIPTION :

Unit I : Differential Calculus : Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms : L – Hospital`s rule, Leibnitz rule for successive differentiation. Euler`s theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points.

Unit II : Integral Calculus : Review of integration and definite integral. Differentiation under integral sign, double integral, change of order of integration, transformation of variables. Beta and Gamma functions : properties and relationship between them.

Unit III : Differential Equations : Exact differential equations, Integrating factors, change of variables, Total differential equations. Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut`s equations. Higher Order Differential Equations : Linear differential equations of order n, Homogeneous and non – homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non – constant coefficients, Reduction of order method, The Cauchy – Euler`s equation of order n, Legendre`s linear equation.

Unit IV : Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non – linear partial differential equation of first order and the different forms. Charpit`s method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non – homogeneous partial differential equations with constant coefficients. Classification of second order linear partial differential equations.

PRACTICALS :

TEXT BOOKS :

I.   Gorakh Prasad : Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition – 1997).
II.   Gorakh Prasad : Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition – 2000).
III. Zafar Ahsan : Differential Equations and their Applications, Prentice – Hall of India Pvt. Ltd., New Delhi (2nd Edition – 2004).
IV.   N. Piskunov : Differential and Integral Calculus, Peace Publishers, Moscow.

COURSE OBJECTIVE :

- To understand the difference between firm and industry.
- To explain the various market structures like perfect competition, monopoly, monopolistic competition, etc.
- To explain how firms make themselves as well off as possible in a world of scarcity.
- To describe how the various factors of production are rewarded for their services.
- To gain an understanding of welfare economics and analyze the efficiency of resource allocation.

COURSE OUTCOMES : Upon completing the course, students will be able to :

- Measure and illustrated firm`s cost, revenue and profit / loss in various market structure.
- Evaluate economic issues and public policy by using economic models or data analysis while identifying underlying assumptions of the model(s) and limitations.
- Analyze how perfect / imperfect competition between buyers and sellers of factors can impact wages, interest, and rents.
- Evaluate the consequences of economic activities and institutions for individual and social welfare.

COURSE DESCRIPTION :

Unit I : The Theory of Firm : Main Market Forms and Concepts of Revenue, Equilibrium of the Firm – A General Analysis; Perfect Competition : Short – run and Long – run Equilibrium of Firm and Industry, Supply Curve (short and long-run of Firm and Industry). Monopoly : Short – run and Long – run Equilibrium of Firm, Price Discrimination.

Unit II : Monopolistic Competition : Short – run and Long – run Equilibrium of Firm, Group Equilibrium, Product differentiation and Selling Costs. Oligopoly : Non – Collusive Oligopoly (Control, Bertrand and Kinked demand models) , Collusive Oligopoly (Cartels, Price Leadership)

Unit III : The Theory of Factor Pricing : Theory of Factor Pricing : Marginal Productivity Theory of Distribution, Backward Sloping Supply Curve of Labor, Modern Theory of Distribution, Rent ; Ricardian and Modern Theories, Quasi Rent, Rent and Price Relationship. Interest & Profit : Basic Concepts of Interest ; Classical, Neo – classical Theories, Profit : Gross and Net Profit and Theories of Profit.

Unit IV : General Equilibrium : Concepts of Partial and General Equilibrium, Walras Excess Demand Model, Existence, Stability and Uniqueness of General Equilibrium. Welfare Economics : Pareto Optimality Criterion and its Limitations.

TEXT BOOKS :

I.   H.L. Ahuja, Principles of Microeconomics, S. Chand and Company Ltd.
II. S Damodaran, Managerial Economics.
III. A. Koutsoyiannis, Modern Microeconomics, Macmillan Press Ltd.
IV. M.L. Jhingan, Microeconomics.

COURSE OBJECTIVE : The purpose of this course is to provide fundamental knowledge of database management system and understanding of how to use and design a DBMS.

COURSE OUTCOMES :

- The student will learn the basics of database management.
- The student will be able to design database using ER diagram.
- The student will be able to optimize database using normalization.
- The student will be able to work on database software MySQL / Oracle.
- The student will learn how to write SQL queries.

COURSE DESCRIPTION :

Unit I : DBMS Concepts, Comparison between Database approach and Traditional file accessing approach, Advantages of database systems, Schemas and instances, Data Dependency, Data Dictionary, and Meta Data. Data models, Types of Data Models (Object Oriented, Record Based and Physical data models), E-R diagram, Relational Data models : Domains, Tuples, Attributes, Keys, Relational database, Schemas, Integrity constraints, Relational algebra and relational calculus.

Unit II : Database Design : Introduction to normalization, Normal forms (1NF, 2NF, 3NF, BCNF), Functional dependency, Decomposition, Dependency preservation and lossless join, multi – valued dependencies. **Structured Query Language :** DDL, DML, DCL, TCL, SQL Functions, integrity constraints, various joins, sub – query, index, View, Sequence, and Clusters. PL/SQL : manipulating data using PL/SQL, Iteration, Exceptions, Cursors, Trigger. (Experiment on Oracle 11g)

Unit III : Transaction Processing and Concurrency Control : Transaction System, Serializability of schedules, conflict & view serializable schedule, Recovery from transaction failures, Log based recovery. Checkpoints dead lock handling, Concurrency Control, locking Techniques for concurrency control, time stamping protocols for concurrency control, validation based protocol, multiple granularity.

Unit IV : Advance Concepts : Introduction to Distributed databases, data mining, data warehousing, Basic Concepts of Object Oriented Database System, Comparative study of OODBMS v/s RDBMS. Introduction to Image and Multimedia databases and data structures, Web and mobile database, Spatial and Geographic Database, Accessing Database from front – end Application. Case Study : Oracle, MySql, DB2.

TEXT BOOKS :

I. A Silberschatz, H Korth, S Sudarshan, "Database System and Concepts", Fifth Edition, McGraw – Hill.

II. Elmasri Ramez and Novathe Shamkant, "Fundamentals of Database Systems", Benjamin Cummings Publishing Company.

III. Rob, Coronel, "Database Systems", Seventh Edition, Cengage Learning.

IV. Ramakrishnan : Database Management System, McGraw – Hill.

V. Fred R. McFadden, Jeffrey A. Hoffer & Marry B. Prescott. "Modern Database Management", Fifth Edition, Pearson Education Asia, 2001.

VI. Gray Jim and Reuter Address, "Transaction Processing : Concepts and Techniques", Morgan Kauffman Publishers.

COURSE OBJECTIVE : The course has been designed to bring about an awareness of a variety of environmental problems and to create a pro – environmental attitude and concern for environment for change in behavioral pattern in society that is based on creating sustainable lifestyles.

COURSE OUTCOMES : The course will empower the undergraduate students by helping them to :

- Gain in – depth knowledge on natural processed that sustain life, and govern economy.
- Predict the consequences of human actions on the web of life, global economy and quality of human life.
- Develop critical thinking for shaping strategies (scientific, social, economic and legal) for environmental protection and conservation of biodiversity, social equity and sustainable development.
- Acquire values and attitudes towards understanding complex environmental – economic – social challenges, and participating actively in solving current environmental problems and preventing the future ones.
- Adopt sustainability as a practice in life, society and industry.

COURSE DESCRIPTION :

Unit I : Introduction : Definition, scope objective and importance of environmental studies, need for public awareness, multi – disciplinary nature of environmental studies.

Natural Resources : Renewable and Non – renewable resources and associated problems : Forest resources, water resources, mineral resources, food resources, energy resources, land resources, role of an individual in conservation of natural resources.

Ecology and Ecosystems : Concepts of an ecosystem, structure and function of an ecosystem, producers, consumers and decomposers, Energy flow in the ecosystem, food chains, food webs and ecological pyramids. Introduction, types, characteristics features, structure and function of the Forest ecosystem, Grassland Ecosystem, Desert ecosystem, Aquatic ecosystems.

Unit II : Biodiversity and its conservation : Bio – geographical classification of India Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, national and local levels, India as a mega – diversity nation.

Environmental Pollution : Cause, effects and control measures of : Air pollution, water pollution, soil pollution, noise pollution, thermal pollution, nuclear hazards, Solid Waste Management : causes, effects and control pollution case studies, disaster management : floods, earthquake, cyclone and landslides.

Unit III : Social Issues and the Environment : From Unsustainable to Sustainable development, urban problems related to energy, water conservation, rain water harvesting, water – shed management, resettlement and rehabilitation of people; its problems and concerns.

Environmental ethics : Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents. Waste land reclamation.

Unit IV : Environment Protection Act : Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, public awareness, role of Information Technology in Environment and human health.

TEXT BOOKS :

I. Mahua Basu and Xavier Savarimuthu SJ, 2017, Fundamentals of Environmental Studies, Cambridge University Press.
II. Bharucha Erach, The Biodiversity of Indian, Mapin Publishing Pvt. Ltd.
III. R. Rajagopalan, Environmental Studies, 2015, Oxford University Press , Third edition.
IV. Anubha Kaushik, Gaurav Garg, Perspectives in Environmental Studies, 2018, New Age International Publishers, Sixth edition.
V. R.J. Ranjit Daniels, Jagdish Krishnaswamy, Environmental Studies, 2013, Wiley, GBTU.
VI. Dr. Sanjay Kumar Batra, Dr. Kanchan Batra, 2018, Environmental Studies, TaxmannPublications Pvt. Ltd.
VII. R.C. Brunner, 1989, Hazardous Waste Incineration, McGraw Hill Inc.

ST4A – 122 : Numerical Methods   **Credits : 4 (3-1-0)**

COURSE OBJECTIVE : This course provides coverage of key numerical methods to solve practical mathematical problems.

COURSE DESCRIPTION :

Unit I : Floating point representation and computer arithmetic, Significant digits, Errors : Round – off error, Local truncation error, Global truncation error, Order of a method, Convergence and terminal conditions, Efficient computations.

Unit II : Bisection method, Secant method, Regula – Falsi method.
Newton – Raphson method, Newton`s method for solving non – linear systems.
Gauss elimination method (with row pivoting) and Gauss – Jordan method, Gauss Thomas method fortri– diagonal systems.
Iterative methods : Jacobi and Gauss – Seidel iterative methods.

Unit III : Interpolation : Lagrange`s form and Newton`s form.
Finite difference operators, Gregory Newton forward and backward differences Interpolation Piecewise polynomial interpolation : Linear interpolation, Cubic spline interpolation (only method), Numerical differentiation : First derivatives and second order derivatives, Richardson extrapolation.

Unit IV : Numerical Integration : Trapezoid rule, Simpson`s rule (only method), Newton – Cotes open formulas. Extrapolation methods : Romberg integration, Gaussian quadrature, Ordinary differential equation : Euler`s method. Modified Euler`s methods : Heun method and Mid – point method, Runge – Kutta second methods : Heun method without iteration, Mid – point method and Ralston`s method Classical 4th order Runge – Kutta method, Finite difference method for linear ODE.

PRACTICALS :

1. Find the roots of the equations by Bisection method.
2. Find the roots of the equations by Secant/Regula – Falsi method.
3. Find the roots of the equations by Newton`s method.
4. Find the solutions of a system of non-linear equations using Newton`s method.
5. Find the solution of Tri-diagonal system using Gauss Thomas method.
6. Find the solution of system of equations using Jacobi/Gauss – Seidel method.
7. Find the cubic spline interpolating function.
8. Evaluate the approximate value of finite integrals using Gaussian/Romberg integration.
9. Solve the boundary value problem using finite difference method.

Note : Programming is to be done in any one of Computer Algebra Systems : MATLAB / MATHEMATICA / MAPLE.

TEXT BOOKS :

I. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

II. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed. , New Age International Publisher, India, 2007.

III. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

IV. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed. , PHI Learning Private Limited, 2013.

V. John H. Mathews and Kurtis D. Fink, Numerical Methods using MATLAB, 4th Ed. , PHI Learning Private Limited, 2012.

VI. Laurence V. Fausett, Applied Numerical Analysis using MATLAB, Pearson, 2/e (2012).

VII. Steven C Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, Tata McGraw Hill, 2/e (2010).

ST4A – 142 : Advanced Excel   **Credits : 3 (0-0-6)**

COURSE OBJECTIVE : The main objective of this course is to learn analysis of data using MS Excel, resulting in less time and better understands what the data means.

COURSE OUTCOMES :

- The student will be able to perform basic operations in Excel.
- The student will be able to summarize data using Grouping and Pivot Table.
- The student will be able to write conditional statements and perform LOOKUP operations.
- The student will be able to create charts in Excel.
- The student will be able to create a dashboard in Excel.

COURSE DESCRIPTION :

Unit I : Introduction to Excel User Interface, Application, Workbook, Worksheets and its Components, Named Ranges; Formatting : Cell Color, Font Color, Indents, Alignments, Number Formats, Custom Formats, Editing commands; Data Sorting : Built-in Sort, Sorting Levels, Custom Sort; Data Filtering : Auto Filter – Filter by Color, Filter by Icono Advanced Filter, Remove Duplicates; Data Subtotal – Built-in Subtotal (Nested Subtotal).

Unit II : Data Validation : Based on cell values (text length, whole no. based on formulae, List Dropdown, Circle Invalid Data, Input & Error Messages; Data Grouping : Grouping Rows, Grouping Columns). Data Tables : Conditional Formatting, Formatting based on cell values, Formatting based on

formulae, Icon sets (bars, scales, icons), Freezing Panes, Text – to – Columns, Delimited, Fixed Length;Data Consolidation (from multiple files), getting External Data into Excel : from MS Access, from Text files, from Web, other Data Sources.

Unit III : Formulae, TEXT Functions, IF, ERROR Functions, LOGICAL Functions, VLOOKUP, HLOOKUP, COUNTIF, SUMIF, SUMPRODUCT, DATE & TIME Functions, Formula Text, Information Functions (ISNA, ISEVEN, ISERR , …).

Unit IV : Charts : Chart Types, Chart Components, Primary v/s Secondary Axis, Chart Formatting, Sparkline (2010 and above); Pivot Tables : Introduction & Creation, Slicer, Time Line, Pivot Charts, Calculated Fields, Calculated Items, Grouping, Formatting – Number/Conditional, Power Pivot, PowerView.

TEXT BOOKS :

   I.   John Walkenbac, "Excel 2016 Bible", John Willey & sons.
  II.   Jordan Goldmeier , "Advanced Excel Essentials", Apress Publisher.
 III.   Conrad George Carlberg , "Business Analysis with Microsoft Excel", Que Publishers.
  IV.   Bernd Held, "Microsoft Excel Functions & Formulas", Wordware publishing, Inc.
   V.   Steven Roman ,"Writing Excel Macros with VBA" , O'Reilly Media.

SCHOOL OF STATISTICS
&
SCHOOL OF DATA SCIENCE AND FORECASTING

PROGRAM CODE : ST4A

PROGRAM TITLE : BACHELOR OF SCIENCE (Hons.)

- APPLIED STATISTICS AND ANALYTICS

PROGRAM OUTCOMES :

- Apply statistical techniques to the solution of real - world business problems, communicate findings, and effectively present results using data visualization techniques.
- Demonstrate knowledge of statistical data analysis techniques utilized in business decision making.
- Apply principles of Data Science to the analysis of business problems.
- Use data mining software to solve real – world problems.
- Employ cutting edge tools and technologies to analyze Big Data.
- Apply algorithms to build machine intelligence.
- Demonstrate use of team work, leadership skills, decision making and organizationtheory.

PROGRAM STRUCTURE :

Third Semester:

Code	Title	Credits (L T P)
CORE COURSES		
ST4A-201	Operations Research	4 (3-1-0)
ST4A-203	Estimation Theory	3 (2-1-0)
ST4A-205	Macro Economics	3 (2-1-0)
ST4A-207	Python	3 (2-0-2)
ELECTIVE COURSES-DISCIPLINE CENTRIC (Any Two)		
ST4A-221	Linear Algebra	4 (3-1-0)
ST4A-223	Data Mining and Data Warehousing	4 (3-0-2)
ST4A-225	Statistical Inference	4 (3-1-0)
ELECTIVE GENERIC: Thestudents can choose following courseor any other UG levelgeneric course being run in this campus.		
ST4A-231	Statistical Techniques for Research Methods	3 (2-1-0)
Comprehensive Viva-Voce		
ST4A-251	Comprehensive Viva-Voce	4
VALUE ADDED (ADD-ON COURSE): It is an additional course. Its credits shall not be counted in calculating SGPA/ CGPA.		
ST4A-261	Data Analysis	3 (2-1-0)

DETAILED SYLLABUS:

ST4A-201:OperationsResearch   **Credits: 4(3-1-0)**

COURSE OBJECTIVE:

This course exposes the students in mathematical modelling, solving and analyzing business and industrial problems using operations research methods.

COURSE DESCRIPTION:

Unit -I:

Introduction, History, Development of Operations Research, Characteristics of Operations Research, Models in Operations Research, Principles of Modelling.

Unit-II:

Linear Programming, Formulation of Linear programming Problems. Solution Methods - Graphical, Simplex, M-Technique, Two-Phase. Special cases of LP problems. Duality, Primal- dual relationships, Dual simplex method. Sensitivity analysis. Solving LP problems using computer software.

Unit-III:

Transportation Model-Formulating the model, Initial Feasible Solution -North-West Method, Least Cost Method, Vogel's Approximation Method. Optimum Solution -MODI method, Stepping Stone Method. Special issues of transportation problems. Assignment Model: Formulating the model, Solving the assignment problem using Hungarian method. Special issues of assignment problems.

Integer programming: Types of integer programming problems, Formulating the model, Solution using Branch and bound method. Dynamic Programming.

Solving the problems using computer software.

Unit-IV:

Project Scheduling:CPM and PERT.

Queuing Models: Goals, elements and characteristics of queuing systems, Measures of system performance, Waiting line models-single channel, multiple channel. Cost considerations.

TEXT BOOKS

Hamdy A. Taha: Operations Research: An introduction, Pearson Prentice Hall
David R. Anderson, Dennis J. Sweeney, Thomas A. Williams: An Introduction to ManagementScience, South-Western CollegePublishing.
William J. Stevenson: Introduction to Management Science, IRWIN.

Course Outcomes:

- Understand the verbal description of the real system and accordingly identify and development of operational research models.
- Understand the mathematical tools that are needed to solve optimisation problems.
- Use of mathematical software to solve the OR models developed.
- Develop a technical report that describes the model, solving technique, results analysis and recommendations.

ST4A - 203 : Estimation Theory   **Credits: 3(2-1-0)**

Course Objective:

The main objective of the Statistical inference refers to the process of drawing conclusions from the model estimation. It is important in order to analyze data properly. Indeed, proper data analysis is necessary to interpret research results and to draw appropriate conclusions. The goal of this course is to make inferences (predictions or decisions) about certain characteristics (for example, mean, standard deviation) of one or more populations based on information contained in the samples frompopulations.

Unit I

Theory of Estimation : Definition of random sample, Parameter and Statistic, Concept of point and interval Estimations, Criterion of good estimator : Unbiasedness, consistency, efficiency andsufficiency, mean square error of an estimate, Method of Maximum Likelihood estimation. Cramer
– Rao, Inequality and its application. Different method of Estimations and their properties.

Unit-II

Testing of Hypothesis : Concept of Test of significance, Null and Alternative Hypothesis, Simple and composite hypothesis, Type I and II error, Critical region and level of significance, One and twotailed tests, Neyman Pearson`s Lemma for construction of most powerful tests for simple null v/s simple alternative. Procedure of Hypothesis testing. Central Limit Theorem.

Unit III

Sampling Distribution : Sampling distribution of Statistics, definition and standard error andsome examples, Sampling distribution of sum of Binomial and Poisson variate, Sampling distribution of mean of normal distribution, derivation of Chi – square, Students` t, Fisher`s F,distribution and their properties, relation between Chi, t and F.

Unit IV

Large Sample Tests : Test of significance of single proportional, Z – test of significance of singlemean

and for difference of mean.

Small Sample Tests : t – test for single mean, difference of mean, paired t – test, F test for

equality of population variance, condition for the goodness of Chi – square test, test for

independence of attributes.

Unit V

Non – Parametric Tests : Order Statistics, definition, distribution, single joint and marginal distribution, Advantages and disadvantages of non – parametric methods, run test for randomness, Wilcoxon signed rank test, Median test.

Course Outcomes:

We briefly describe statistical estimation and then devote the remainder of this section to providinga conceptual overview of hypothesis testing. The goal in statistical inference is to use probability theory to make inferences about population parameters of interest. Students will learn interval estimation and methods of constructing confidence intervals. Interval estimation is concerned with quantifying the uncertainty or variability associated with the estimate. This approach supplements point estimation because it gives important information about the variability (or confidence) in the point estimate.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. & Dasgupta B. (1994): An Outline of Statistical Theory (Vol-1),WorldPress
2. Ross S.M. (1972): Introduction to Probability Models, Academic Press
3. Mood A.M., Graybill F. & Boes D.C. (1974): An Introduction to the Theory ofStatistics (3rd ed), McGraw Hill
4. Rao C.R. (1952): Advanced Statistical Methods in Biometric Research, John Wiley
5. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
6. Rohatgi V.K. (1984): An Introduction to Probability Theory & Mathematical Statistics, JohnWiley
7. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
8. Goon A. M., Gupta M. K. and Dasgupta B. (1997): Fundamentals of Statistics (V-1), WorldPress

PRACTICAL/LAB. WORK

List of Practical

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem,Complete Sufficient estimators
5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region
12. Unbiased critical region
13. Likelihood ratio tests for simple null hypothesis against simple alternativehypothesis
14. Likelihood ratio tests for simple null hypothesis against composite alternativehypothesis
15. Asymptotic properties of LR tests

ST4A – 205 : Macroeconomics   **Credits: 3(2-1-0)**

Course Objectives:

- To identify the determinants of various macroeconomic aggregates such as output, unemployment, inflation, productivity and the major challenges associated with the measurementof these aggregates.
- To describe the main macroeconomic theories of short term fluctuations and long term growth in the economy.
- To explain how the rate of inflation is calculated and identifies the consequences of inflation.
- To critically evaluate the consequences of basic macroeconomic policy under differing economic conditions within a business cycle.

Unit-I

Introduction to Macroeconomics: Definition and Importance of Macroeconomics.

Determination of Income and Employment: Classical Theory of Employment, Say's Law of Market and its
Implications, Keynesian Theory of Income and Employment Determination.

Consumption: Consumption Function, Technical Attributes of Consumption, Keynesian Psychological Law of Consumption and Its Implications, Empirical evidence. Income- Consumption Relationship: Absolute & Relative Income Hypothesis, Permanent Income Hypothesis, Life Cycle Hypothesis.

Unit-II

Investment function: Types of Investment, Determination of Level of Investment, Marginal Efficiency of Capital (MEC). Theories of Investment: Classical and Keynesian Theory of Investment (Marginal Efficiency of Investment), Saving-Investment Equality.

Theory of multiplier: Concept, Relation between Multiplier, MPC &MPS, Comparative Static and Dynamic Process, Working of Multiplier in UDCs, Acceleration Principle and Concept of Super Multiplier.

Unit-III

Determination of General Price Level: Classical and Keynesian Theory of Money and Prices. Inflation: Types, Cost Push and Demand Pull Inflation, Effects, Inflation –Unemployment Tradeoff (Phillips Contribution-Introductory Version)

Rate of Interest: Keynesian and IS-LM Theories of Interest rate

Unit-IV

Trade cycles: Meaning, Types, Phases and Theories of Trade Cycles (Hicks and Samuelson)

Macro Economic policies: Monetary and Fiscal Policies (Objectives, Instruments, Policy-Mix, Limitations

Learning Outcomes: Upon completing the course, students will be able to:

- Apply the principle of Macroeconomics in explaining the behaviour of Macroeconomic variables at national as well as global level.
- Apply economic reasoning to understand the operation of an economy.

- Understand the roles of fiscal and monetary policy in fighting recessions and inflation.
- Understand the implications of interference in a market economy, including government policy.

BOOKS RECOMMENDED:

[1] H. L. Ahuja, Macroeconomics Theory and Policy*, S. Chand and Company Ltd.*

[2] Errol D'Souza, *Macroeconomics*, Pearson Education

[3] D. N. Dwivedi, Macroeconomics Theory and Policy, Tata McGraw-Hill Publishing Company Ltd.

[4] M. L. Jhingan, Macroeconomics

ST4A – 207 : Python   **Credits: 3(2-0-2)**

Objective: The main objective is to help students to understand the fundamentals of python. Student will learn how to analysis data using Python.

COURSE DESCRIPTION:

UNIT I: Introduction to Python: Python versus Java, Python Interpreter and it's Environment, Python installation, Pythonbasics:variables,operators,Strings,ConditionalandControl Statements,loops; Datastructures: listsanddictionaries;functions:globalfunctions,local functions, lambda functions and methods.

UNIT II: Object Oriented Programming Concepts: Class, object, constructor, destructor and inheritance; Modules&Packages,FileInputandOutput,Catchingexceptionstodealwith baddata, Multithreading, Database Connectivity.

UNIT III: Numpy: Creating Arrays, Arrays Operations, Multidimensional Arrays, Arrays transformation, Array Concatenation, Array Math Operations, Multidimensional Array and its Operations, Vector and Matrix. **Visualization:** Visualization with matplotlib, Figures and subplots, Labeling and arranging figures, Outputting graphics.

UNIT IV: Pandas: Manipulating data from CSV, Excel, HDF5, and SQL databases, Data analysis and modelling with Pandas, Time-series analysis with Pandas, Using Pandas, the Python data analysis library, Series and Data Frames, Grouping, aggregating and applying, Merging and joining.

Text Books:
1. McKinney Wes, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media,2012.
2. Hauck Trent, "Instant Data Intensive Apps with Pandas How-To", Packt Publishing Ltd,2013.
3. Beazley David M., "Advanced Python Programming", Pearson Education,2009.
4. Chun Wesley, Core Python Programming, 3rd Edition, Prentice Hall Professional, 2012.
5. Telles Matt "Python Power!: The Comprehensive Guide", Cengage Learning, 2008.
6. McKinney Wes & PyData Development Team, "pandas: powerful Python data analysis toolkit", Release 0.13.1, Feb2014.
7. https://docs.python.org/3.4/tutorial/
8. http://www.tutorialspoint.com/python/python_quick_guide.htm

Course Outcomes:

- The student will learn core data types of python.
- The student will learn conditional and looping operations in python.
- The student will be able to work with Object-oriented concepts and Database connectivity in python.
- The student will be able to analyze data using Pandas and Numpy.
- The student will be able to visualize the data using seaborn and matplotlib.

ST4A-221 : Linear Algebra   **Credits: 4 (3-1-0)**

Vector space and subspaces, linear dependence and independence, basis and dimension of avector space, finite dimensional vector spaces, completion theorem, examples of vector spaces over real and complex fields, linear equations. (5 L)

Vector spaces with an inner product, Gram-Schmidt ortf301hogonalization process, orthonormal basis and orthogonal projection of a vector (5 L)

Liner transformations, algebra of matrices, row and column spaces of a matrix, elementary matrices, determinants, rank and inverse of a matrix, null space and nullity, partitioned matrices, Kronecker product. (4 L)

Hemite canonical form, generalized inverse, Moore-Penrose generalized inverse, idem potent matrices, solutions of matrix equations. (6 L)

Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix. (6 L)

Characteristic roots and vectors, Cayley-Hamilton theorem, minimal polynomial, similar matrices, algebraic and geometric multiplicity of a characteristic root, spectral decomposition of a real symmetric matrix, reduction of a pair of real symmetric matrices,Hermitian matrices. (6 L)

Singular values and singular value decomposition, Jordan decomposition, extreme of quadraticform, vector and matrix differentiation. (8 L)

References :
Graybill, F.A.(1983), matrices with application and statistics, second edition, Wadsworth

Rao, C.R.(1973), Linear Statistical Inference and its application, second edition. John Wiley and Sons, Inc.Scarle, S.R.(1982), Matrix Algebra useful for Statistics, John Wiley and Sons,Inc.

Additional References
1. Bellman, R. (1970) Introduction to Matrix Analysis, Second Edition.
2. McGraw Hill Biswas, S.(1984), Topics in Algebra of Matrices. Academic
3. Publications. Hadley, G.(1987). Linear Algebra, Narosa Publishing House
4. Halmos, P.R.(1958), Finite Dimensional Vector Spaces, Second

   Edition,D.Van Nostrand Company, Inc.

5. Hoffman, K. and Kunze, R.(1971), Linear Algebra , Second Edition, Prentice Hall,Inc.
6. Rao, A. R. and Bhimasankaram, R(1992) Linear Algebra, Tata Mcgraw Hill Publishing
7. Company Limited.
8. Rao, C. R. and Mtra, S.K.(1971) Generalized Inverse of Matrices and its
9. Applications, John Wiley and Sons, Inc.

Practicals: Ranks,Finding Eigenvalues Eigenvectors, Quadratic forms,Linear transformations, Orthogonal transformation, Gram Schmidt Orthogonalisation, Finding G Inverse, Solving systemof Linear Equations.

ST4A-223: Data Mining & Data Warehousing   **Credits: 4 (3-0-2)**

Course Objective The main objective of this course is to provide understanding of data warehouse fundamentals and data mining techniques for business applications.

COURSE DESCRIPTION:

UNIT I: Data Warehousing: Introduction data warehousing, Data Mart, Data Warehouse Architecture; Star, Snowflake and Galaxy Schemas for Multidimensional databases, Fact and dimension data, Partitioning Strategy -Horizontal and Vertical Partitioning. ETL Concepts. OLAP technology: Multidimensional data models and different OLAP Operations, OLAP Server: ROLAP, MOLAP, Data Warehouse implementation, Efficient Computation of Data Cubes, Processing of OLAP queries, indexing data.

UNIT II: Data Mining: Basics of data mining, Data mining techniques, KDP (Knowledge Discovery Process), Application and Challenges of Data Mining; Introduction to Web Mining, TextMining. Data Processing: Data Cleaning, Data Integration and Transformation; Data Reduction: Data Cube Aggregation,   Dimensionality reduction, Data Compression, Numerosity Reduction, Data Discretization and Concept hierarchy generation for numerical and categorical data.

UNIT III: Mining Association Rules in Large Databases: Association Rule Mining, Single-Dimensional Boolean Association Rules, Multi -Level Association Rule, Apriori Algorithm, FP- Growth Algorithm, latest trends in association rules mining.

UNIT IV: Classification methods: Decision tree, Bayesian Classification, Rule based; clustering methods: Partitioning methods (K-Means, K-Mediods) and Hierarchical Clustering (Agglomerative and Divisive Clustering, Multi-phase method) Prediction: Linear and non- linear regression.

Text Books:
1. P.Ponnian, "Data Warehousing Fundamentals", John Wiley.
2. Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann.
3. P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", Pearson Education.
4. G. Shmueli, N.R. Patel, P.C. Bruce, "Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner", Wiley India.
5. Michael Berry and Gordon Linoff "Data Mining Techniques", Wiley Publications.
6. M.H.Dunham, "Data Mining Introductory & Advanced Topics", Pearson Education.

Course Outcomes:

- The student will learn basics of Data Warehouse.
- The student will learn basics of Data Mining.
- The student will be able to Pre-process the data.
- The student will be able to perform Market Basket analysis.
- The student will be able to work with Classification Algorithms.
- The student will be able to cluster the data.

ST4A-231 : Statistical Techniques for Research Methods   **Credits: 3 (2-1-0)**

Objective:

This course will familiarize students with the rudiments of statistical theory and ready them for effective academic and professional practice in the field of research process of industrial, system and social science.

COURSE DESCRIPTION:

Unit I

Introduction to Research Methods and Measures of central tendency : Meaning and Objectives of Research, Significance of Research. Data collection primary and secondary data. Different Sampling techniques, questionaries' and survey. Google Document. **Measure of Central Tendency** : Mean, Median & Mode.

Unit II

Basis Statistics and Regression : Mean deviation, Standard deviation, Variance, Co -efficient of variation. Types of correlation, Methods of Correlation, Co -efficient of correlation, Properties of correlation, Rank Correlation. Difference between correlation and regression, Regression Lines, Regression Equations.

Unit III

Testing of Hypothesis : Testing of Hypothesis : Procedure of Testing Hypothesis, Standard Error and Sampling distribution, Estimation, Student's t -distribution, Chi-Square test and goodness of fit, F -test and analysis of variance..

Unit IV

Statistical Packages : Introduction to SPSS, R, MS Excel.

Applications of Statistical Packages to find Central Tendency, Deviation, Correlation, Regression, Chi – square test, F – test.

Text Books:
S.P. Gupta: Statistical Method, S. Chand
C.K. Kothari: Research Methodology, New Age International

Course Outcomes:
- To be able to understand the basic concept of statistics and data collection.
- To be able apply advanced knowledge in statistics to experimental and applied research
- To be able to understand the concepts of validity and probability as they apply to different set of data.
- To be able to critically evaluate the methodological designs and select appropriate analytical strategies for their research projects.
- To understand the interpretation and appropriate reporting requirements for statistical and data analysis.
- To be able to use statistical packages required quantitative analysis (e.g., R, SPSS and Excel).

SCHOOL OF STATISTICS

&

SCHOOL OF DATA SCIENCE AND FORECASTING

PROGRAM CODE : ST4A   **BATCH :** 2019 – 22

PROGRAM TITLE : BACHELOR OF SCIENCE (Hons.)

- APPLIED STATISTICS AND ANALYTICS

PROGRAM OUTCOMES :

- Apply statistical techniques to the solution of real - world business problems, communicate findings, and effectively present results using data visualization techniques.
- Demonstrate knowledge of statistical data analysis techniques utilized in business decision making.
- Apply principles of Data Science to the analysis of business problems.
- Use data mining software to solve real – world problems.
- Employ cutting edge tools and technologies to analyze Big Data.
- Apply algorithms to build machine intelligence.
- Demonstrate use of team work, leadership skills, decision making and organization theory.

PROGRAM STRUCTURE :

Fourth Semester :

Code	Title	Credits (L T P)
CORE COURSES		
ST4A - 202	Sampling Theory and Applications	4 (3-1-0)
ST4A - 204	Designs of Experiments	3 (2-0-2)
ST4A - 206	R Programming	3 (2-1-0)
ST4A - 208	Econometrics	3 (2-1-0)
ELECTIVE COURSES – DISCIPLINE CENTRIC (Any Two)		
ST4A - 222	Multivariate Calculus	4 (3-1-0)
ST4A - 224	Machine Learning	4 (3-1-0)
ST4A - 226	Statistical Quality Control	4 (2-1-2)
ELECTIVE GENERIC : The students can choose following course or any other UG level generic course being run in this campus.		
ST4A - 242	Statistical - Data Analysis Using Software Packages	3 (2-0-2)
Comprehensive Viva – Voce		
ST4A - 252	Comprehensive Viva – Voce	4

Note : The above course contents can be modified as per requirement from time to time in accordance with University Ordinance No. 14.

DETAILED SYLLABUS :

Fourth Semester :

ST4A – 202 : Sampling Theory and Applications   **Credits : 4 (3-1-0)**

COURSE OBJECTIVE : The main objective of the sampling theory is to obtain optimum results, i.e., to construct maximum information about the characteristics of the population with the available sources at our disposal in terms of time, money and man-power by studying the sample values only.

COURSE DESCRIPTION :

Unit I : Sample Survey – Concept of population and sample, need for sampling, steps in a sample survey, principles of sample survey, sampling and non-sampling errors, complete census v/s sample survey, limitations of sampling.

Unit II : Simple Random Sampling – Definition of Simple random sampling, Simple random sampling with & without replacement. Unbiasedness of the sample mean, mean square error of the sample mean, merits, demerits and limitations of simple random sampling, simple random sampling for attributes.

Stratified Random Sampling – Definition and advantages of stratified random sampling, proportional allocation, optimum allocation, cost function. Comparison of stratified random sampling with simple random sampling without stratification, proportional allocation versus simple random sampling, Neyman allocation versus Proportional allocation, Neyman allocation versus Simple Random Sampling.

Unit III : Systematic Sampling – Definition, linear systematic sampling, circular systematic sampling, mean and variance of a systematic sample mean, comparison of systematic sampling to simple random sampling, Systematic Sampling versus Stratified Random Sampling, Stratified Random Sampling versus Simple Random Sampling for a population with linear trend, merits and demerits of systematic sampling.

Unit IV : Ratio Method of Estimation – Definition, bias of ratio estimate, excepted value of ratio estimate for first order approximation under simple random sampling without replacement, variance of ratio estimate for first order approximation under simple random sampling without replacement.

Regression Method of Estimation – Definition, simple regression estimate, determination of beta, excepted value of regression estimate for first order approximation under simple random sampling without replacement, variance of regression for first order approximation under simple random sampling without replacement.

PRACTICALS :

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible sample of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size.
4. Stratified Sampling : allocation of sample to strata by proportional and Neyman`s methods. Compare the efficiencies of above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presences of a linear trend.

COURSE OUTCOMES : By completing this course the students will learn to perform the following :

- Students will learn to reduce variability within the sample.
- To collect the desired information about the universe in minimum time and high degree of reliability.
- To get the estimate precisely and reliability of estimate.
- How to use simple random sampling, stratified or systematic sampling techniques.
- To learn advantages and disadvantages of sampling methods of data collection.

TEXT BOOKS :

I. Cochran W.G. (1984) : Sampling Techniques (3rd Ed.), Wiley Eastern.
II. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984), Sampling Theories of Survey with Applications, IOWA State University Press and Indian Society of Agricultural Statistics.
III. Murthy M.N. (1997) : Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
IV. Des Raj and Chandhok P. (1998) : Sampling Survey Theory, Narosa Publishing House.
V. Goon A.M., Gupta M.K. and Dasgupta B. (2001) : Fundamentals of Statistics (Vol. - 2), World Press.
VI. Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics, Sultan Chand and Co.
VII. P. Mukhupadhyaya : Theory and Method of Survey Sampling, PHI Learning.

COURSE OBJECTIVE : The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. Both design and statistical analysis issues are discussed.

COURSE DESCRIPTION :

Unit I : Analysis of Variance – One-way classification and Two-way classification (for fixed, random and mixed effect models). Definition of different terms, Fundamental Principles of Design : Randomization, replication and local control. Layout and analysis of Completely Randomized Design (CRD).

Unit II : Layout and analysis of Randomized Block Design (RBD), Estimation and analysis of one missing observation in RBD, efficiency of RDB relative to CRD.

Unit III : Layout and analysis of Latin Square Design. Estimation and analysis of one missing observation in LSD. Efficiency of LSD relative to CRD and RDB.

Unit IV : Factorial Experiments, advantages of factorial experiments, 2^2 and 2^3 designs, main and interaction effects, contrast. Definition of confounding, complete and partial confounding.

COURSE OUTCOMES : After completing this course, students should have developed a clear understanding of :

- The fundamentals concepts of design of experiments.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Full and confounded factorial designs with two and three levels.

TEXT BOOKS :

   I.   Montgomery, D.C. (2008) : Design and Analysis of Experiments, John Wiley.
  II.   Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics, Sultan Chand and Co.
 III.   Das, M.N. and Giri, N.C. (1979) : Design and Analysis of Experiments, Wiley Eastern Ltd.
  IV.   Dey Aloke (1986) : Theory of Block Design, Wiley Eastern.
   V.   Angela Deal and Daniel Voss (1999) : Design and Analysis of Experiments, Springer.
  VI.   Giri N. (1986) : Analysis of Variance, Asia Publisher.
 VII.   John P.W. (1971) : Statistical Design and Analysis of Experiments, Mac Millon.

COURSE OBJECTIVE : This course is an introduction to R, a powerful and flexible statistical language and environment that also provides more flexible graphics capabilities than other popular statistical packages. After taking the course, students will be able to –

- Use R for statistical programming, computation, graphics, and modelling.
- Write functions and use R in an efficient way.
- Fit some basic types of statistical methods.
- Use R in their own research.
- Be able to expand their knowledge of R on their own.

COURSE DESCRIPTION :

Unit I : Introduction to R programming language – Getting R, Managing R, Arithmetic and Matrix Operations, Introduction to Functions, Control Structures. Working with Objects and Data : Introduction to Objects, Manipulating Objects, Constructing Data Objects, types of Data items, Structure of Data items, Reading and Getting Data, Manipulating Data, Storing Data.

Unit II : Data Distribution and Statistical Testing – Types of Data distribution, Normal distribution, Poisson distribution, Random number generation, Chi - square Testing, Student`s t - test, F - test, Monte Carlo Simulation.

Unit III : Graphical Analysis using R – Basic Plotting, Manipulating the plotting window, Box - Whisker Plots, Scatter Plots, Pair Plots, Pie Charts, Bar Charts.

Unit IV : Advanced R – Statistical models in R, Correlation and Regression analysis, Analysis of Variance (ANOVA), creating data for complex analysis, Summarizing data, and case studies.

PRACTICALS :

1. Practical based on matrix operation and retrieving matrix elements.
2. Adding and deleting columns / rows from existing data - frame.
3. Coding for simple functions and nested functions.
4. Coding for structure (i.e., loops and controls).
5. Calculate probabilities for Binomial distribution.
6. Calculate probabilities for Poisson distribution.
7. Calculate probabilities for Normal distribution.
8. Generate random numbers from uniform distribution.
9. Monte - Carlo Simulation.
10. Chi - square (Goodness of fit, independence and homogeneity) test for the given data.
11. Testing of mean and variance for the given data (t - test and F - test).
12. Generating statistical plots for the given data.
13. Fitting a Linear model for the given data and interpretation of the results.
14. Fitting a Logistic Regression model for the given data and interpretation of the results.
15. Fitting a Poisson Regression model for the given data and interpretation of the results.
16. Comparing the mean of multiple groups using ANOVA.

COURSE OUTCOMES :

- Data manipulation – acquiring skills in flexible matrix manipulation.
- Access online resources for R and import new function packages into the R workspace.
- Scripting in such a way that the script can be used with minimal efforts for similar data - sets and analyzes and for especially large data - sets.
- Explore data - sets to create testable hypotheses and identify appropriate statistical tests.
- Perform appropriate statistical tests using R.
- Learn how to create high - quality figures, especially associated with more complex analyzes (e.g. – three dimensional scatter plots, animated chart Trellis display, etc.).

TEXT BOOKS :

I. Mark Gardener : Beginning R – The Statistical Programming Language, Wiley Publication.
II. Norman Matloff : The Art of R Programming – A Tour of Statistical Software Design, O'Reilly & Associated Inc.

ST4A – 208 : Econometrics   **Credits : 3 (2-1-0)**

COURSE DESCRIPTION :

Nature of Econometrics. The general linear model (GLM) and its extensions. Ordinary least squares (OLS) estimation and prediction. Use of dummy variables and seasonal adjustment. Generalized least square (GLS) estimation and prediction. Heteroscedastic disturbances. Pure and mixed estimation.

Grouping of observations and of equations. **[12 L]**

Auto correlation, its consequences and tests, Theil BLUS procedure. Estimation and prediction.

Multi-collinearity problem, its implications and tools for handling the problem. Ridge regression. **[8 L]**

Linear regression with stochastic regressors. Instrumental variable estimation. Errors in variables.

Auto-regressive linear regression. Distributed lag models. Use of principal components, canonical correlations and discriminant analyses in econometrics. **[8 L]**

Simultaneous linear equations model. Examples. Identification problem. Restrictions on variances and co-variances. **[8 L]**

Estimation in simultaneous equations model. Recursive systems. 2 SLS Estimators. Limited information estimators, k-class estimators. 3 SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation. **[12 L]**

TEXT BOOKS :

  I. Apte PG (1990) : Text Book of Econometrics, Tata McGraw Hill.
 II. Cramer, J.S. (1971) : Empirical Econometrics, North Holland.
III. Gujarathi. D (1979) Basic Econometrics, McGraw Hill.
 IV. Intrulligator, MD (1980) : Econometric Models – Techniques and Applications, Prentice Hall of India.
  V. Johnston, J. (1984) : Econometric Models, Third edition, McGraw Hill.
 VI. Klein, L.R. (1962) : An Introduction to Econometrics, Prentice Hall of India.
VII. Koutsoyiannis, A. (1979) : Theory of Econometrics, Macmillan Press.
VIII. Srivastava, V.K. and Giles D.A.E. (1987) : Seemingly unrelated Regression Equations Models, Marcel Dekker.
 IX. Theil, H. (1982) : Introduction to the Theory and Practice of Econometrics, John Wiley.
  X. Walters, A (1970) : An Introduction to Econometrics, McMillan & Co.
 XI. Wetjeroll, G.B. (1986) : Regression Analysis with Applications, Chapman Hall.

COURSE OBJECTIVE : The main objective is to help students to understand different ways of representing functions of several variables including algebraic formulas, graphs, contour diagrams, cross sections, and numerical tables.

COURSE DESCRIPTION :

Unit I : Partial Differentiation : Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.

Unit II : Differentiation : Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler`s theorem for homogeneous functions, Taylor`s theorem for functions of two variables and more variables, Envelops and evolutes.

Unit III : Extrema of Functions and Vector Field : Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems, Definition of vector field, Divergence, curl, gradient and vector identities.

Unit IV : Double and Triple Integrals : Double integration over rectangular and non - rectangular regions, Double integrals in polar coordinates, Triple integral over a parallelopiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals, Dirichlet integral.

Unit V : Green`s, Stokes` and Gauss Divergence Theorem : Line integrals, Applications of line integrals : Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green`s theorem, Area as a line integral, Surface integrals, Stokes` theorem, The Gauss divergence theorem.

COURSE OUTCOMES : This course will enable the students to :

- Learn conceptual variations while advancing from one variable to several variables in calculus.
- Apply Multivariate Calculus in optimization problems.
- Inter-relationship amongst the line integral, double and triple integral formulations.
- Applications of Multivariate Calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space, etc.
- Realize importance of Green, Gauss and Stokes` theorems in other branches of mathematics.

TEXT BOOKS :

I.   Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009) : Basic Multivariable Calculus, Springer India Pvt. Limited.
II.   James Stewart (2012) : Multivariable Calculus, 7th edition, Brooks/Cole, Cengage.
III. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011) : Calculus, 3rd edition, Pearson Education, Dorling Kindersley (India) Pvt. Ltd.
IV.   George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018) : Thomas` Calculus, 14th edition, Pearson Education.

COURSE OBJECTIVE : The main objective is to help students to understand the fundamentals concepts of Machine Learning.

COURSE DESCRIPTION :

Unit I : Introduction to Machine Learning, History and Overview of Machine Learning, Applications, Types of Machine Learning, Basic Concepts. Concept Learning and candidate elimination learning Algorithm.

Unit II : Artificial Neural Network - Biological Neural Network, Evolution of Artificial Neural Network, McCulloch-Pitts neuron models, Learning (Supervised & Unsupervised) and activation function. Supervised Learning : Perceptron learning, Single layer / Multi-layer, Linear separability, Adaline, Madaline, Back propagation network, RBFN.

Unit III : Bayesian Learning, Bayes Theorem, Naïve Bayesian classifier, Bayesian belief, EM Algorithm. Dimensionality Reduction : Factor Analysis, Principal Component Analysis, Linear Discriminant Analysis.

Unit IV : Markov and Hidden Markov Models, PAC learning, Support Vector Machine, Evolutionary Learning : Genetic algorithm, generating off-spring, applications and genetic programming.

COURSE OUTCOMES :

- The students will be able to understand the basics of Machine Learning.
- The students will be able to understand Regression Analysis.
- The students will be able to work on classification problems.
- The students will be able to work with unsupervised learning approaches.
- The students will be able to perform machine learning operations in scikit-learn.

TEXT BOOKS :

I. Tom Mitchell, "Machine Learning", McGraw Hill, 1997.
II. Stephen Marsland, "Machine Learning : An Algorithmic Perspective", CRC Press, 2009.
III. Kevin P. Murphy, "Machine Learning : A Probabilistic Perspective", MIT Press, 2012.
IV. Ethem Alpaydin, "Introduction to Machine Learning", Prentice Hall of India, 2005.
V. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
VI. Sanjeev Kulkarni, Gilbert Harman, "An Elementary Introduction to Statistical Learning Theory", 2011.
VII. N. Shivnandam, "Principle of Soft Computing", Wiley.

ST4A – 242 : Statistical Data Analysis using Software Packages　　　　　　　　**Credits : 3 (2-0-2)**

COURSE OBJECTIVE : Statistics is the art of using data to make numerical conjectures about problems. Descriptive Statistics is the art of summarizing data. Statistical Inference is the art of making valid generalizations from samples. This is an introductory course in statistics designed to provide students with the basic concepts of data analysis and statistical computing. Topics covered include basic descriptive measures, measures of association, confidence intervals, and hypothesis testing. The main objective is to provide students with pragmatic tools for assessing statistical claims and conducting their own statistical analyses.

Data Analysis using MS EXCEL and SPSS software packages.

COURSE DESCRIPTION :

Unit I : Collection of Data – Census. Sampling surveys – Classification and tabulation – diagrammatic and graphical representation (creating and editing graph from worksheet) of data with software packages. Use of Pivot Tables.

Unit II : Measures of Central Tendency – Measures of dispersion and Coefficient of variation – Problems based on raw data and grouped data. Moments – raw and central. Measures of Skewness. Measure of Kurtosis and their applications.

Unit III : Curve Fitting – Fitting of Least Square curve, non - linear exponential and growth curves.

Unit IV : Parametric Tests – Test for single population mean, equality of mean for two independent sample, paired t - test, testing correlation coefficient.

Unit V : Non-parametric Tests – Mann Whitney U test, Wilcoxon signed rank test, Kruskall Wallis test, One - way ANOVA, Simple and Multiple Linear Regression, Association of attributes.

PRACTICALS :

1. Creating and editing graph from worksheet.
2. Changing Scales.
3. Adding background grids.
4. Fitting of Least Square curve.
5. Managing use of more than one worksheet, workbook.
6. Use of spreadsheets for statistical analysis : Presentation, graphical analysis, and Regression Analysis.
7. Pivot tables.
8. Tests of Statistical hypotheses.
9. Fitting of commonly used statistical distributions.
10. Correlation, etc.

COURSE OUTCOMES :

- Demonstrate their understanding of descriptive statistics by practical application of quantitative reasoning and data visualization by SPSS and Excel.
- Demonstrate their knowledge of the basics of Inferential Statistics by making valid generalizations from sample data, in terms of Software`s (SPSS and Excel) skills.
- Recognize pitfalls in using statistical methodology without Software`s packages.

TEXT BOOKS :

I.   Microsoft Excel 2016 : Step by Step, Curtis Frye.
II. Microsoft Excel Functions & Formulas by Bernd Held.

REFERENCE BOOKS :

I.   Excel Functions and Formulas, paperback by Bernd Held.
II.   Microsoft Excel 2010 : Data Analysis and Business Modelling, paperback by Winston.
III. Microsoft Office 2000 – Gini Coumrter and Annette Marquis, BPB Publications.