UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 17-12-2022 has approved the recommendations of the Academic Council made at its meeting dated 11-03-2022 and 21-03-2022 respectively, regarding approval of the revised Syllabi/Scheme of Studies of M.Sc. Statistics Program at the College of Statistical Sciences only for those students who have already admitted in the Session, 2020-2021.

The revised Syllabi/Scheme of Studies for M.Sc. Statistics Program is attached herewith as Annexure 'A'.

Sd/-
TASLEEM KAMRAN
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.
No. D/ 572 /Acad. **Dated: 16- 01 /2023.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Sciences.
2. Principal, College of Statistical Sciences.
3 Controller of Examinations
4 Director, IT for placement at website
5 Admin Officer (Statutes)
6. Secretary to the Vice-Chancellor.
7. PS to the Registrar.
8. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

Revised

Scheme of Studies

M.Sc. Statistics

28-4-2021

College of Statistical
and Actuarial Sciences
University of the Punjab
Lahore

Program Title: **M.Sc. Statistics**

Department: College of Statistical and Actuarial Sciences

Faculty: Science

1. College Mission

College of Statistical and Actuarial Sciences for M.Sc. Program in Statistics is committed to the advancement of statistical procedures / methods by applying new techniques and exploring their applications in society, sciences and industry. Our mission is to provide trained students to the field of sciences, industry and hence the society. Our students are expected to be expert in the modern statistical knowledge which they can use in aforesaid major domains.

2. Introduction

The subject of statistics was introduced in the University of the Punjab at the undergraduate and post-graduate levels in 1941. In 1950 the Department of Statistics was established by late Dr. M. Zia ud Din. In the same year in addition to postgraduate diploma course, a two-year Master's Degree Program in Statistics was started. In 1952, the Department was upgraded to the status of the Institute. Since its inception, the Institute has been engaged in individual and collective research in the field of theoretical and applied statistics. In 2007, the Institute of Statistics was upgraded to the College of Statistical and Actuarial Sciences which cater the modern needs of statisticians in the modern era.

3. Program Introduction

The M.Sc. Statistics is two years degree program under semester system.

a) Program Vision

This program provides essential knowledge in statistics regarding the sciences, society and industry.

b) Program Mission

The courses of M.Sc. Statistics program aim to train students in the field of statistics and prepare them for the posts in education and industrial sectors, health sectors, agriculture sectors, research organizations, banks, government offices and consultancy firms.

4. Program Objectives

The objectives of the courses/modules contained in the program are given as:

i) To educate students for the theoretical concepts of statistics.

ii) To train students for the applications of statistics.

iii) To prepare students for the further higher education.

iv) To enable the students as experts of statistical analyses about the modern research in the field of science.

v) To enable the students for the job market by teaching them statistical packages and programming languages.

5. Market Need / Rationale of the Program

a) Potential Students for the program:

There has been a steady increase in the number of job postings for skilled professionals in Statistics for data analysis. While the demand is going up rapidly and the number of skilled professionals is quite low.

From advertising to healthcare, almost every industry is now adopting new-age technologies like statistical analysis through different software, operation research and data science to get an edge over the businesses. Most companies will tap into algorithmic models for their operational and customer-facing functions.

A professional with the new age data skills can become a vital asset to an organization and these companies are actively looking forward to hiring the best talent. Thus, it becomes important for you to showcase your skills through valued credentials and projects.

b) Potential Employers:

Many industries offer job opportunities for statisticians like Banking and Health sectors. Similarly most of NGOs need data analysts. Furthermore despite of education sector, the Planning and Development and Life Stock Departments also need data analysts.

c) Academic Projections:

The following national and international institutes are offering graduate and postgraduate degree programs in Statistics:

1. College of Statistical and Actuarial Sciences, University of the Punjab Lahore, Pakistan.
2. Department of Statistics, BZU Multan, Pakistan.
3. F.C. College University, Lahore
4. Khyber Medical University, Peshawar, Pakistan.
5. Kinnaird College for Women University, Lahore

6. Lahore College for Women University, Lahore
7. Quaid-e-Azam University, Islamabad
8. Rollins School of Public Health, USA.
9. Saint Louis University, United States.
10. Simmons University Boston, United Kingdom.
11. The Agha Khan University, Karachi, Pakistan.
12. University of Buffalo, New York, USA**.**
13. University of Waterloo, Canada.

d) Faculty: The College has the following faculty with respective specializations.

Degree	**Area /Specialization**	**Total**
PhD	1. Prof. Dr. Sohail Chand (Statistical Modeling) 2. Dr. Rehan Ahmad Khan (Applied Statistics) 3. Dr. Maryam Ilyas (Statistical Modeling) 4. Dr. Sana Saeed (Data Science) 5. Dr. Nadia Saeed (Applied Statistics) 6. Dr. Samar Abbas (Computer Science and Data Science)	(06)
M.Phil.	1. Mr. Munawar Iqbal (Mathematical Statistics) 2. Ms. Irum Sajjad Dar (Applied Statistics) 3. Ms. Aasma Riaz (Applied Statistics) 4. Ms. Shumaila Abbas (Applied Statistics) 5. Mr. Ghulam Nabi (Finance) 6. Ms. Huma Shakeel (Applied Statistics) 7. Ms. Wajiha Batool (Applied Statistics) 8. Ms. Maham Faheem (Applied Statistics) 9. Ms. Deeba Akhter (Business Statistics)	(09)

e) Physical Facilities:

The College has the largest state-of-art academic building for statistics community in the country. College consists of academic blocks, administration block, cafeteria, lawns and play grounds. The four academic blocks of the college consist of more than thirty lucrative class rooms, seminar halls and workshop rooms to meet the modern era requirements. The college has sufficient parking space for the students, faculty and the visitors. The College Library is well equipped with the latest books on Statistics, Biostatistics and the related fields. The computer lab of the college has more than 70 latest computers available for computational purposes.

6. Admission Eligibility Criteria

- B.A./B.Sc. degree with **Statistics and Mathematics as elective subjects** from a recognized University.
- The minimum marks required for admission in M.Sc. Statistics is 45%.

7. Duration of the Program

Years	Semesters	Courses	Credit Hours
2	4	22	66

8. Categorization of Courses as per HEC Recommendation and Difference

Semester	Courses	Category (Credit Hours)					
		Core Courses	Basic Courses	Major Electives	Minor Electives	Any Other	Semester Load
1	5	5	-	-	-	-	15
2	6	6	-	-	-	-	18
3	5	4	-	1	-	-	15
4	6	3	-	3	-	-	18

**** List of Core and Major Electives.***

Core	Major Electives
Statistical Methods	Thesis (equivalent to two courses)
Probability Theory and Distributions-I	Stochastic Processes
Design and Analysis of Experiments-I	Demography and Population Studies
Sampling Techniques-I	Spatial Statistics
Statistical Computer Packages-I	Machine Learning
Parametric and Nonparametric Tests	Operations Research
Probability Theory and Distributions-II	Total Quality Management (TQM)
Experimental Design and Analysis-II	Research Methodology (*Compulsory for thesis*)
Sampling Techniques-II	Data Mining
Statistical Computer Packages-II	Biostatistical Models
Time Series Analysis	
Statistical Inference-I	
Econometrics-I	
Multivariate Techniques	
Statistical Programming	
Statistical Inference-II	
Econometrics-II	
Categorical Data Analysis	

9. Scheme of Studies: M.Sc. Statistics

Revised Scheme of Studies / Semester wise Workload
(w.e.f. Session 2020 and onwards)

Years	Semesters	Courses	Credit Hours
2	4	22	66

Course Titles, Credit Hours, Course Codes and Outlines for all Eight Semesters

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
		Semester-I			
1.	STAT-301	Statistical Methods	Core	N / A	3
2.	STAT-302	Probability Theory and Distributions-I	Core	N / A	3
3.	STAT-303	Design and Analysis of Experiments-I	Core	N / A	3
4.	STAT-304	Sampling Techniques-I	Core	N / A	3
5.	STAT-305	Statistical Computer Packages-I	Core	N / A	3
		Total Credit Hours			**15**
		Semester-II			
1.	STAT-306	Parametric and Nonparametric Tests	Core	N / A	3
2.	STAT-307	Probability Theory and Distributions-II	Core	Probability Theory and Distributions-I	3
3.	STAT-308	Experimental Design and Analysis-II	Core	Design and Analysis of Experiments-I	3
4.	STAT-309	Sampling Techniques-II	Core	Sampling Techniques-I	3
5.	STAT-310	Statistical Computer Packages-II	Core	Statistical Computer Packages-I	3
6.	STAT-311	Time Series Analysis	Core	N / A	3
		Total Credit Hours			**18**
		Semester-III			
1.	STAT-401	Statistical Inference-I	Core	N / A	3
2.	STAT-402	Econometrics-I	Core	N / A	3
3.	STAT-403	Multivariate Techniques	Core	N / A	3
4.	STAT-404	Statistical Programming	Core	N / A	3
5.		Elective-I	Major Elective	N / A	3
		Total Credit Hours			**15**

		Semester-IV			
1.	STAT-405	Statistical Inference-II	Core	Statistical Inference-I	3
2.	STAT-406	Econometrics-II	Core	Econometrics-I	3
3.	STAT-407	Categorical Data Analysis	Core	N / A	3
4.		Elective-II	Major Elective	N / A	3
5.		Elective-III	Major Elective	N / A	3
6.		Elective –IV	Major Elective	N / A	3
		Total Credit Hours			**18**

LIST OF ELECTIVE SUBJECTS

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
1.	STAT-409	Thesis (equivalent to two courses)	Major Elective	N / A	6
2.	STAT-410	Stochastic Processes	Major Elective	N / A	3
3.	STAT-411	Demography and Population Studies	Major Elective	N / A	3
4.	STAT-412	Spatial Statistics	Major Elective	N / A	3
5.	STAT-413	Machine Learning	Major Elective	N / A	3
6.	STAT-414	Operations Research	Major Elective	N / A	3
7.	STAT-415	Total Quality Management (TQM)	Major Elective	N / A	3
8.	STAT-416	Research Methodology (*Compulsory for thesis*)	Major Elective	N / A	3
9.	STAT-417	Data Mining	Major Elective	N / A	3
10.	STAT-418	Biostatistical Models	Major Elective	N / A	3

* Elective courses will be offered on the availability of the faculty.

Research Thesis

Thesis is equivalent to two elective courses. The student will be assigned a research problem under the supervision of assigned supervisor. The student will study the theoretical and / or applied aspects of statistics and write a thesis. The thesis will be evaluated by an external examiner appointed as per Punjab University rules.

10. Award of Degree

(As per Punjab University Rules & Regulations)

Minimum requirements for the award of Master's Degree:

i. A candidate must have qualified, in accordance with the existing Rules and Regulation in each one of the semesters from I – IV separately, i.e. by securing at least a 'D' Grade in the course(s) as to fulfill the requirements laid down in (ii & iii) below:

ii. He / she must have earned the prescribed number of credits required for the Master's Degree i.e. 66 credits.

iii. He / she must have obtained a minimum Cumulative Grade Point Average of 2.00.

11. NOC from Professional Councils (If Applicable)

(Not Applicable)

12. Faculty Strength

Degree	Area /Specialization	Total
PhD	1. Prof. Dr. Sohail Chand (Statistical Modeling) 2. Dr. Rehan Ahmad Khan (Applied Statistics) 3. Dr. Maryam Ilyas (Statistical Modeling) 4. Dr. Sana Saeed (Data Science) 5. Dr. Nadia Saeed (Applied Statistics) 6. Dr. Samar Abbas (Computer Science and Data Science)	(06)
M.Phil	1. Mr. Munawar Iqbal (Mathematical Statistics) 2. Ms. Irum Sajjad Dar (Applied Statistics) 3. Ms. Aasma Riaz (Applied Statistics) 4. Ms. Shumaila Abbas (Applied Statistics) 5. Mr. Ghulam Nabi (Finance) 6. Ms. Huma Shakeel (Applied Statistics) 7. Ms. Wajiha Batool (Applied Statistics) 8. Ms. Maham Faheem (Applied Statistics) 9. Ms. Deeba Akhter (Business Statistics)	(09)

13. Present Student Teacher Ratio in the Department

No. of Students:	350
No. of Permanent Faculty Members:	15
Student Teacher Ratio:	1 : 24

14. Course Outlines Separately for each course

* Core courses are according to scheme

COURSE OUTLINES
FOR
SEMESTER – I

Course Title:	Statistical Methods
Course Code:	STAT-301
Semester:	I
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To revise and introduce some basic principles and standard methods in probability and Statistics;
2. To complete exercises requiring the fundamental results, properties and tests outlined in the course;
3. To identify any deficiencies in their background knowledge;
4. To prepare the students to be able to use this knowledge for widespread use in different statistical fields.

Course Outline

Unit 1: Introduction of software

1.1 Introduction to SPSS as a tool for statistical methods and introduction to internet.

Unit 2: Standard discrete and continuous distributions

2.1 Applications of standard discrete and continuous distributions:

2.2 Bionomial, Hyper-geometric, Multinomial, Negative Binomial, geometric, Poisson, Exponential and Normal probability distributions.

Unit 3: Sampling Distributions

3.1 Basic ideas about sampling distributions with particular reference to chi-square, t and f distributions.

Unit 4: Statistical Inference

4.1 Basic ideas of statistical inference.

4.2 Point and interval estimation.

4.3 Construction of Confidence intervals of relevant parameters.

4.4 Testing of hypotheses. Simple and composite hypotheses.

4.5 Calculation of type I and type II errors, Power of a test, Operating characteristic (OC) function.

4.6 Inferences about means, proportions and variances etc.

4.7 Determination of sample size.

4.8 Finite and divided differences. Newton's formulae for interpolation. Inverse interpolation.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Dixon, W.J., and Massey, F.J. (1979). Introduction to Statistical Analysis. (4th ed.) McGraw-Hill Company, New York.
2. Steel, R.G.D. and Torrie, J.H. (1980). Introduction to Statistical Analysis (2nd ed.) McGraw-Hill Book company, New York.
3. Mood, A.M., Graybill, F.A. and Boes, D.C. (1963). Introduction to the Theory of Statistics (3rd ed.) McGraw-Hill International Editions.
4. Walpole, R.E. (1982). Introduction to Statistics". (3rd ed.) Macmillan Publishing Co., New York.
5. Walpole, R.E. Myless, L.S., Ye. K. (2007). "Probability and Statistics for Engineers and Scientists". (8th edition). Pearson Prentice Hall.

Suggested Readings

1. Larson, H.J. (1982). "Introduction to Probability Theory and Statistical Inference" John Wiley and Sons, New York, Third Edition.
2. Wilcox, Rand R. (2001). "Fundamentals of modern Statistical methods", Springer N.Y.
3. Vaidyanathan, M. (2001). "Latest Statistical Methods", S. Chand and Company, New Delhi.
4. Aggarwal, Y. P. (1998). "Statistical Methods" Sterling publisher, New Delhi.

Course Title:	Probability Theory and Distributions – I
Course Code:	STAT-302
Semester:	I
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To revise the concept of elementary probability theory.
2. To provide an introduction to the language of distribution theory regarding discrete univariate cases.

Course Outline:

Unit 1: Introduction to Probability

1.1 Basic Rules of Probability.
1.2 Conditional probability and independence.
1.3 Total probability and Bayes theorem.
1.4 Random variables.
1.5 Distribution function, probability function and probability density function.

Unit 2: Moment generating functions and related tools

2.1 Definition and construction of Moments.
2.2 Factorial moments and. Moments generating functions, Cumulant generating functions. Chebyshev inequality.

Unit 3: Univariate distributions

3.1 Discrete uniform, binomial, hyper-geometric, multinomial, Poisson, geometric, negative binomial distributions.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Rohatgi, V.K. and Saleh, A.K. Md. E. (2001). An Introduction to Probability and Statistics (2nd ed.). John Wiley and Sons.
2. Lipschutz, S. and Lipson, M.L. (2000). Probability. (2nd ed.) McGraw Hill New Dehli.
3. Hogg. R.V. and Craig, A.T. (1995). Introduction to Mathematical Statistics (5th ed.). Prentice-Hall International, Inc. Engle Wood Cliffs.
4. Mood, A.M., Graybill, F.A. and Bloes, D.C. (1974). Introduction to the Theory of Statistics (3rd ed.). McGraw-Hill Book Company, New York.

Suggested Readings

1. Bhuyan, K.C. (2010). Probability Distributions Theory and Statistical and Inference. New Central Book Agency, London,
2. M, J. S. and Arnold, J.C. (2003). Introduction to Probability and Statistics". McGraw Hill
3. Ross, S. (2003). "Introduction to probability models (6th ed.). Academic Press.s
4. Dudewicz, E.J. and Misra, S.N. (1988). Modern Mathematical Statistics. John Wiley and Sons, New York.
5. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2006). Probability and Statistical Inference (7th ed.). McMillan Publishing Company, New York.
6. Stuart, A. and Ord, J.K. (1994). Kendall's Advanced Theory of Statistics Vol.-I (6th ed.). Edward Arnold, London.

Course Title:	Design and Analysis of Experiments-I
Course Code:	STAT-303
Semester:	I
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To introduce distinctive methodologies specifically related to design of experiment.
2. To build on students' existing knowledge of design of experiments,
3. To develop enough of the theory to allow a proper understanding of what these methods can achieve, while showing how and when these methods are applied to data arising in practical context.
4. To illustrate applications of statistics within agriculture and medical fields.
5. To understand the main ways of improving the accuracy of a designed experiment, and the need for randomization; and understand the importance of designing for the contrasts of interest and the actual experimental situation.

Course Outline

Unit 1

1.1 Basic principles of experimental design

Completely randomized, Randomized Complete Block and Latin Square Designs. Descriptions, layout, statistical analysis, advantages and limitations of these designs. Application of these designs (Analysis of all these designs for single observation in each cell).

1.2 Analysis of Variance (ANOVA)

Inference about means after ANOVA. Multiple comparison tests: LSD test, Duncan's test, Tukey's test, Orthogonal contrast test, Scheffe's Test, Transformations.

Unit 2

2.1 Layout and analysis of experimental Designs

Layout and analysis of Completely Randomized, Randomized Complete Block, Latin Square and Graeco-Latin Square designs. Estimation of missing observations. Relative efficiency of these designs. Fixed, Random and Mixed effect models. Expected mean squares deviations. Partitioning of treatment and error SS. Orthogonal Polynomials.

2.2 Covariance analysis of experimental Designs

Covariance analysis for Completely Randomized, Randomized Complete Block and Latin Square designs; single and double covariates.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Cochran, W.C. and Cox, G.M. (1957). "Experimental Design" John Wiley and Sons, New York, Second Edition.
2. Montgomery, D.C. (1997). "The Design and Analysis of Experiments". John Wiley and Sons, New York, Fourth Edition.
3. John, J.A. and Quenoville, M.H. (1977). "Experiments and Analysis of Experiments", Charles Griffin & Co. London, Second Edition.

Suggested Readings

1. Kempthorone, O. & Hin Kelmann, K. (1994). "Design and Analysis of Experiments, Vol.1", John Wiley and Sons, New York.
2. Barker, T.B. (1994). "Quality by Experimental Design", Second Edition, Marcel Dekker, Inc. New York.
3. Boniface, D.R., (1995). "Experiment Design and Statistical Methods for Behavioural and Social Research", Champman & Hall, London, First Edition.
4. Ostle, B. and Mensing, R.W. (1971). "Statistics in Research" The lowa State University Press, New York, Second Edition.
5. Winer, B.J. (1971). "Statistical Principles in Experimental Design", McGraw-Hill Book Company, New York, Second Edition.
6. Federer, W.T. (1955). "Experimental Design". Macmillan Company, New York.
7. Graybill, F.A. (1961). "An Introduction to Linear Statistical Models Vol.1", McGraw Hill Book Company, New York.
8. Heath, D. (1996). "An Introduction to Experimental Design and Statistics for Biology", UCI Press, London, Second Edition.
9. Clewer, Alan, G. (2001). "Practical Statistics and Experimental Design for Plant and Crop Science", Wiley, N.Y.
10. Quinn Gerry, P. (2002). "Experimental Design and Data Analysis for Biologists", Cambridge Press, Cambridge.
11. JeffWu, C.F. (2002). "Experimental: Planning Analysis", Wiley N.Y.
12. Kuehl, R.O. (2000). "Design of Experiments: Statistical principles of research design and analysis" Duxbury, Boston.

Course Title:	Sampling Techniques-I
Course Code:	STAT-304
Semester:	I
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To convey existing knowledge of sampling techniques.
2. To introduce distinctive methodologies related to sampling designs.
3. To get the knowledge about the economical use of available resources such as time, money and manpower in connection with the information obtained through sample survey.
4. To apply the sampling tools in real life problems.
5. To give a theoretically study of the impact of various types of errors encountered in a sample survey.

Course Outline

Unit 1 Errors in Survey Sampling

1.1 Sampling and non-sampling errors and their sources, Non-response errors and their sources, Bias and sources of bias, Probability and Non-probability samples.

Unit 2 Simple random sampling

2.1 Estimation of mean, total, proportion and variance**,** Confidence limits**,** Determination of sample size**,** Inverse Sampling.

Unit 3 Stratified random sampling

3.1 Estimation of mean, total, proportion and variance**,** Arbitrary, proportional and optimum allocations and their comparisons**,** Determination of sample size, Effect of deviation from optimum allocation**,** Controlled and two way selection**,** Gain in precision in stratified sampling as compared with simple random sampling. Construction of strata.

Unit 4 Systematic sampling

4.1 Estimation of mean, total and variance**,** Systematic sampling under stratification**,** Comparison of systematic, stratified and random sampling for population with linear trend**,** Population in random order**,** Periodic variations.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Cochran, W.G. (2014). Sampling techniques (3rd ed.). New York: John Wiley and Sons.
2. Kish, L. (2014). Survey sampling. New York: John Wiley and Sons.
3. Singh, D. Chaudhry, F.S. (1986). Theory and analysis of sample survey designs. New Dehli, India: Wiley Eastern Limited.

Suggested Readings

1. Fuller, W. A. (2009). Sampling statistics. New Jersey: John Wiley and Sons.
2. Brewer, K. (2002). Combined survey sampling inference. New York: Oxford University Press.
3. Raj, D. (1971). Sampling theory. New York: Mc-Graw-Hill Book Company.
4. Som, R.K. (1973). A manual of sampling techniques. London: Heinemaan Educational Books Limited.
5. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling theory of surveys with applications (3rd ed.). Ames, IOWA: Iowa State University Press.

Course Title:	Statistical Computer Packages-I
Course Code:	STAT-305
Semester:	I
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To enable the student to use the computer effectively in a multitude of academic scenarios.
2. To enable the Students to usebasic computer skills related to subject of intrest and word processing, Microsoft Word, the Internet, web search and email.

Course Outline

Unit 1: Basics of Excel

1.1 Data Formatting in Excel.
1.2 Basic Sorting and Filtering.
1.3 Basic Formulae like SUM, AVERAGE, COUNT, MAX, MIN etc,

Unit 2: Spreadsheet Basics

2.1 Creating, Editing.
2.2 Saving and Printing spreadsheets, Getting data, Creating subtotal, Using Automatically Outline, Grouping Data Manually.

Unit 3: Sorting Data

3.1 Sorting Data by values, colors, etc, Filtering by numbers, text, values, logical functions,
3.2 Creating a custom AutoFilter, Advance Filtering Options, Protecting your work sheet.
3.3 Custom and Conditional Formats, Data Validation, Working with Range, Names, Using range names in formulas and headings.
3.4 Using Formulas and Functions: Text Function, Logical Functions,
3.5 Date and Time Functions, Information Function, Database Functions, Math and Trigonometry Functions, Statistical Functions, Lookup and reference functions, Absolute and Relative cell reference.

Unit 4: Managing Tables

4.1 Creating Tables, Naming the Tables, Removing the duplicate record.
4.2 Charts, Pivot Tables and Reports: Creating a chart, Formatting a chart, Adding Labels, Changing the chart type, Data source.
4.3 Creating Pivot tables, Changing the summary functions, Creating report filter page, Creating Subtotals, Using advanced options of pivot table, pivot charts, Consolidating data from multiple sheets and files using pivot tables, Using external data source, Using data consolidation feature to consolidate data.

Unit 5: conditional shifts

5.1 What-IF Analysis and Macros: Goal Seek.

Unit 6: Data Tables

6.1 Data Tables and Scenario Manager.
6.2 Display the developer Tab.
6.3 Changing Macro security Settings.
6.4 Recording and running a Macro.

Unit 7: Hands on applications

7.1 Statistical Analysis: Descriptive and Inferential Statistical Analysis.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Schmuller, J. (2016). "Statistical Analysis with Excel for dummies".
2. Stephen L. Nelson and E.C. Nelson (2014). Excel® Data Analysis For Dummies,® 2nd Edition. John Wiley & Sons, Inc., Hoboken, New Jersey.
3. Neil J. Salkind (2016). Excel Statistics: A Quick Guide, 3rd Edition. ISBN-13: 978-1483374048.
4. Beverly Dretzke (1998).Statistics with Microsoft Excel, 5th Edition. ISBN-13: 978-0321783370.
5. Cynthia Fraser. "Business Statistics for Competitive Advantage with Excel 2010: Basics, Model Building, and Cases". 2nd Ed, Springer.

COURSE OUTLINES
FOR
SEMESTER – II

Course Title:	Parametric and Nonparametric Tests
Course Code:	STAT-306
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To revise and introduce some basic principles and standard methods in probability and Statistics;
2. To provide practical exposure on fundamental results, properties and tests outlined in the course;
3. To identify the deficiencies in their background knowledge of students and how to handle with them.

Course Outline

Unit 1: Hypothesis testing

1.1 Tests of hypothesis: parametric methods, Z-test, t-test, F-test.

Unit 2: Categorical data Analysis

2.1Analysis of categorized data. Goodness of fit tests. Homogeneity of variance. Bartlett test and Cochran test. Contingency tables. Test of independence in contingency tables. Fisher's exact test for 2x2 contingency tables.

Unit 3: Non-parametric methods

3.1 Non-parametric methods, advantages and disadvantage.

3.2 When to use non parametric method Chebyshev's inequality. The sign test. the binomial test, Cox-Stuart test for trend. Wilcoxon's signed rank test. Wilcoxon's ranked sum test. Mann-Whitney U test. Tukey's quick test, the mood test, Mose's test. Median test. Run test. Kolmogrorov-Smirnov test. Kruskal-Wallis test. Median test for k-samples. Friedman's test. Sequential test. Test for proportion.

3.3 Operating characteristic (OC) function. Average sample number (ASN) function. Test for standard deviation.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Dale, C.G.W. (2018). Non-parametric Statistics. John Wiley & Sons Ltd.
2. Steel, R.G.D. and Torrie, J.H. (1980). Introduction to Statistical Analysis (2nd ed.) McGraw-Hill Book Company, New York.
3. Dixon, W.J., and Massey, F.J. (1979). Introduction to Statistical Analysis. (4th ed.) McGraw-Hill Company, New York.
4. Danes, W.W. (1978). Applied Non-parametric Statistics. Houghton Mifflin Company Boston, New Jersey, London.

Suggested Readings

1. Larson, H.J. (1982). "Introduction to Probability Theory and Statistical Inference" (3rd ed.) John Wiley and Sons, New York.
2. Wilcox, Rand R. (2001). "Fundamentals of modern Statistical methods", Springer N.Y.
3. Vaidyanathan, M. (2001). "Latest Statistical Methods", S. Chand and Company, New Delhi.
4. Aggarwal, Y.P. (1998). "Statistical Methods" Sterling publisher, New Delhi.

Course Title:	Probability Theory and Distribution-II
Course Code:	STAT-307
Semester:	II
Credit Hours:	3
Pre-requisites:	Probability Theory and Distribution-I

Learning Outcomes

1. To provide an introduction to the language of distribution theory regarding continuous univariate and bivariate cases.
2. To provide the concepts of joint distribution, conditional distribution and their expectation.
3. To provide the concept of order statistics.

Course Outline:

Unit 1

1.1 Continuous Distributions

Continuous distributions: continuous uniform, normal, exponential, gamma, beta, lognormal, Weibull, Pareto and Cauchy distributions and their properties.

Unit 2

2.1 Bivariate Distributions

Marginal distribution. Conditional distribution and independence. Conditional expectation and conditional variance. Bivariate normal distribution and its properties.

Unit 3

3.1 Transformation of Random Variables

Sum, product and quotient of random variables. Moment generating function techniques. Derivations of chi-square, t and F distributions and their properties.

Unit 4

4.1 Order Statistics

Distribution of the r^{th}-order statistics. Distribution of sample range, sample median and sample mid-range.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Rohatgi, V.K. and Saleh, A.K. Md. E. (2001). An Introduction to Probability and Statistics (2nd ed.). John Wiley and Sons.
2. Lipschutz, S. and Lipson, M.L. (2000). Probability. (2nd ed.) McGraw Hill New Dehli.
3. Hogg. R.V. and Craig, A.T. (1995). Introduction to Mathematical Statistics (5th ed.). Prentice-Hall International, Inc. Engle Wood Cliffs.
4. Mood, A.M., Graybill, F.A. and Bloes, D.C. (1974). Introduction to the Theory of Statistics (3rd ed.). McGraw-Hill Book Company, New York.

Suggested Readings

1. Bhuyan, K.C. (2010). Probability Distributions Theory and Statistical and Inference. New Central Book Agency, London.
2. M, J. S. and Arnold, J.C. (2003). Introduction to Probability and Statistics". McGraw Hill.
3. Ross, S. (2003). "Introduction to probability models (6th ed.). Academic Press.
4. Dudewicz, E.J. and Misra, S.N. (1988). Modern Mathematical Statistics. John Wiley and Sons, New York.
5. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2006). Probability and Statistical Inference (7th ed.). McMillan Publishing Company, New York.
6. Stuart, A. and Ord, J.K. (1994). Kendall's Advanced Theory of Statistics Vol.-I (6th ed.). Edward Arnold, London.

Course Title:	Experimental Design and Analysis-II
Course Code:	STAT-308
Semester:	II
Credit Hours:	3
Pre-requisites:	Experimental Design and Analysis-I

Learning Outcomes

1. To introduce distinctive methodologies specifically related to design of experiment.
2. To build on students' existing knowledge of design of experiments,
3. To develop enough of the theory to allow a proper understanding of what these methods can achieve, while showing how and when these methods are applied to data arising in practical context.
4. To illustrate applications of statistics within agriculture and medical fields.
5. To understand the main ways of improving the accuracy of a designed experiment and the need for randomization; and understand the importance of designing for the contrasts of interest and the actual experimental situation.
6. Compare the efficiencies of different block and row-column designs; and understand the main features of factorial designs;
7. Be able to obtain efficient designs in non-standard situations.

Course Outline

Unit 1

1.1 Factorial experiments

Advantages. (pxq) Factorial in Randomized Complete Block designs. 2nd series Factorial experiments. Linear and quadratic components of main effects and interactions. 3rd series Factorial experiments.

Unit 2

2.1 Confounding

Types and its advantages. Complete and partial confounding in 2nd series.
Fractional replication. Quasi-Latin squares. Split-plot designs and Split-split plot designs.

2.2 Incomplete Block Designs

Balanced incomplete and Partially Balanced incomplete block designs. Comparison of Incomplete Block design with Randomized Complete Block design. Youden Squares.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Cochran, W.C. and Cox, G.M. (957). "Experimental Design", John Wiley and Sons, New York, Second Edition.
2. Montgomery, D.C. (1997). "The Design and Analysis of Experiments", John Wiley and Sons, New York, Fourth Edition.
3. John, J.A. and Quenoville, M.H. (1977). "Experiments Design and Analysis", Second Edition, Charles Griffin & Co. London.

Suggested Readings

1. Kempthorone, O. & Hin Kelmann, K. (1994). "Design and Analysis of Experiments, Vol.1", John Wiley and Sons, New York.
2. Barker, T.B. (1994). "Quality by Experimental Design", Marcel Dekker, Inc. New York, Second Edition.
3. Boniface, D.R., (1995). "Experiment Design and Statistical Methods for Behavioural and Social Research", Chapman & Hall, London. First Edition.
4. Ostle, B. and Mensing, R.W. (1975). "Statistics in Research", The lowa State University Press, Third Edition.
5. Winer, B.J. (1971). "Statistical Principles in Experimental Design". McGraw-Hill Book Company, New York, Second Edition.
6. Federer, W.T. (1955). "Experimental Design", Macmillan Company, New York.
7. Graybill, F.A. (1961). "An Introduction to Linear Statistical Models, Vol.1" McGraw Hill Book Company, New York.
8. Heath, D. (1996). "An Introduction to Experimental Design and Statistics for Biology", UCI Press, London, second edition.
9. Clewer, Alan G. (2001). "Practical Statistics and Experimental Design for Plant and Crop Science", Wiley N.Y.
10. Quinn Gerry P. (2002). "Experimental Design and Data Analysis for Biologists" Cambridge Press, Cambridge.
11. JeffWu, C.F. (2002). "Experimental: Planning Analysis", Wiley, New York.
12. Kuehl, R.O. (2000). "Design of experiments: Statistical principles of research design and analysis" Duxbury, Boston.

Course Title:	Sampling Techniques-II
Course Code:	STAT-309
Semester:	II
Credit Hours:	3
Pre-requisites:	Sampling Techniques-I

Learning Outcomes

1. To build on students' existing knowledge of sampling techniques.
2. To introduce distinctive methodologies related to sampling designs.
3. To get the knowledge about the economical use of available resources such as time, money and manpower in connection with the information obtained through sample survey.
4. To apply the sampling tools in real life problems.
5. To theoretically study the impact of various types of errors encountered in a sample survey.

Course Outline

Unit 1

1.1 Ratio and Regression estimation

Estimation of total, mean square error and bias using design based approach and model based approach in simple random sampling. Unbiased ratio-type estimators. Ratio estimation in stratified sampling**,** Estimation of mean and variance in linear regression estimates**.** Best linear unbiased estimator (BLUE). Bias of the linear regression estimates**.** Regression estimation in stratified sampling**.** The Linear regression estimator under the general linear model

Unit 2

2.1 Cluster sampling

Estimation of mean, total and variance for single-stage cluster sampling**,** Cost function, Variance function**.** Cluster sampling for proportions**,** Sampling with unequal probability with replacement.

2.2 Two-stage sampling

Estimation of mean, total, proportion and variance. Both stages with equal probability. Two-stage sampling with units of unequal sizes, first stage PPS (with replacement) and second stage with equal probability. Both stages with probability proportional to size and with replacement. Sampling methods when a single primary unit is selected for the sample. Basic concept of double sampling.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Cochran, W.G. (2014). Sampling techniques (3rd ed.). New York: John Wiley and Sons.
2. Kish, L. (2014). Survey sampling. New York: John Wiley and Sons.
3. Singh, D. Chaudhry, F.S. (1986). Theory and analysis of sample survey designs. New Delhi, India: Wiley Eastern Limited.

Suggested Readings

1. Fuller, W. A. (2009). Sampling statistics. New Jersey: John Wiley and Sons.
2. Brewer, K. (2002). Combined survey sampling inference. New York: Oxford University Press.
3. Raj, D. (1971). Sampling theory. New York: Mc-Graw-Hill Book Company.
4. Som, R.K. (1973). A manual of sampling techniques. London: Heinemaan Educational Books Limited.
5. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling theory of surveys with applications (3rd ed.). Ames, IOWA: Iowa State University Press.

Course Title:	Statistical Computer Packages-II
Course Code:	STAT-310
Semester:	II
Credit Hours:	3
Pre-requisites:	Statistical Computer Packages-I

Learning Outcomes

1. To train students on data handling technique.
2. To introduce them with real applications of statistical tools using computer software.
3. To have hands on training for analysis of case studies with the help of computer packages.

Course Outline

Unit 1: Data Handling

1.1 Variable types.

1.1.1 Entering data, Importing and Exporting data.

1.1.2 Data cleaning, Merging and splitting data.

1.1.3 Transforming data and applying filter.

Unit 2: Charts and Graphs

1.2 Displaying data using pie charts, bar charts, histograms, line graphs, scatter diagram and other important visual display of data useful for statistical analysis.

Unit 3: Summarizing of Data

1.3 Summarizing data, averages, dispersion, skewness, kurtosis, quantiles. Detecting outliers in the data.

Unit 4: Modeling

4.1 Statistical modeling, correlation, regression and time series models. Computing probabilities for standard probability distributions.

Unit 5: Inference

5.1 Statistical inference using parametric and non-parametric tests.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Field, A. P. (2016). "Discovering statistics using SPSS". 4th Ed. London, England: SAGE.
2. Sabine Landau and Brian S. Everitt. (2012). "A Handbook of Statistical Analyses using SPSS". CHAPMAN & HALL/CRC, Boca Raton London New York Washington, D.C.
3. Nicola Brace, Richard Kemp and Rosemary Snelgar. (2015). "SPSS for Psychologists: A Guide to Data Analysis Using SPSS for Windows".

Course Title:	Time Series Analysis
Course Code:	STAT-311
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To familiarize the students with ideas, techniques and uses of time series analysis.
2. To describe the various decomposition methods.
3. To make the students understand the various time series models and the procedure of model building to various time series data.
4. To provide the students hands-on training on time series modeling and forecasting with the help of computer software.

Course Outline:

Unit 1 Introduction of Time Series Analysis

1.1 Introduction to time series.

1.2 Time Series Analysis

Decomposition of time series, Estimation of various components of time series, Averaging and Smoothing methods of forecasting. Stochastic modeling of time series. Box-Jenkins approach of time series models. Evaluating dependence structure in time series data.

Unit 2 Types of Autocorrelation

2.1 Autocovariance, Autocorrelation, Partial Autocorrelation functions and their estimation. Stationarity, Mathematical definitions of strict stationarity and second-order stationarity. Transformations for non-stationary time series.

Unit 3 Stochastic Processes

3.1 Various forms of stochastic processes models used in time series analysis. Definition and derivation of theoretical properties of purely random process, random walk, moving average process, autoregressive process and mixed autoregressive moving average process. Yule-Walker equations. Models for non-stationary time series. Models for seasonal time series.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. "Time Series Analysis: Forecasting and Control" 4th Edition, 2013.
2. Chatfield, C. "The Analysis of Time Series" Sixth Edition, 2004.
3. Brockwell, P.J. and Davis, R.A. "Introduction to Time Series and Forecasting" Second Edition, 2002.
4. Wei, W.W. "Time Series Analysis: Univariate and Multivariate Methods", 1990.
5. Makridakis, S., Wheelwright, S.C. and McGee, V.E. "Forecasting: Methods and Applications", 2nd Edition, 1983.

Suggested Readings

1. Anderson, T.W. "The Statistical Analysis of Time Series", 1971.
2. Connel, O. and Bowerman, "Time Series Forecasting", Second Edition, 1987. Duxbury Press, Boston.
3. Diggle P. "Time Series", 1990, London.
4. Montgomery D.C. "Forecasting and Time Series Analysis", Second Edition, 1990, McGraw Hill Book Company, New York.

COURSE OUTLINES
FOR
SEMESTER – III

Course Title:	Statistical Inference-I
Course Code:	STAT-401
Semester:	III
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To extend understanding of the practice of statistical inference.
2. To familiarize the students with ideas, techniques and some uses of statistical tools of estimation.
3. To apply the estimation techniques to the real life problems and systems.

Course Outline

Unit 1

1.1 Point Estimation and Properties of an Estimator

Point estimation and problems of estimation. Properties of a good estimator: Unbiasedness, Consistency, Efficiency and Sufficiency. Mean-squared error. Consistency and Best asymptotically normal estimator. Minimal sufficient statistics. Joint sufficiency. Exponential family. Sufficiency and Completeness. Cramer-Rao inequality.

1.2 Minimum Variance Bound estimators

Rao-Blackwell and Lehmann-Sheffe theorems. Uniformly Minimum Variance Unbiased estimators. Joint completeness. Location invariant and scale-invariant estimators. Pitman estimators for location and scale.

Unit 2

2.1 Bayes Estimation

Bayes estimators. Prior and Posterior distributions. Posterior Bayes estimators. Loss function and Risk function. Bayes estimator, Minimax Methods of estimation.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Hogg, R.V. and Craig, A.T. (1995). “Introduction to Mathematical Statistics”, Prentice-Hall International, Inc. Engle Wod Cliff, N.J., Fifth Edition.
2. Mood, A.M. Graybill, F.A. and Boes, D.C., (1974). “Introduction to the Theory of Statistics”, McGraw-Hill Book Company, New York, Third Edition.
3. Levy, P.S. and Lemeshow, S, (2008). “Sampling of Populations: Methods and Applications”, John Wiley, New York, Fourth Edition.
4. Lehman, E.L. (1998). “Theory of Point Estimation”, John Wiley, New York.
5. Rao, C.R., (2001). “Linear Statistical Inference and its Applications”, John Wiley, New York.
6. Hoel, P.G. (1984). “Introductions to Mathematical Statistics” Fifth Edition, John Wiley.

Suggested Readings

1. Hogg, R.V. and Tanis E.A., (2015). “Probability and Statistical Inference” Macmillan Publishing Company, New York, Ninth Edition.
2. Radhakrishna. (2013). “Linear Statistical Inference and its Applications”. Second Edition.
3. Panik, M.J. (2012). “Statistical Inference”.
4. Rajapogalan. (2012). “Statistical Inference”.
5. Casella. (2002). “Statistical Inference”. Second Edition.
6. Manoj, S.K. (2014). “Statistical Inference: Theory of Estimation”.
7. Helio S. Migon. (2015). “Statistical Inference: An Integrated Approach”. Second Edition.
8. Hastie, Trevor. (2016). “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”. Second Edition.
9. Prado, Requel. (2010). “Time Series Modeling, Computation and Inference”.
10. Lindgrind, B.W. (1993). “Statistical Theory” Macmillan Publishing Company, New York, Fourth Edition.
11. Stuart, A. and Ord, J.K. (1991). “Kendalls Advanced Theory of Statistics, Vol-2, Edward Arnold, London, Fifth Edition.
12. Spanos. A (1999). “Probability theory and Statistical Inference” Cambridge University Press.
13. Welsh, A.H. (1996). “Aspects of Statistical Inference” John Wiley.
14. Freund, J.E. (1999). “Mathematical Statistics” Sixth Edition.
15. Kale, B.K. (2005). “A First course on Parametric Inference” Narosa, India.
16. Hagan, A. (1994). “Kendall’s Advanced theory of Statistics Vol.2B; Baysian inference” Arnold, U.K.

Course Title:	Econometrics-I
Course Code:	STAT-402
Semester:	III
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To review and extend the students' knowledge of the standard linear model.
2. To introduce the more general ideas of generalized linear models, hierarchal models and errors in variable models by building on the familiar concepts of the linear models.
3. To show how these methods are applied to data, and what kind of conclusions are possible
4. To derive minor extensions and applications of the general theory to carry out the straight forward regression analysis.
5. To assess the fit of the model to the data, and make at least some suggestions as to how to improve if it is unsatisfactory.

Course Outline:

Unit 1

1.1 Econometrics

Its nature, methodology and functions.

Unit 2

2.1 Simple Linear regression

Ordinary least squares method; assumptions and estimation. Maximum likelihood method; assumptions and estimation properties of OLS and ML estimators. Partition of total sum of squares. Sampling distribution of sum of squares, Testing of hypotheses confidence intervals for the parameters and Linear combinations of SLR. Comparison of SL regressions, Chow test.

Unit 3

3.1 General Linear regression

Ordinary least squares method; assumptions and estimation. Maximum likelihood method; assumptions and estimation properties of OLS and ML estimators. Partition of total sum of squares. Sampling distribution of sum of squares, Testing of hypotheses confidence intervals for the parameters and Linear combinations of SLR. Comparison of SL regressions, Chow test. Gauss Markov's theorem.

Unit 4

4.1 Other topics

Stepwise regression, Ridge regression, GLR partitioned form, Use of extraneous information in linear regression. Restricted least squares estimator.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Gujrati, D. (1995). "Basic Econometrics", McGraw Hill Book Company, Third Edition.
2. Johnston, J. (1985). "Econometric Methods", McGraw-Hill Book Company, Third Edition.
3. Koutsoyiannis, A. (1979). "Theory of Econometrics", Macmillan Press Ltd., Hong Kong.

Suggested Readings

1. Chatterjee, S. and Hadi, A.S. (2015). "Regression Analysis by Example", Fifth Edition, John Wiley and Sons, New York.
2. Asteriou, D. and Hall, S.G. (2016). "Applied Econometrics", 3rd Edition, Dimitrios Asteriou & Stephen G. Hall.
3. Dutta, M. (1975). "Econometric Methods, "South-Western Publishing Company, England.
4. Goldberger, A.S. (1964). "Econometric Theory", John Wiley and Sons, New York.
5. Wonnacott, T.H. and Wonnacott, R.J. (1979). "Econometrics", John Wiley and Sons, New York.
6. Draper, N.R. and Smith, I.I. (1998). "Applied Regression", John Wiley & sons, New York.

Course Title:	Multivariate Techniques
Course Code:	STAT-403
Semester:	III
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To acquaint with multivariate normal distribution as a basis of multivariate analysis.
2. To introduce the principal components analysis as a tool of data reduction.
3. To find out the latent factors underlying some set of multivariate data.
4. To study the correlation between the sets of variables.
5. To allocate observation to difference classes on the basis of discriminant function.

Course Outline:

Unit 1

1.1 Matric Algebra

Review of matrix algebra, Notions of multivariate list.

Unit 2

2.1 Linear Combination

Linear compound and linear combination, estimation of mean vector and covariance matrix.

Unit 3

3.1 Some Selected Distributions

Joint distribution of sample mean vector and sample covariance matrix, Multivariate normal distribution and its properties, the Wishart distribution and its properties, Hotelling's T^2 distribution.

Unit 4

4.1 Hypotheses Testing and Confidence Interval

Tests of hypotheses and confidence intervals for mean vectors (one and two sample procedure). Principal components, Factor analysis, Canonical correlation analysis, discrimination and classification.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Hair, J.F. (2013). "Multivariate Data Analysis". (7th ed). Pearson Dehli Cheenai.
2. Rencher, A.C. (2002). "Methods of Multivariate Analysis". John Wiley and Sons, New York.
3. Johnson, R.A. and Wichern, D.W. (2002). "Applied Multivariate statistical analysis", Pearson Education, Singapore.
4. Morrison, D.F. (1990). "Multivariate Statistical Methods". (3rd ed.). McGraw Hill Publishing Co. New York.
5. Anderson, T.W. (1980). "Introduction to Multivariate Statistical Analysis". (2nd ed.) John Wiley & Sons, New York.
6. Chatfield, C. and Collins, A.J. (1980). "Introduction to Multivariate Analysis". Chapman and Hall, London.

Suggested Readings

1. Bhoyan, K.C. (2008). "Multivariate Analysis and its Application". New Central Book Agency.
2. Kandall, M.G. and Stuart, A. (1983). "The Advanced Theory of Statistics". (4th ed.). Vol.-III Charles Griffin and Company, London.
3. Rao, C.R. (1973). "Linear Statistical Inference and its Applications". (2nd ed.) John Wiley and Sons, New York.

Course Title:	Statistical Programming
Course Code:	STAT-404
Semester:	III
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To develop the programming logic.
2. To introduce the students with modern statistical programming languages.
3. To train students for writing programs based on statistical theory.

Course Outline:

Unit 1: Introduction of programming languages

1.1 Introduction to statistical programming languages R/Python/Matlab, basic built-in functions, help functionality.

Unit 2: Data types & data structures

1.1 data types, simple operations, data structures: vectors, matrices, arrays, lists; subsetting, slicing and dicing.

Unit 3: Data Frames

3.1 Data frames, reading data, tables and sorting.

Unit 4: Statistical data analysis

4.1 Basic statistical analysis, sampling, statistical inference using built-in functions, Extracting output, Importing data, Exporting results, Building and exporting graphs.

Unit 5: logic control

5.1 Control structure Logic and flow control structures, *for* and *while* loops, *if* - *ifelse* conditions.

5.2 Writing functions, Simulation.

5.3 Writing programs for verification of basic statistical theories, Statistical modeling

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Jones, O., Maillardet, R. and Robinson, A. "Introduction to Scientific Programming & Simulation Using R", 2nd edition, 2014.
2. Gaddis, T. "Starting Out with Python", 4th edition, 2018.
3. Daalgard, P. "Introductory Statistics with R", 2008
4. Attawy, S. "Matlab: A practical introduction to Programming and Problem Solving", 4th edition, 2016.Brockwell, P.J. and Davis, R.A. "Introduction to Time Series and Forecasting" Second Edition, 2002.

COURSE OUTLINES
FOR
SEMESTER – IV

Course Title:	Statistical Inference-II
Course Code:	STAT-405
Semester:	IV
Credit Hours:	3
Pre-requisites:	Statistical Inference – I

Learning Outcomes

1. To extend understanding of the practice of statistical inference.
2. To describe computational implementation of moments, likelihood, and likelihood-ratio based analysis.
3. To describe the parametric interval estimation, sequentially probability ratio tests and minimum chi-square estimation.
4. To familiarize the students with Bayesian approach to inference.
5. To apply the estimation techniques to the real life problems and systems.

Course Outline:

Unit 1

1.1 Interval Estimation and Confidence Interval

Interval estimation. Confidence interval and its interpretation. One-sided confidence intervals. Methods of finding confidence intervals. Pivotal quantity method. Confidence intervals for the mean and variance. Confidence region for the mean and variance. Large-sample confidence intervals. Bayesian interval estimates. Shortest sets of confidence intervals.

Unit 2

2.1 Testing

Tests of Hypotheses. Simple and composite hypotheses. Power function. Size and power of a test. Randomized and Non-randomized tests. Most powerful tests. Neyman-Pearson lemma. Loss function and Risk function. Bayes test. Generalized likelihood-ratio tests. Uniformly most powerful tests. Unbiased test. Uniformly most powerful unbiased test. Monotone likelihood ratio tests of hypotheses. Sequential probability ratio test. Approximate sequential probability ratio test. Approximate expected sample size of sequential probability ratio test.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Hogg, R.V. and Craig, A.T. "Introduction to Mathematical Statistics", Prentice-Hall International, Inc. Engle Wod Cliff, N.J., Fifth Edition, 1995.
2. Mood, A.M. Graybill, F.A. and Boes, D.C., "Introduction to the Theory of Statistics", McGraw-Hill Book Company, New York, Third Edition, 1974.
3. Levy, P.S. and Lemeshow, S, "Sampling of Populations: Methods and Applications", John Wiley, New York, Fourth Edition, 2008.
4. Lehman, E.L. "Theory of Point Estimation", John Wiley, New York, 1998.
5. Rao, C.R., "Linear Statistical Inference and its Applications", John Wiley, New York, 2001.
6. Hoel, P.G. "Introductions to Mathematical Statistics" Fifth Edition, John Wiley, 1984.

Suggested Readings

1. Hogg, R.V. and Tanis E.A., "Probability and Statistical Inference" Macmillan Publishing Company, New York, Ninth Edition, 2015.
2. Radhakrishna. "Linear Statistical Inference and its Applications". Second Edition, 2013.
3. Panik, M.J. "Statistical Inference". 2012.
4. Rajapogalan. "Statistical Inference". 2012.
5. Casella. "Statistical Inference". Second Edition, 2002.
6. Manoj, S.K. "Statistical Inference: Theory of Estimation", 2014.
7. Helio S. Migon. "Statistical Inference: An Integrated Approach". Second Edition, 2015.
8. Hastie, Trevor. "The Elements of Statistical Learning: Data Mining, Inference, and Prediction". Second Edition, 2016.
9. Prado, Requel. "Time Series Modeling, Computation and Inference". 2010.
10. Lindgrind, B.W. "Statistical Theory" Macmillan Publishing Company, New York, Fourth Edition, 1993.
11. Stuart, A. and Ord, J.K. "Kendalls Advanced Theory of Statistics, Vol-2, Edward Arnold, London, Fifth Edition, 1991.
12. Spanos. A "Probability theory and Statistical Inference" Cambridge University Press, 1999.
13. Welsh, A.H. "Aspects of Statistical Inference" John Wiley, 1996.
14. Freund, J.E. "Mathematical Statistics" Sixth Edition, 1999.
15. Kale, B.K. "a first course on parametric inference" Narosa, India, 2005.
16. Hagan, A. "Kendall's Advanced theory of Statistics Vol.2B; Baysian inference" Arnold, U.K. 1994.

Course Title:	Econometrics-II
Course Code:	STAT-406
Semester:	IV
Credit Hours:	3
Pre-requisites:	Econometrics-I

Learning Outcomes

1. To review and extend the students' knowledge of the standard linear model.
2. To introduce the more general ideas of generalized linear models, hierarchal models and errors in variable models by building on the familiar concepts of the linear models.
3. To show how these methods are applied to data, and what kind of conclusions are possible
4. To derive minor extensions and applications of the general theory to carry out the straight forward regression analysis.
5. To assess the fit of the model to the data, and make at least some suggestions as to how to improve if it is unsatisfactory.

Course Outline:

Unit 1

1.1 OLS and GLS Methods

Non-spherical disturbances, Consequences of using OLS estimators, ML method assumption and estimation, Generalized least squares; assumption, estimation, properties of GLS estimators. Aitken theorem, Stochastic regressors.

Unit 2

2.1 Multicollinearity

Multicollinearity: types, reasons consequences, remedial measures, Farrar and Glauler test.

2.2 Heteroskedasticity

Heteroskedasticity: Reasons, tests, remedial measures.

2.3 Autocorrelation

Autocorrelation: Reasons, tests, remedial measures.

Unit 3

3.1 Specification Errors

Specification Errors: Over and under specified models and their consequences. Error in variables.

Unit 4

4.1 Other variables

Other variables: Instrumental variables, Lagged variables, Dummy variables.

4.2 Other regression

Other regression: Polynomial regression, Orthogonal polynomials and their use.

4.3 Simultaneous Equations

Key terms of simultaneous linear equations: Reduced form equations, Simultaneous equations lines, identification (order and rank conditions), Methods of estimation for identified equations. Income and Wealth distribution: Techniques for income distribution analysis (Lovernz curve, Gini coefficients, Pareto curve).

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1 Gujrati, D. "Basic Econometrics", McGraw Hill Book Company, Third Edition, 1995.
2. Johnston, J. "Econometric Methods", McGraw-Hill Book Company, Third Edition, 1985.
3. Koutsoyiannis, A. "Theory of Econometrics", Macmillan Press Ltd., Hong Kong, 1979.

Suggested Readings

1. Chatterjee, S. and Hadi, A.S. "Regression Analysis by Example", Fifth Edition, John Wiley and Sons, New York, 2015.
2. Asteriou, D. and Hall, S.G. "Applied Econometrics", 3rd Edition, Dimitrios Asteriou & Stephen G. Hall, 2016.
3. Dutta, M. "Econometric Methods, "South-Western Publishing Company, England, 1975.
4. Goldberger, A.S. "Econometric Theory", John Wiley and Sons, New York, 1964.
5. Wonnacott, T.H. and Wonnacott, R.J. "Econometrics", John Wiley and Sons, New York, 1979.
6. Draper, N.R. and Smith, I.I. "Applied Regression", John Wiley & sons, New York, 1998.

Course Title:	Categorical Data Analysis
Course Code:	STAT-407
Semester:	IV
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. The aim of this course is to enable students to use generalized linear models (GLMs) and other methods to analyse categorical data with proper alternative to the underlying assumptions.
2. To give a practical expertise on categorical data in marketing and industry.

Course Outlines

Unit 1: introduction of categorical data

1.1 Introduction & Historical Background of Categorical Data, Categorical Response Data.
1.2 Types of Categorical Variables.
1.3 Measurement Scales Distinction.

Unit 2: Data sources and tests of fit

2.1 Sampling distributions, Testing goodness of fit and independence, Large Sample confidence intervals and the Idea of p-value. Chi-square Test for Categorical Data with its Assumptions.

2.2 Uses and Application, Phi Co-efficient, Contingency Co-efficient (C), Cramer's-V, Adjusted Chi-square (Yates' Correction), Fisher's Exact Test (An Exact Test for (2x2) Contingency Table), Kendall's Tau b Statistic.

2.3 Meta-Analysis for (2x2xk) Tables and Cochran-Mantel-Haenszel Test, Matched Samples and McNemar Test, Testing of Statistical Significance of Relative Risk and Odds Ratio with its Confidence Limits, Sensitivity, Specificity and Kappa Statistic. Models for Binary Response Variables, Log Linear Models and Fitting of Log-linear and Logit Models, Binomial and Normal Probability Plots.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Agresti, A. *Categorical data analysis*. Third Edition. 2012. John Wiley & Sons.
2. Agresti, A. *Analysis of Ordinal Categorical Data.* Second Edition, 2010, John Wiley & Sons.
3. Lloyd, C. J. *Statistical analysis of categorical data*. First Edition. 1999, John Wiley & Sons.
4. Powers D. A. & Xie Y. *Statistical Methods for Categorical Data Analysis*. Second Edition, 2008, Emerald Group Publishing.

Suggested Readings

1. Leonard, T. *A course in categorical data analysis*. 1999, Chapman & Hall / CRC.
2. Wrigley, N. *Categorical data analysis for geographers and environmental scientists.* 1985, Longman Group Limited.

List of Elective Subjects

Course Title:	Thesis (equivalent to two courses)
Course Code:	STAT-409
Semester:	II
Credit Hours:	6
Pre-requisites:	N / A

Students will have to undertake a thesis under the supervision of his / her teacher after the approval by the Coordinator / Principal.

Course Title:	Stochastic Processes
Course Code:	STAT-410
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To introduce the markov process, markov chains.
2. To introduce the certain properties of stochastic processes.
3. To acquaint the application of stochastic processes in real life phenomenon.

Course Outline:

Unit 1: Introduction

1.1 Introduction to stochastic processes.

1.2 Markov chains, Transition and absolute probability, Calculation of K-step transition probabilities. Chapman-Kolmogorov equations.

Unit 2: Classification

2.1 Classification of states.

2.2 The ergodic property.

2.3 Classification of Markov chains.

2.4 The random walk.

2.5 Gambler's ruin and expected duration of game.

Unit 3: processes

3.1 Poisson processes.

3.2 Birth and death processes.

3.3 Branching processes.

Unit 4: Queuing theory

4.1 Queuing theory and its meaning.

4.2 Characteristics of queuing system.

4.3 Simple queues.

4.4 Multiple service channels.

4.5 Optimization of queuing systems.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Jones, P.W. and Smith, P. “Stochastic Process”, Oxford University Press Inc., New York, 2001.
2. Sheldon, M. Ross, “Introduction to probability modes”, Academic press, 2003.
3. Grimmett, G.R. and Stirzaker, “Probability and Random processes”, Oxford science publications, 1997.
4. Basu, A.K. “Introduction to Stochastic Process”, Narosa publishing house, New Delhi, 2003.

Course Title:	Demography and Population Studies
Course Code:	STAT-411
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To introduce the source of demographic and the sampling techniques used in the collection of demographic data.
2. Testing the accuracy of demographic data.
3. To have a knowledge about construction of life tables.

Course Outline:

Unit 1: Rates and Ratios

1.1 Standardized death and birth rates.
1.2 Gross and net reproduction rates.
1.3 Intrinsic rate.

Unit 2: Life tables

2.1 Life tables. Construction of complete and abridged life tables.
2.2 Graphs of 1x, qx, and dx, Description and uses of life tables columns.
2.3 Stationary population. Model life tables.

Unit 3: Population estimates and Projections

3.1 Population estimates and projections.
3.2 Intercensal estimates and postcensall estimates. Components and mathematical methods for intercensal and postcensal estimates.
3.3 Population projections component method for population projections.
3.4 Mortality basis for population projections.
3.5 Fertility and migration basis for population projections.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Barclay G.W. (1958). “Techniques of Population Analysis”. John Wiley and Sons, New York.
2. Speigleman, M. (1969). “Introduction to Demography”. Oxford University Press London, Revised Edition.
3. Shroyock, H.S. Siegel J.S. et al (1971). “Methods and Materials of Demography”. U.S. Department of Commerce, Bureau of Census. Washington.

Suggested Readings

1. Yusuf, F., Marlins, J.M. and Swanson, D.A. (2018). “Methods of Demographic Analysis, DOI: 10.1007/978-94-007-6784-3-1, Springer Science + Business Media Dordrectil.
2. Pollard A.H., Yusuf, F. and Pollard G.N. (1981). “Demographic Techniques” Pergaman Press, Oxford Second Edition.

Course Title:	Spatial Statistics
Course Code:	STAT-412
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To provide a geo-statistical data handling exposure.
2. To give an understanding of spatial analysis.
3. To give hands on Spatio-temporal analysis.
4. To give an awareness of data handling tools regarding environment, industry and ecology

Course Outline

Unit 1: An overview of spatial field

1.1 Overview of spatial data; types of data, examples, projections;

1.2 basics of point referenced data models, spatial processes.

Unit 2: Stationarity and variogram

2.1 stationarity and its different forms.

2.2 Variograms with respect to coordinates and different number of variables.

Unit 3: exploratory data analysis

3.1 Spatial exploratory data analysis (EDA),

3.2 Kriging, basics of areal data models, EDA; Markov random fields, conditional autoregressive models.

Learning Outcomes

Students will be able to

- Distinguish different types of spatial data.
- Understand how spatial autocorrelation plays a role in statistical modelling.
- Determine which spatial methods to use in their own research.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Blangiardo, M., & Cameletti, M. (2015). *Spatial and spatio-temporal Bayesian models with R-INLA*. John Wiley & Sons.
2. Cressie, N., & Wikle, C. K. (2015*). Statistics for spatio-temporal data*. Wiley.
3. Chiles, J. P., & Delfinder, P. (2012). *Geostatistics: Modeling spatial uncertainty*. Wiley.
4. Carlin, B. P., Gelfand, A. E., & Banerjee, S. (2014). *Hierarchical modeling and analysis for spatial data*. CRC Press.
5. Gamerman, D., & Lopes, H. F. (2006). *Markov chain Monte Carlo: Stochastic simulation for Bayesian inference*. CRC Press.

Suggested Readings

1. Gilks, W. R., Richardson, S., & Spiegelhalter, D. (1995). *Markov chain Monte Carlo in practice*. CRC Press.
2. Gelfand, A. E., Diggle, P., Guttorp, P., & Fuentes, M. (Eds.). (2010). *Handbook of spatial statistics*. CRC press.
3. Waller, L. A., & Gotway, C. A. (2004). *Applied spatial statistics for public health data* (Vol. 368). John Wiley & Sons.

Course Title:	Machine Learning
Course Code:	STAT-413
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

Students will be able to

- To introduce students to the basic concepts and techniques of Machine Learning.
- To develop skills of using recent machine learning software for solving practical problems.
- To gain experience in doing independent study and research.

Course Outline

Unit 1: an introduction to machine learning.

1.1 Introduction to machine learning.
1.2 Machine learning and pattern recognition.
1.3 Supervised learning.

Unit 2: Regression patterns.

2.1 Linear and non-linear regression with reference to machine learning.
2.2 Non-parametric methods, Support vector machines, and large-margin
2.3 Classifiers, Kernel methods, Model/Feature selection.
2.4 Unsupervised Learning: Clustering algorithms, K-means, Expectation-maximization, Gaussian mixture models, Anomaly detection.
2.5 Artificial neural networks. Reinforcement Learning: Markov decision processes and Ensemble learning: Bagging, random forests, and boosting.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Alpaydin, E. (2014). *Introduction to machine learning*. MIT Press.
2. Anzai, Y. (2012). *Pattern recognition and machine learning*. Elsevier.
3. Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
4. Marsland, S. (2011). *Machine learning: an algorithmic perspective*. Chapman and Hall/CRC.

Course Title:	Operations Research
Course Code:	STAT-414
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To apply mathematical sciences for decision making.
2. To provide rational basis for decision making by seeking to understand and structure complex situations.

Course Outline

Unit 1 Some Definitions

1.1 Definitions

Definition and nature of Operations Research (OR) Major Phases of an OR study.

1.2 Linear Programming

Linear Programming, Feasible and Optimal Solutions Linear Programming Techniques, Graphical Solution of two-variable linear model, Simplex method. Duality Theory.

1.3

The Transportation model, Assignment model.

1.4

Network Analysis, CPM and PERT model.

Unit 2

2.1

Decision Analysis, Decision making without & with experimentation, Decision trees, Utility Analysis.

2.2

Game theory, the formulation of two-person zero-sum games, Games with mixed strategies, Graphical solution procedure, solving by linear programming.

2.3

Queuing Theory, Single channel and Multi-channel problems, Single server waiting time models.

2.4

Inventory theory, Inventory model with production planning and simulation techniques.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Hillier, F.A. and Lieberman, G.J. (1955). "Introduction to Operations Research". (6^{th} ed.) Holden-day, San Franciso.
2. Taha, H.A. "Operations Research. (1998). "An Introduction". (5^{th} ed.) Macmillan Publishing Company, New York.

Suggested Readings

1. Bronson, R. (1983). "Theory and Problems of Operations Research". Schaum's Outlines Series. McGraw Hill Book Company, New York.
2. Sarieni, M. (1959). "Operations Research methods, and Problems". John Wiley and Sons, New York.
3. Shamblin, J.E. (1971). "Operations Research. A Fundamental Approach". McGraw Hill Book Company, New York, 1971.

Course Title:	Total Quality Management (TQM)
Course Code:	STAT-415
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

By the end of this course, students will be able to:

1. Learn the basics of quality management and its key concepts.
2. Discover the various techniques for continuous process improvement.
3. Develop and critically analyze statistical control charts.
4. Get a vast knowledge of different types of sampling plans and quality management systems.

Course Outlines

Unit 1: Basics of management

1.1 The basics of Management and Levels and Functions of Management.
1.2 The Management Process.
1.3 Defining Quality. Dimensions of Quality. Quality Management.
1.4 Principles of Quality Management. Eras of Quality Management.

Unit 2: Total Quality Management

2.1 Introduction to Total Quality Management.
2.2 Basic Concepts, Philosophy, History, Purpose and Benefits of TQM.
2.3 Implementation of TQM. Barriers to TQM Implementation, Guru's of TQM, their Philosophies and Pioneering Works.
2.4 Continuous Process Improvement: The PDSA Cycle, SWOT Analysis, Six Sigma Methodology: History and Philosophy of Six Sigma, DMAIC Road Map of Six Sigma. The Costs of TQM.
2.5 Benchmarking: Reasons, Types, Benefits and Obstacles of Benchmarking, Benchmarking Process.

Unit 3: Statistical Process Control.

3.1 Statistical Process Control: Statistical Control Charts.
3.2 Statistical Basis of the Control Chart, Steps in the Development of Control Charts.
3.3 Types of Control Charts, Process Capability. Acceptance Sampling: Lot by lot Acceptance Sampling for attributes. Types of Sampling Plan. Single Sampling Plans: Construction of OC-curve, Rectifying Inspection.
3.4 Double and Multiple Sampling Plans.

Unit 4: ISO series

4.1 Quality Management Systems: ISO 9000 Series of Standards.
4.2 Requirements, Implementation & Benefits. Environmental Management System:
4.3 ISO 14000 series of Standards: Requirements, Implementation and Benefits.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Textbooks

1. Besterfield, D.H., Michna, C.B., Besterfield, G.H. & Sacre, M.B. (2003). Total quality management (3rd ed.). Pearson Education.
2. Oakland, J.S. (2003). Total quality management (3rd ed.). Butterworth-Heinemann
3. Montgomery, D.C. (2009). Statistical quality control (6th ed.). New York: John Wiley & Sons.
4. Ryan, T.P. (2011). Statistical methods for quality improvement (3rd ed.). New Jersey: John Wiley & Sons.

Suggested Readings

1. Qiu, P. (2014). Introduction to statistical process control. London, New york: Taylor & Francis Group, CRC press.
2. Evans, J.R. & Lindsay, W.M. (2005). The management and control of quality (6th ed.). Thomson South-Western.
3. Grant, E.L. & Leaven-worth, R.S. (1996). Statistical quality control handbook (7th ed.). New York: McGraw-Hill Book Company.

Course Title:	Research Methodology (Compulsory for thesis)
Course Code:	STAT-416
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To review and extend the students' knowledge of the research methodology.
2. To introduce the more general ideas of research methodology.
3. To assess the fit of the model to the data, and make at least some suggestions as to how to improve if it is unsatisfactory.

Course Outline:

Unit 1: Types of research

1.1 Business Research, Definition, Characteristics, Types and Importance.

1.2 The Need of Research in Business.

1.3 Research in functional Areas of Business. Need of Research in Business, who does the Research? Where and why study Research?

1.4 Need for Better Business Research and Its Criteria Hall Marks of Scientific Research Problem, research problem.

1.5 Definition, causes, types, formulation, importance. The Research Process, the Theoretical Framework, its Components. The Variables, Definition and Types Hypothesis, Definition, Features Types and Needs. The Development of Hypothesis. The Stages in its Development.

Unit 2 Hypothesis and Research Designs

2.1 Hypothesis Testing with Quantities and Qualitative Data. The Research Process. The Research Design, Definition, Features, Functions and Components Difference B/W Research Design, Proposal & Plan.

Unit 3 Types of Experimental Designs

3.1 The Experimental, Design Sampling and Sample Definition, Features Types and Needs Population, Universe, element and Sample Types of Sample/Sampling the Probability and Non Probability Sampling. The Research Process: Research Instruments. Research Survey sample census Surveys and Pilot Surveys. Data Definition, Nature and Types Primary and Secondary. The Research Process Data Collection Sources, Methods and Settings Interview Definition, Nature Features Types, Importance.

Unit 4 Data Collection Tools

4.1 Data Collection Methods Types of Interview and their Respective Units and Demerits Questionnaire, Definition, Nature and Importance. Types of Question and Their Respective Merits and Demerits. Data Collection Methods Observation, Definition, Features TY1)es and Importance. Different Types of Observation and their Respective Merits and Demerits. Statistical Terms and Test Used in Business Research Description Statistics. Measures of Central Tendency and Dispersion Frequencies.

4.2 Data Analysis and Interpretation Data Completion, Processing Edition, Coding, Representation. Data Analysis, Programming Validity and Reliability Data Interpretation. Research Report Definition Components, Types Research Report Format Title, Table of Contents, Introduction, Executive Summary, Main Body, Summary and Conclusions, Plan of Action.

- **Teaching-learning Strategies:**
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- **Assignments-Types and Number with calendar:**
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- **Assessment and Examinations:**
  According to the University's Semester Rules.

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Textbooks

1. Research Mythology fOI" Business, --- Umma Sekaran (Latest Edition).
2. Business Research --- William Emmoy 1980 Edition Richard D. Irvin Inc. Ilinios USA.
3. Introduction to Business Research --- Prof. Fazli Wahid Additions, Research and Development.

Course Title:	Data Mining
Course Code:	STAT-417
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

1. To build theoretical and conceptual foundations of key data mining tasks;
2. To discuss analysis and implementation of algorithms;
3. To introduce major research sub-areas such as web/network mining

Course Outline

Unit 1

1.1

An Overview of Data Mining, Need and motivation; data mining process; data mining tasks and functionalities, interestingness measures.

Unit 2

2.1

Data Preprocessing Data cleaning, data integration and transformation, data reduction, discretization, concept hierarchies.

Unit 3

3.1

Mining Association Rules Basic definitions, market basket analysis, types of association rules, interestingness measures, frequent Item-set generation, Apriori algorithm, TIDApriori algorithm, Hybrid Apriori algorithm, FP- growth algorithm, mining multilevel, multidimensional and quantitative association rules.

Unit 4

4.1

Clustering Analysis Basic terminology, Partitioning methods: K-Means, K-Medoids, CALARANS Hierarchical methods: BIRCH, CURE etc Density based methods: DBSCAN, OPTICS Grid based methods: STING, WaveCluster, CLIQUE.

Unit 5

5.1

Mining Complex Data Types mining time-series and sequence datasets; web/network data mining; security and data mining.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
  According to the University's Semester Rules.

Sr. No.	Elements	Weightage	Details
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Textbook:

1. Data Mining: Concepts and Techniques, Jiawei Han and Micheline Kamber, Morgan Kaufmann Publishers, 2001.

Suggested Readings:

1. Data Mining: Introductory and Advanced Topics, M.H. Dunham, Pearson Education, 2003.
2. Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, I.H. Witten and E. Frank, Morgan Kaufmann, 2000.
3. Selected papers.

Course Title:	Biostatistical Models
Course Code:	STAT-418
Semester:	II
Credit Hours:	3
Pre-requisites:	N / A

Learning Outcomes

By the end of this course, students will be able to:

- learn to identify key statistical issues in observational studies and methods and study designs to address issues of confounding.
- become proficient with advanced statistical methods for observational studies: methods for missing data, matching based inference, sensitivity analysis, propensity score methods, instrumental variables.
- understand which methods are useful in different situations, and which conditions have to be checked for the method to be applicable.
- be able to perform detailed data analyses on a variety data using the statistical computation environment r. you should be able to implement all the methods presented in this course.

Course Outline

Unit 1

1.1

Simple randomized experiments (theory and practice) and the Rubin Causal Model, Randomized experiments (including Randomized Block and Matched Pairs Designs) and complications that make them look like observational studies, Observational Studies and simple ways of adjusting for covariates.

Unit 2

2.1

Propensity Score Approaches – Theory, Instrumental Variables Models – Introduction and Theory, Difference in Differences/ Fixed Effects models, Regression Discontinuity, Potential outcomes framework for causal inference. Causal inference in randomized experiments, Controlling for measured confounders in observational studies, Tests of Hidden Bias: Known Effects and Multiple Control Groups.

- **Teaching-learning Strategies:**
  Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

- **Assignments-Types and Number with calendar:**
  According to the choice of respective teacher.

- **Assessment and Examinations:**
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Textbooks

1. Gelman, Andrew and Hill, Jennifer (2006) *Data Analysis Using Regression and*
2. *Multilevel/Hierarchical Models,* Cambridge University Press
3. Holland, P. Statistics and causal inference (with discussion). *Journal of the American*
4. *Statistical Association* 1986; 81: 945-970.
5. Marubini, E., & Valsecchi, M. G. (2004). *Analysing survival data from clinical trials and observational studies* (Vol. 15). John Wiley & Sons.
6. Morgan, S. and Winship, C. (2007) *Counterfactuals and Causal Inference: Methods and Principlesfor Social Research,* Cambridge University Press
7. Rosenbaum, P. R. (2010). *Design of observational studies* (Vol. 10). New York: Springer.
8. Rubin, D. B. (2006). *Matched sampling for causal effects*. Cambridge University Press.