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 meetings dated 11-03-2022 and 21-03-2022 respectively regarding approval of the replacement of Fortran Language with R Language and C++ Computer Programming Language with Categorical Data Analysis of BS Statistics (04 year) Program for affiliated Colleges w.e.f. the Academic Session, 2021.

Sd/-
SHAHID JAVED
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.
No. D/ 482 /Acad. **Dated: 13 – 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. Principals of all the affiliated colleges.
4. Controller of Examinations
5. Director, IT for placement at website
5. 6dmin Officer (Statutes)
7. Secretary to the Vice-Chancellor.
8. PS to the Registrar.
9. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

UNIVERSITY OF THE PUNJAB

NOTIFICATION

The Syndicate at its meeting held on 15-11-2021 has approved the recommendations of the Academic Council made at its meeting dated 07-10-2021 regarding approval of the revised Courses outlines /Scheme of Studies for BS Statistics (4 years Degree Program) under Semester System w.e.f. the Academic Session, 2020 and onwards.

The revised Courses outlines /Scheme of Studies for BS Statistics (4 years Degree Program) is attached herewith as Annexure-A.

Sd/-

Dr. Muhammad Khalid Khan
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.
No. D/ 12388 **/Acad.**

Dated: 29-12-**/2021.**

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 & Actuarial Sciences.
3. Chairperson, DPCC.
4. Controller of Examinations
5. Director, Quality Enhancement Cell
6. Director, IT.
7. Admin. Officer (Statutes)
8. Secretary to the Vice-Chancellor.
9. Secretary to the Pro-Vice Chancellor
10. P.S. to the Registrar
11. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

Revised

Scheme of Studies

BS Statistics

28-4-2021

College of Statistical
and Actuarial Sciences

University of the Punjab

Lahore

Program Title: **BS Statistics**

Department: College of Statistical and Actuarial Sciences

Faculty: Faculty of Science

1. College Mission

We are committed to the advancement of statistical methods by applying new techniques and exploring their applications in society and industry. Our mission is to train our students with the modern statistical knowledge and to prepare them for the challenges of modern world.

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.

3. Program Introduction (BS Statistics)

The BS Statistics is four years degree program under semester system. This program provides essential knowledge in statistical methods, applications and theory. The courses of BS Statistics program aim to train students in the field of statistics and prepare them for the posts in education and industrial 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 them for the applications of statistics.

iii) To make them prepared for the job market by teaching them statistical packages and programming languages.

iv) To prepare them for the further higher education.

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. Institute of Public Health, Govt. of Punjab, Pakistan.
5. Khyber Medical University, Peshawar, Pakistan.
6. Kinnaird College for Women University, Lahore
7. Lahore College for Women University, Lahore
8. Quaid-e-Azam University, Islamabad
9. Rollins School of Public Health, USA.
10. Saint Louis University, United States.
11. Simmons University Boston, United Kingdom.
12. The Agha Khan University, Karachi, Pakistan.
13. University of Buffalo, New York, USA**.**
14. 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 (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

- Intermediate or Equivalent.
- The students from any discipline can apply for the admission in the program.
- The minimum marks required for admission in BS Statistics is 45%.

7. Duration of the Program

Years	Semesters	Course	Credit Hours
4	8	47	138

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	6	4	1	-	1	-	17
2	6	3	2	-	1	-	17
3	5	1	3	-	1	-	15
4	6	1	4	-	1	-	17
5	6	-	-	6	-	-	18
6	6	-	-	6	-	-	18
7	6	-	-	3	3	-	18
8	6	-	-	3	3	-	18
HEC Guidelines	40-44	9	9-10	15-17	7-8	-	124-136
Difference b/w HEC & PU	+4	0	0	+1	+2		+2

List of Core Courses

- Islamiat
- English-I
- Mathematics-I
- Computer-I
- Pakistan Studies
- English-II
- Mathematics-II
- English-III
- English-IV

List of Basic Courses

- Statistics-I
- Statistics-II
- Introduction to Finance
- Statistics-III
- Mathematics-III
- Statistical Computer Packages-I
- Statistics-IV
- Mathematics-IV
- Statistics-V
- Linear Programming

List of Major Elective Courses

- Regression Analysis
- Experimental Design-I
- Sampling Techniques-I
- Probability & Probability Distributions-I
- Total Quality Management
- Statistical Computer Packages – II
- Experimental Design-II
- Sampling Techniques-II
- Multivariate Techniques – I
- Probability & Probability Distributions-II
- Categorical Data Analysis
- Advanced Computer Languages
- Statistical Inference-I
- Time Series Analysis-I
- Research Methodology
- Statistical Inference-II
- Econometrics
- Stochastic Processes

9. Scheme of Studies: BS Statistics

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

Years	Semesters	Courses	Credit Hours
4	8	47	138

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

Combination: Mathematics and Computer Science / Economics

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
		SEMESTER-I			
1.	ISE-101	Islamiat / Ethics	Core	N / A	2
2.	ENG-101	English-I	Core	N / A	3
3.	STAT-101	Statistics-I	Basic	N / A	3
4.	MATH-101	Mathematics-I	Core	N / A	3
5.	ECON-101	Economics-I	Elective	N / A	3
6.	COMP-101	Computer-I	Core	N / A	3
		Semester's Total Credits			**17**
		SEMESTER-II			
1.	PST-101	Pakistan Studies	Core	N / A	2
2.	ENG-102	English-II	Core	English-I	3
3.	STAT-102	Statistics-II	Basic	Statistics-I	3
4.	MATH-102	Mathematics-II	Core	Mathematics-I	3
5.	ECON-102/ COMP-102	Economics-II/Computer-II	Elective	Economics-I / Computer-I	3
6.	ACTS-101	Introduction to Finance	Basic	N / A	3
		Semester's Total Credits			**17**
		SEMESTER-III			
1.	ENG-201	English-III	Core	English-II	3
2.	STAT-201	Statistics-III	Basic	Statistics-II	3
3.	MATH-201	Mathematics-III	Basic	Mathematics-II	3
4.	ECON-201/ COMP-201	Economics-III/Computer-III	Elective	Economics-II/Computer-II	3
5.	STAT-202	Statistical Computer Packages – I	Basic	N / A	3
		Semester's Total Credits			**15**

		SEMESTER-IV			
1.	ENG-202	English-IV	Core	English-III	3
2.	STAT-203	Statistics-IV	Basic	Statistics-III	3
3.	MATH-202	Mathematics-IV	Basic	Mathematics-III	3
4.	ECON-202/ COMP-202	Economics-IV/Computer-IV	Elective	Economics-III/Computer-III	3
5.	STAT-204	Statistics-V	Basic	Statistics-III	2
6.	STAT-205	Linear Programming	Basic	N / A	3
		Semester's Total Credits			**17**
		SEMESTER-V			
1.	STAT-301	Regression Analysis	Major Elective	N / A	3
2.	STAT-302	Experimental Design-I	Major Elective	N / A	3
3.	STAT-303	Sampling Techniques-I	Major Elective	N / A	3
4.	STAT-304	Probability & Probability Distributions-I	Major Elective	N / A	3
5.	STAT-305	Total Quality Management	Major Elective	N / A	3
6.	STAT-306	Statistical Computer Packages – II	Major Elective	Statistical Computer Packages – I	3
		Semester's Total Credits			**18**
		SEMESTER-VI			
1.	STAT-307	Experimental Design-II	Major Elective	Experimental Design-I	3
2.	STAT-308	Sampling Techniques-II	Major Elective	Sampling Techniques-I	3
3.	STAT-309	Multivariate Techniques – I	Major Elective	N / A	3
4.	STAT-310	Probability & Probability Distributions-II	Major Elective	Probability & Probability Distributions-I	3
5.	STAT-311	Categorical Data Analysis	Major Elective	N / A	3
6.	STAT-312	Advanced Computer Languages	Major Elective	N / A	3
		Semester's Total Credits			**18**
		SEMESTER-VII			
1.	STAT-401	Statistical Inference-I	Major Elective	N / A	3
2.	STAT-402	Time Series Analysis-I	Major Elective	N / A	3
3.	STAT-403	Research Methodology	Major Elective	N / A	3
4.		Elective-I	Minor Elective	N / A	3
5.		Elective-II	Minor Elective	N / A	3
6.		Elective-III	Minor Elective	N / A	3
		Semester's Total Credits			**18**

		SEMESTER-VIII			
1.	STAT-404	Statistical Inference-II	Major Elective	Statistical Inference-I	3
2.	STAT-405	Econometrics	Major Elective	N / A	3
3.	STAT-406	Stochastic Processes	Major Elective	N / A	3
4.		Elective-IV	Minor Elective	N / A	3
5.		Elective-V	Minor Elective	N / A	3
6.		Elective-VI	Minor Elective	N / A	3
		Semester's Total Credits			**18**

Electives (Group-I) Biostatistics

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
1.	STAT-407	Thesis (equivalent to two courses)	Minor Elective	N / A	6
2.	STAT-408	Internship	Minor Elective	N / A	3
3.	STAT-409	Multivariate Analysis-II	Minor Elective	Multivariate Analysis-I	3
4.	STAT-410	Time Series Analysis-II	Minor Elective	Time Series Analysis-I	3
5.	BIOS-401	Demography	Minor Elective	N / A	3
6.	BIOS-402	Analysis of Repeated Measurements	Minor Elective	N / A	3
7.	BIOS-403	Bio-informatics	Minor Elective	N / A	3
8.	BIOS-404	Hospital Management	Minor Elective	N / A	3
9.	BIOS-405	Design & Analysis of Medical Studies	Minor Elective	N / A	3
10.	BIOS-406	Epidemiology	Minor Elective	N / A	3
11.	BIOS-407	Clinical Trials	Minor Elective	N / A	3
12.	BIOS-408	Survival Analysis	Minor Elective	N / A	3

Electives (Group-II) Operations Research

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
1.	STAT-407	Thesis (equivalent to two courses)	Minor Elective	N / A	6
2.	STAT-408	Internship	Minor Elective	N / A	3
3.	STAT-409	Multivariate Analysis-II	Minor Elective	Multivariate Analysis-I	3
4.	STAT-410	Time Series Analysis-II	Minor Elective	Time Series Analysis-I	3
5.	COMP-401	Metaheuristic Algorithms	Minor Elective	N / A	3
6.	OPRS-401	Non-Linear and Dynamic Programming	Minor Elective	N / A	3
7.	OPRS-402	Sequential Optimization	Minor Elective	N / A	3
8.	OPRS-403	Inventory Systems & Modeling	Minor Elective	N / A	3
9.	OPRS-404	Queuing Theory	Minor Elective	N / A	3
10.	OPRS-405	Network Analysis	Minor Elective	N / A	3
11.	OPRS-406	Simulation and Modeling	Minor Elective	N / A	3
12.	OPRS-407	Game Theory	Minor Elective	N / A	3
13.	OPRS-408	Integer Programming	Minor Elective	N / A	3
14.	OPRS-409	Decision Analysis	Minor Elective	N / A	3

Electives (Group-III) Actuarial Science

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
1.	STAT-407	Thesis (equivalent to two courses)	Minor Elective	N / A	6
2.	STAT-408	Internship	Minor Elective	N / A	3
3.	STAT-409	Multivariate Analysis-II	Minor Elective	Multivariate Analysis-I	3
4.	STAT-410	Time Series Analysis-II	Minor Elective	Time Series Analysis-I	3
5.	ACTS-401	Financial Mathematics	Minor Elective	N / A	3
6.	ACTS-402	Advanced Financial Mathematics	Minor Elective	N / A	3
7.	ACTS-403	Life Contingencies & Life Tables	Minor Elective	N / A	3
8.	ACTS-404	Mortality Data Analysis	Minor Elective	N / A	3

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
9.	ACTS-405	Employee Benefit Management	Minor Elective	N / A	3
10.	ACTS-406	Life and Health Insurance	Minor Elective	N / A	3
11.	ACTS-407	Investment & Portfolio Management	Minor Elective	N / A	3
12.	ACTS-408	Pension Models	Minor Elective	N / A	3
13.	ACTS-409	General Insurance	Minor Elective	N / A	3
14.	ACTS-410	Takaful & Insurance Practices	Minor Elective	N / A	3
15.	ACTS-411	Islamic Mode of Finance	Minor Elective	N / A	3
16.	ACTS-412	Financial Risk Management	Minor Elective	N / A	3
17.	ACTS-413	Trade Finance	Minor Elective	N / A	3
18.	ACTS-414	Advanced Risk Management	Minor Elective	N / A	3

Electives (Group-IV) Data Science

#	Code	Course Title	Course Type	Prerequisite	Credit Hours
1.	STAT-407	Thesis (equivalent to two courses)	Minor Elective	N / A	6
2.	STAT-408	Internship	Minor Elective	N / A	3
3.	STAT-409	Multivariate Analysis-II	Minor Elective	Multivariate Analysis-I	3
4.	STAT-410	Time Series Analysis-II	Minor Elective	Time Series Analysis-I	3
5.	COMP-401	Metaheuristic Algorithms	Minor Elective	N / A	3
6.	DTSC-401	Data Mining	Minor Elective	N / A	3
7.	DTSC-402	Big Data	Minor Elective	N / A	3
8.	DTSC-403	Machine Learning	Minor Elective	N / A	3
9.	DTSC-404	Neural Network	Minor Elective	N / A	3
10.	DTSC-405	Cloud Computing	Minor Elective	N / A	3
11.	DTSC-406	Bayesian Machine Learning	Minor Elective	N / A	3
12.	DTSC-407	Natural Language Processing	Minor Elective	N / A	3
13.	DTSC-408	Computer Vision	Minor Elective	N / A	3
14.	DTSC-409	Artificial Intelligence	Minor 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 3.5 – 4 years Bachelors Degree

i. A candidate must have qualified in accordance with the existing Rules and Regulations in each one of the semesters from I to VIII separately, i.e. by securing at least a 'D' 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 3.5 – 4 years Bachelors degree i.e. 130 -136 credits.

iii. He / She must have obtained 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	7. Prof. Dr. Sohail Chand (Statistical Modeling) 8. Dr. Rehan Ahmad (Applied Statistics) 9. Dr. Maryam Ilyas (Statistical Modeling) 10. Dr. Sana Saeed (Data Science) 11. Dr. Nadia Saeed (Applied Statistics) 12. Dr. Samar Abbas (Computer Science and Data Science)	(06)
M.Phil.	10. Mr. Munawar Iqbal (Mathematical Statistics) 11. Ms. Irum Sajjad Dar (Applied Statistics) 12. Ms. Aasma Riaz (Applied Statistics) 13. Ms. Shumaila Abbas (Applied Statistics) 14. Mr. Ghulam Nabi (Finance) 15. Ms. Huma Shakeel (Applied Statistics) 16. Ms. Wajiha Batool (Applied Statistics) 17. Ms. Maham Faheem (Applied Statistics) 18. 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 undergraduate scheme

COURSE OUTLINES
FOR
SEMESTER – I

Course Title:	Statistics-I
Course Code:	STAT-101
Semester:	I
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the key concepts of Statistics.
2. Compute various summary statistics and make use of the graphical techniques to represent data.
3. Know the practical application of Index Numbers along with their computations.
4. Have the basic knowledge of Time Series, its components and the methods to analyze them.

Course Outline

Unit 1

1.1 Introduction

Meaning of Descriptive and Inferential statistics. Population and Sample. Types of variables, Measurement Scales. Sources of Statistical data in Pakistan.

1.2 Tables and Graphs

Description of data by frequency tables and graphs. Stem and Leaf plots and Box plots.

1.3 Measures of Central Tendency

A.M. H.M. G.M., Mode, Median, Quantiles. Properties of Mean with proofs. Weighted Arithmetic Mean. Empirical Relation between Mean. Median and Mode. Relative Merits and Demerits of various averages.

Unit 2

2.1 Measures of Dispersion

Absolute and Relative Measures, Range. Semi-Inter Quartile Range, Mean Deviation, Variance, Standard Deviation. Coefficient of Variation, Coefficient of Mean Deviation, Coefficient of Quartile Deviations, Properties of Variance and Standard Deviation with proofs. Standardized variables, Moments, Moment Ratios, Sheppards Correction, Kurtosis and Skewness.

Unit 3

3.1 Index Numbers

Construction and application of wholesale price Index Numbers. Fixed and chain base methods. Weighted Index Numbers (Laspeyre's, Paasche's Fisher's Ideal and Marshall-Edgeworth Indices). Tests for the consistency of Index Numbers Construction of Consumer price Index Numbers. Sensitive price Indicator.

3.2 Basics of Time series

Components of a time series. Analysis of time series. Measurement of secular trend and seasonal variations by various methods. Deseasonalization of data.

- **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.

Text Books

1. Bluman (2011). *Elementary Statistics* (8th ed.). McGraw Hill, New York.
2. Chaudhry, S.M. & Kamal, S. (2010). *Introduction to Statistical Theory Part I*. Ilmi Kitab Khana,Urdu Bazar, Lahore.

Suggested Readings

1. Beg, M.A., & Mirza, M.D. (2006). *Statistics, Theory and Methods,* Volume I, Carvan Book House, Kutechery Road, Lahore.
2. Clarke G., & Cooke D. (2011). *A basic Course in Statistics* (5th ed.). Arnold Publisher, London.
3. Crawshaw, J., & Chambers, J. (2014). *A concise course in advanced level Statistics with worked examples*, Nelson Thornes, Revised Edition.
4. Johnson, R.A., & Wichern, D.W. (2003). *Business Statistics: Decision making with data,* John Wiley & Sons Inc.
5. Levin, J., & Fox, J.A. (2013). *Elementary Statistics in Social Research* (12th ed.). Pearson Education.
6. Levine, D.M., Kschbiel, T.C., & Berenson, M.L. (2009). *Business Statistics: A first course* (5th ed.). Pearson Education.
7. Macfie, B.P., & Nufrio, P.M. (2006). *Applied Statistics for public policy*, Prentice Hall of India.

COURSE OUTLINES
FOR
SEMESTER – II

Course Title:	Statistics-II
Course Code:	STAT-102
Semester:	II
Credit Hours:	3 Credit Hours
Pre-requisites:	Statistics – I

Learning Outcomes

By the end of this course, students will have:

1. The understanding of basic probability and its laws.
2. The idea of discrete and continuous random variables and their probabilistic models.
3. The knowledge of discrete and continuous probability distributions along with their practical applications.

Course Outline

Unit 1

1.1 Preliminaries

Random experiments, sample space and events. Counting techniques. Definitions and axioms of probability. Basic laws of probability. Independence of events. Bayes Theorem and its application. Random variable, distribution function,

Unit 2

2.1 Discrete random variable

Probability distribution of a discrete random variable. Joint distribution of two discrete random variables, marginal and conditional distributions, mathematical expectation and its properties, mean, variance and moments. Concept of m.g.f. and its properties. Bernoulli trail and applications of Binomial distribution with examples.

2.2 Continuous random variable

Probability distribution of a single continuous random variable, probability density function and distribution function. Mean, variance and moments of continuous random variables. Mean, variance, shape and properties of Normal distribution. Fitting of Normal distribution by area method.

- **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.

Text Books

1. Bluman. (2011). *Elementary Statistics* (8th ed.). McGraw Hill, New York.
2. Chaudhry, S.M., & Kamal, S. (2010). *Introduction to Statistical Theory Part I*, Ilmi Kitab Khana, Urdu Bazar, Lahore.

Suggested Readings

1. Beg, M.A., & Mirza, M.D. (2006). *Statistics, Theory and Methods*, Volume I, Carvan Book House, Kutechery Road, Lahore
2. Crawshaw, J., & Chambers, J. (2014). *A concise course in advanced level Statistics with worked examples*. Nelson Thornes, Revised Edition.
3. Johnson, R.A., & Wichern, D.W. (2003). *Business Statistics: Decision making with data.* John Wiley & Sons Inc.
4. Macfie, B.P., & Nufrio, P.M. (2006). *Applied Statistics for public policy*. Prentice Hall of India.
5. Medhi, J. (2006). *Statistical Methods: An Introductory text*, New Age International Publishers.
6. Levine, D.M., Kschbiel, T.C. & Berenson, M.L. (2009). *Business Statistics: A first course* (5th ed.). Pearson Education.
7. Levin, J. & Fox, J.A. (2013). *Elementary Statistics in Social Research* (12th ed.). Pearson Education.

Course Title:	Introduction to Finance
Course Code:	ACTS-101
Semester:	II
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the key principles of finance and taxation along with their various dimensions.
2. Get hold of financial instruments with particular reference to real world examples.
3. Understand the financial derivatives, quotations, and capital and dividend policies.

Course Outline

Unit 1

1.1The key principles of Finance

Finance and real resources, objective of an organization. Stakeholders, effects of capital market, agency theory, maximization of shareholders wealth, Characteristics of sole traders, partnerships and limited companies and their advantages and disadvantages, private and public companies, medium and short term company finance: hire purchase, credit sale, leasing, bank loans, bank overdrafts, trade credit, factoring and bill of exchange.

1.2 Taxation

Principles of personal and corporate taxation, capital gain tax, company tax, taxes on shareholders, double taxation relief, Financial Instruments: Methods of financing, Loans and share capitals, characteristics of financial instruments, debenture stocks, unsecured loan stocks, Eurobonds, preference shares, ordinary shares, convertible unsecured loan stock and preference shares, warrants, floating rate notes, subordinate debt, options issued by companies.

Unit 2

2.1 Derivatives

Financial futures, options, interest rates and currency swaps, Issue of shares: Quotation on stock exchange, quotation for securities: offer for sale, off for sale by tenders, offer for subscription, placing, introduction, scrip issue, right issue.

2.2 Capital structure and dividend policies

Market valuation of the company, principal factors for setting dividend policies, market valuation of the company by dividend policies.

2.3 Weight average cost of capital

Bond valuation. Stock valuation, capital structure, WACC, Marginal cost of capital.

2.4 Capital project appraisal

Methods of project evaluation, evaluate risky investments with probability trees, simulation and certainty equivalents, assessment of capital investment projects, variability of a capital project, required rate of return, assumption and limitation for weighted average cost of capital, allowance for leverage, allowance for risk.

- **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.

Text Book

1. Brealey, R. A., Myers, S. C. (2003). *Principles of corporate finance* (7th ed.). McGraw-Hill.

Suggested Readings

1. Brealey, R. A., Myers, S. C. (2003). *Principles of corporate finance* (7th ed.). McGraw-Hill.
2. Brigham, E. F., Houston, J. F. (2000). *Fundamentals of financial management* (9th ed.). Harcourt Brace.
3. Holmes, G., Sugden, A., Gee, P. (2002). *Interpreting company reports and accounts* (8th ed.). Pearson Education.
4. Samuels, J.M., Brayshaw, R. E., & Craner, J. M. (1995). *Financial statement analysis in Europe*. Chapman & Hall.

COURSE OUTLINES
FOR
SEMESTER – III

Course Title:	Statistics-III
Course Code:	STAT-201
Semester:	III
Credit Hours:	3 Credit Hours
Pre-requisites:	Statistics – II

Learning Outcomes:

By the end of this course, students will get to:

1. Learn the several types of sampling designs and their applications.
2. Know that how to construct the sampling distributions of various statistics.
3. Understand the concepts and applications of statistical methods employed to draw inferences about the population.
4. Have the basic ideas about rates and ratios.

Course Outline

Unit 1

1.1 Concept of sampling and sampling designs

Sampling designs of Simple random, Stratified, Systematic and Cluster sampling, Judgment and Quota Sampling. Random Numbers and their uses in sampling. Advantages of sampling. Probability and non-probability sampling, sampling and non-sampling error.

1.2 Estimation based on Sampling

Calculation of sample mean, proportion and variance of simple random samples and stratified random samples. Sampling distribution of a statistic and its standard error. Distribution of sample mean, sample proportion, difference between two proportions and means. Central limit theorem with illustration (Proof not required).

Unit 2

2.1 Basics of statistical Inference

Nature of statistical inference, point estimation of parameter, properties of point estimator and its interpretation. Null and alternative hypothesis, simple and composite hypothesis. Type I and Type II errors. Level of significance. P-value and power of test (only concept and definition), Acceptance and rejection regions, one sided and two sided tests, test procedure. Inference about single mean and difference between means for paired and un-paired observations for small and large sample sizes. Inference about proportion and difference between two proportions. Determination of sample size. (Application of Normal distribution and t-distribution)

- **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.

Text Books

1. Beg, M.A., & Mirza, M.D. (2006). *Statistics, Theory and Methods*, Volume II, Carven Book House, Kutechery Road, Lahore.
2. Chaudhry, S.M., & Kamal, S. (2010). *Introduction to Statistical Theory Part II*, Ilmi Kitab Khana, Urdu Bazar, Lahore.

Suggested Readings

1. Blumen. (2011). *Elementary Statistics* (8th ed.). McGraw Hill, New York.
2. Crawshaw, J., & Chambers, J. (2014). *A concise course in advanced level Statistics with worked examples*. Nelson Thornes, Revised Edition.
3. Johnson, R.A., & Wichern, D.W. (2003). *Business Statistics: Decision making with data*. John Wiley & Sons Inc.
4. Levin, J., & Fox, J.A. (2013). *Elementary Statistics in Social Research* (12th ed.). Pearson Education.
5. Levine, D.M., Kschbiel, T.C., & Berenson, M.L. (2009). *Business Statistics: A first course (*5th ed.). Pearson Education.
6. Macfie, B.P., & Nufrio, P.M. (2006). *Applied Statistics for public policy*. Prentice Hall of India.

Course Title:	Statistical Computer Packages- I
Course Code:	STAT-202
Semester:	III
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

This course aims to provide students with:

1. The background knowledge of data analysis including issues related to data entry, editing and manipulating data files.
2. The knowledge of different ways in which data can be explored (descriptive statistics, cross-tabulations, bar/pie charts, plots etc.)
3. The hands-on experience of how to apply the tools of inferential statistics including Regression, Correlation, Parametric and Non-Parametric Tests.

Course Outline

Unit 1

1.1 Introduction to Computer and Windows and SPSS

Starting SPSS, How to exit from SPSS, Different windows in SPSS, Data Entry in SPSS: Defining a variable, Entering data, Saving data file, Defining Value Labels, Computing frequencies, Computing the new variables, Selection of cases, Defining Date Variable, Defining weights variable, Recoding and categorizing the existing variables, Categorizing the variables, Ranking the cases, Defining the missing values, Replacing the missing values, Creating a time series, Exploring the variable.

Unit 2

2.1 Graphs and tables

Finding descriptive statistics, Editing Output., Cross tabulation and measures of association, Entering a Cross-tabulated data, Graphs for variables and cross-tabulated variables, Merging and Splitting files, Bar Chart, Pie Chart, Histogram, and Historigram, Box plot, P-P plot, Q-Q plot.

2.2 Parametric Test

One sample t-test, Independent Samples t-test, Paired samples t-test, Parametric statistical inference (one sample, Two sample, More than two sample).

2.3 Regression Analysis

Scatter Diagram, Correlation, Partial Correlation, Simple and Multiple regressions,

Non-Parametric Tests, Test of inference about proportions (one & several), Computing probability distribution and distribution functions.

- **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.

Text Book

1. Brace, N., Kemp, R., & Snelgar, R. (2012). *SPSS for Psychologists* (5th ed.). Palgrave and Macmillan.

Suggested Readings

2. Ho, R. (2013). *Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS* (2nd ed.). Chapman and Hall/CRC.
3. Kirkpatrick, L.A., & Feeney, B.C. (2014). *A Simple Guide to SPSS for Windows* (14th ed.). Wadsworth: Thompson Learning.

COURSE OUTLINES
FOR
SEMESTER – IV

Course Title:	Statistics-IV
Course Code:	STAT-203
Semester:	IV
Credit Hours:	3 Credit Hours
Pre-requisites:	Statistics - III

Learning Outcomes

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

1. Differentiate between parametric and non-parametric tests based on their assumptions.
2. Learn the practical implementation of Z-test and t-test (And their non-parametric alternatives).
3. Estimate simple and multiple regression models, and learn the concept of correlation.

Course Outline

Unit 1

1.1 Tests of hypothesis

Z-test, t-test and their non-parametric alternatives.

1.1 Logic of regression and correlation

Scatter diagram, simple linear regression model, least square estimators and their properties, standard error of estimate. Meaning and application of linear correlation coefficient. Properties of correlation co-efficient. Correlation coefficient for bi-varlate frequency distribution. Mean derivation and application of Rank correlation, tied ranks.

Unit 2

2.1 Multiple linear regression

Multiple linear regression with two regressors, coefficient of multiple determination, Partial and multiple correlation up to three variables.

- **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.

Text Books

1. Blumen. (2011). *Elementary Statistics* (8th ed.). McGraw Hill, New York.
2. Chaudhry, S.M., & Kamal, S. (2010). *Introduction to Statistical Theory Part II*, Ilmi Kitab Khana, Urdu Bazar, Lahore.

Suggested Readings

1. Beg, M.A., & Mirza, M.D. (2006). *Statistics, Theory and Methods*, Volume II, Carvan Book House, Kutechery Road, Lahore.
2. Crawshaw, J., & Chambers, J. (2014). *A concise course in advanced level Statistics with worked examples*, Nelson Thornes, Revised Edition.
3. Johnson, R.A., & Wichern, D.W. (2003). *Business Statistics: Decision making with data*, John Wiley & Sons Inc.
4. Levin, J., & Fox, J.A. (2013). *Elementary Statistics in Social Research* (12th ed.). Pearson Education.
5. Levine, D.M., Kschbiel, T.C., & Berenson, M.L. (2009). *Business Statistics: A first course* (5th ed.). Pearson Education.
3. Macfie, B.P., & Nufrio, P.M. (2006). *Applied Statistics for public policy*, Prentice Hall of India.

Course Title:	Statistics-V
Course Code:	STAT-204
Semester:	2 Credit Hours
Credit Hours:	IV
Pre-requisites:	Statistics – III

Learning Outcomes

By the end of this course, students will:

1. Have sound knowledge of chi-square distribution, its related concepts and applications.
2. Get familiar with F-distribution and its applications.
3. Be able to learn one-way and two-way analysis of variance along with multiple comparison tests.

Course Outline

Unit 1

1.1 Chi-square distribution

Introduction and application of Chi-square distribution**,** Interval estimation and test of hypothesis about population variance (Interval estimation for variance – single sample). Test of Independence, test of goodness of fit and test of homogeneity.

1.2 F-distribution

Introduction and application of F-distribution. Test of hypothesis for equality of two variances.

1.3 Analysis of variance

One-way classification and two-way classification. Multiple comparison tests; least significant difference and Duncans multiple range 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.

Text Books

1. Beg, M.A., & Mirza, M.D. (2006). *Statistics, Theory and Methods*, Volume II, Carvan Book House, Kutechery Road, Lahore.
2. Chaudhry, S.M., & Kamal, S. (2010). *Introduction to Statistical Theory Part II*, Ilmi Kitab Khana, Urdu Bazar, Lahore.

Suggested Readings

1. Blumen. (2011). *Elementary Statistics* (8th ed.). McGraw Hill, New York.
2. Crawshaw, J., & Chambers, J. (2014). *A concise course in advanced level Statistics with worked examples*, Nelson Thornes, Revised Edition.
3. Graybill, Iyer & Burdick (1998). *Applied Statistics, A first course in inference*. Prentice Hall, New
4. Johnson, R.A., & Wichern, D.W. (2003*). Business Statistics: Decision making with data,* John Wiley & Sons Inc.
5. Levin, J., & Fox, J.A. (2006). *Elementary Statistics in Social Research* (10th ed.). Pearson Education.
6. Levine, D.M., Kschbiel, T.C., & Berenson, M.L. (2009). *Business Statistics: A first course* (5th ed.). Pearson Education.
7. Macfie, B.P., & Nufrio, P.M. (2006). *Applied Statistics for public policy*, Prentice Hall of India.

Course Title:	Linear Programming
Course Code:	STAT-205
Semester:	IV
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Get familiar with the Simplex method and its application on various problems.
2. Understand Sensitivity and Post-Optimal analysis along with practical examples.
3. Learn the Transportation technique and the Transshipment model.

Course Outline

Unit 1

1.1 The Dual LP problem

Theory of Simplex method. Economic Interpretation of the Dual LP problem. Duality theorem. Dual Simplex method and its application on various problems.

Unit 2

2.1 Sensitivity Analysis

Sensitivity Analysis after adding a new variable and a new constraint. Apply sensitivity analysis to various problems. Sensitivity and Post-optimal Analysis. Linear systems solvability theory and linear systems duality theory.

2.2 Transportation Technique

North-West Corner. Least Cost and Vogel's Approximation Methods. Finding optimal using MODI method. The Method of Multipliers. The Assignment Model using Hungrian Method. The Transshipment Model. Integer and mixed LP problems. Solving assignment and transportation method using integer and mixed LP method.

- **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.

Text Books

1. Gillet, B. E. (2001). *Introduction to Operation Research*. Tata McGraw Hill Publishing Company, Ltd., New Delhi.
2. Vanderbi, R.J. (2001). *Linear Programming Foundations and Extensions* (2nd ed.). Kluwer's International Services, London.

Suggested Readings

1. Hamdy, A. T. (2017). *Operations Research-An Introduction*. Prentice Hall, India.
2. Harvey, C. M. (1999).*Operations Research*. North Holland, New Delhi.
3. Hillier, F. A., & Lieberman, G. J. (2001). *Introduction to Operations Research* (7th ed.) McGraw Hill, New York.

COURSE OUTLINES
FOR
SEMESTER – V

Course Title:	Regression Analysis
Course Code:	STAT-301
Semester:	3 Credit Hours
Credit Hours:	V
Pre-requisites:	N / A

Learning Outcomes

By the end of this course, you should be able to:

1. Select, implement and interpret appropriate regression models to explain real-world phenomena.
2. Demonstrate an understanding of the limitations and uncertainties associated with regression models.
3. State the assumptions of regression models, and investigate these assumptions using appropriate plots and statistics.
4. Demonstrate a command of the mathematical foundations of regression models.
5. Demonstrate competence in using statistical software to implement regression procedures.

Course Contents

Unit 1

1.1 Simple Linear Regression

The simple linear regression model, least squares, properties of the least squares estimators, model assumptions, interpretation of model parameters, inference on the slope and intercept, prediction, maximum likelihood estimation, the coefficient of determination, ANOVA for regression.

1.2 Introduction to Multiple Linear Regression

The multiple linear regression model, matrix notation, properties of the least squares estimators, inference on model parameters, estimation and prediction, interpretation of output, standardized regression coefficients, multicollinearity.

1.3 Model Assumptions and Checking Model Adequacy

Residual analysis, standardized and studentized residuals, residual plots, partial regression and partial residual plots, outliers, lack of fit tests.

Unit 2

2.1 Polynomial Regression Models, Indicator Variables

Including higher order terms in the linear regression model, the use of indicator variables to representcategorical explanatory variables, one-way ANOVA as a regression.

2.2 Transformations and Weighting

Variance stabilizing transformations, intrinsically linear models, the Box-Cox transformation, weighted leastsquares.

2.3 Leverage and Influence

Leverage, influence, measures of leverage and influence, treatment of influential observations.

2.4 Model Building

Model building techniques, forward selection, backward selection, stepwise selection, Mallow's Cp.

2.5 Nonlinear Regression and Generalized Linear Models

A brief introduction to nonlinear and generalized linear models, logistic regression, interpretation of parameters and Poisson regression.

- **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.

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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.

Text Book

1. Peck, E. A., Vining, G., & Montgomery, D. C. (2012). *Introduction to Linear Regression Analysis* (5th Edition). Wiley.

Suggested Readings

1. Gunst, R. F. (2018). *Regression analysis and its application: a data-oriented approach. New York*. Routledge
2. Fox, J. (2015). *Applied Regression Analysis and Generalized Linear Models* (3rd ed.). SAGE Publications.

Course Title:	Experimental Design-I
Course Code:	STAT-302
Semester:	V
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. To have sound understanding of basic principles of experimental design.
2. To apply ANOVA and various multiple comparison tests.
3. To learn the layout and covariance analysis of different experimental designs.
4. To estimate the missing observations.

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.

Text Books

1. Cochran, W.C., & Cox, G.M. (1992). *Experimental Design* (2nd ed.). John Wiley and Sons, New York.
2. Montgomery, D.C. (2012). *Design and Analysis of Experiments*, John Wiley & Sons, New York.

Suggested Readings

7

1. Clewer, A. G. (2001). *Practical Statistics and Experimental Design for Plant and Crop Science*. John Wiley and Sons, New York.
2. JeffWu, C.F. (2002). *Experimental: Planning Analysis.* John Wiley and Sons, New York.
3. Kuehl, R.O. (2000). *Design of Experiments: Statistical principles of research design and analysis*. Duxbury, Boston.
4. Quinn Gerry, P. (2002). *Exp. Design and Data Analysis for Biologists*. Cambridge Press, Cambridge.
5. Steel, R.G.D., Torrie, J.H., & Dickey, D.A. (2008). *Principles and Procedures of Statistics: A Biometrical Approach*. McGraw-Hill, Michigan, USA.

Course Title:	Sampling Techniques I
Course Code:	STAT-303
Semester:	V
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Differentiate between Probability and Non-probability samples, and sampling and non-sampling errors.
2. Estimate mean, proportion and variance under Simple, Stratified and Systematic Random Sampling.
3. Compare systematic, stratified and random sampling for populations with linear trend.

Course Contents

Unit 1

1.1 Errors in Survey Sampling

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

1.2 Simple random sampling

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

1.3 Stratified random sampling

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.

1.4 Systematic sampling

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
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Text Books

1. Cochran, W.G. (1977). *Sampling Techniques* (3rd ed.). John Wiley and Sons, New York.
2. Fuller, Wayne A. (2009). *Sampling Statistics*. John Wiley and Sons, New Jersey.

Suggested Readings

1. Bethelem, J. (2009). *Applied Survey Methods: A Statistical Perspective*. Wiley
2. Brewer, K. (2002). *Combined Survey Sampling Inference*. Oxford University Press, New York.
3. Kish, L. (1992). *Survey Sampling*. John Wiley, New York.
4. Raj, D., & Chandhok P. (1998). *Sample Survey Theory*. Narosa Publishing House, New Delhi.
5. Raj. D. (1971). *Sampling Theory*. Mc-Graw-Hill Book Company, New York.
6. Singh, R., & Singh, N. (1996). *Elements of Survey Sampling*. Kulwar, Dodrecht.

Course Title:	Probability & Probability Distributions-I
Course Code:	STAT-304
Semester:	V
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Derive the probability function and properties of various discrete and continuous distributions.
2. Grasp the knowledge of the practical applications of these distributions.
3. Learn the relationship between different distributions.

Course Outline

Unit 1

1.1 Random Variables

Distribution function, probability function and probability density function, mean, variance and shape. Moments, factorial moments and cumulants. Probability generating function. Moments generating function. Cumulant generating function. Chebyshev inequality.

Unit 2

2.1 Discrete Univariate Distributions

Uniform, binomial, hyper-geometric, multinomial, Poisson, geometric and negative binomial distributions with their applications. Normal approximation to the Binomial and Poisson distribution (just application).

2.2 Continuous Distributions

Continuous uniform, exponential, gamma, Beta, lognormal, Pareto, Cauchy and Weibull distributions along with their properties.

- **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.

Text Books

1. Hogg, R.M., McKean, J., & Craig, A.T. (2013). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey, USA.
2. Milton, J.S., & Arnold, J.C. (2003). *Introduction to probability and statistics*. McGraw Hill.

Suggested Readings

1. Hirai, A.S. (2002). *A Course in Mathematical Statistics.* Ilmi Katab Khana, Lahore.
2. Mood, A.M., Graybill, F.A., & Boes, D.C. (2007). *Introduction to the Theory of Statistic*. McGraw Hill, New York, USA
3. Ross, S.M. (2003). *Introduction to probability modes*. Academic press.

Course Title:	Total Quality Management (TQM)
Course Code:	STAT-305
Semester:	V
Credit Hours:	3 Credit Hours
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 Contents

Unit 1

1.1 The Basics of quality Management

Defining Quality. Different views of Quality. Dimensions of Quality. Quality Management. Principles of Quality Management. Eras of Quality Management, their foci and major developments

1.2 Basics of TQM

Introduction Basic concepts, Purpose, benefits and framework of TQM. Implementation of TQM. Barriers to TQM implementation. Guru's of TQM, their Philosophies and Pioneering Works. Customer satisfaction. Internal and External Customer, Customer perception of quality Employee involvement, Quality Control Circles & Teams

Unit 2

2.1 Continuous Process Improvement

The PDSA Cycle, Kaizen, Six Sigma, Japanese 5-S practice, SWOT Analysis, Costs of Quality and Quality Function Deployment

2.2 Benchmarking

Reasons to Benchmark, Types and benefits of Benchmarking, Benchmarking process, Obstacles to successful Benchmarking. New and old tools of Quality Management

2.3 Statistical Process Control

Statistical basis of the Control Chart, Steps in the development of control charts, Types of control charts and Process Capability

Unit 3

3.1 Acceptance Sampling

Lot by lot Acceptance Sampling for attributes. Types of Sampling Plans: Single Sampling Plans, Double and Multiple Sampling Plans. Construction of OC-curve, Rectifying Inspection.

3.2 Quality Management Systems

ISO 9000 Series of Standards: Requirements, Implementation & Benefits. Environmental Management System: ISO 14000 series of Standards and 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.

Text Books

1. Besterfield, D.H., Michna, C.B., Besterfield, G.H. & Sacre, M.B. (2003). *Total Quality Management* (3rd ed.). Pearson Education.
2. Montgomery, D.C. (2009). *Statistical Quality Control* (6th ed.). John Wiley & Sons, New York.

Suggested Readings

1. Evans, J.R., & Lindsay, W.M. (2005). *The Management and Control of Quality* (6th ed.). Thomson South-Western.
2. Grant, E.L., & Leaven-worth, R.S. (1996). *Statistical Quality Control Handbook* (7th ed.). McGraw-Hill Book Company, New York.
3. James, P. (1996). *Total quality management*. Prentice Hall.
4. Oakland, J.S. (2003). *Total Quality Management* (3rd ed.). Butterworth-Heinemann.

Course Title:	Statistical Computer Packages- II
Course Code:	STAT-306
Semester:	V
Credit Hours:	3 Credit Hours
Pre-requisites:	Statistical Computer Packages- I

Learning Outcomes

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

1. Understand the different data types and data structures
2. Use the package for mathematical operations and reshape data to support different analyses.
3. Understand basic regular expressions and graphics.
4. Use the package for descriptive statistic and inferential statistics
5. Understand how to link data and statistical methods.

Course Outline

Unit 1

1.1 Preliminaries

Downloading, Installing and Starting the package and associate libraries. Calculating environment of the statistical package, Writing Scripts.

1.2 Basic programming skills

Logical statements, Looping, Programming flow and basic debugging, Using built-in functions, Input and Output files, Programming with functions, Graphics.

Unit 2

2.1 Numerical Techniques

Finding roots, Numerical integration and optimization.
Probability and probability distributions, Generating random numbers, Selecting random samples, Empirical study of the sampling distribution of estimators.

2.2 Simulation of data

Simulation of data from a probability distribution, Simulation of data for a regression model, Simulation of data for time series model, Monte Carlo simulation, Bootstrapping.

- **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.

Suggested Readings

1. Acock, A. C. (2018). *A Gentle Introduction to Stata* (6th Edition). A Stata Press Publication,Texas.
2. Agung, I.G.N. (2011). *Time Series Data Analysis Using EViews*. Wiley and Sons, New York.
3. Wellin, P.(2016). *Essentials of Programming in Mathematica*. Cambridge university Press,UK.

COURSE OUTLINES
FOR
SEMESTER – VI

Course Title:	Experimental Design-II
Course Code:	STAT-307
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	Experimental Design-I

Learning Outcomes

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

1. Learn the concept of Factorial experiments and its various dimensions.
2. Ascertain the knowledge of confounding, split-plot designs and split-split plot designs.
3. Identify the different types of Incomplete Block designs.

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.

Text Books

1. Cochran, W.C., & Cox, G.M. (1992). *Experimental Design* (2nd ed.). John Wiley and Sons, New York.
2. Montgomery, D.C. (2012). *Design and Analysis of Experiments*. John Wiley & Sons, New York, USA.

Suggested Readings

1. Clewer, Alan, G. (2001). *Practical Statistics and Experimental Design for Plant and Crop Science*. Wiley, N.Y.
2. JeffWu, C.F. (2002). *Experimental: Planning Analysis*. Wiley N.Y.
3. Kuehl, R.O. (2000). *Design of Experiments: Statistical principles of research design and analysis*. Duxbury, Boston.
4. Quinn, P.G. (2002). *Experimental Design and Data Analysis for Biologists*. Cambridge Press, Cambridge.
5. Steel, R.G.D., Torrie, J.H., & Dickey, D.A. (2008). *Principles and Procedures of Statistics: A Biometrical Approach*. McGraw-Hill, Michigan, USA.

Course Title:	Sampling Techniques - II
Course Code:	STAT-308
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	Sampling Techniques - I

Learning Outcomes

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

1. Obtain Ratio and Regression estimates under various sampling designs.
2. Learn the estimation under Cluster sampling along with Cost and Variance Function.
3. Know the dimensions of Two-stage sampling and its applications in the real world.

Course Contents

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.

Text Books

1. Cochran, W.G. (1977). *Sampling Techniques* (3rd ed.). John Wiley and Sons, New York.
2. Fuller, W.A. (2009). *Sampling Statistics*. John Wiley and Sons, New Jersey.

Suggested Readings

1. Bethelem, J. (2009). *Applied Survey Methods: A Statistical Perspective*. Wiley.
2. Brewer, K. (2002). *Combined Survey Sampling Inference*. Oxford University Press, New York.
3. Kish, L. (1992). *Survey Sampling*. John Wiley, New York.
4. Raj, D. (1971). *Sampling Theory*. Mc-Graw-Hill Book Company, New York.
5. Raj, D., & Chandhok, P. (1998). *Sample Survey Theory*. Narosa Publishing House, New Delhi.
6. Singh, R., & Singh, N. (1996). *Elements of Survey Sampling*. Kulwar, Dodrecht

Course Title:	Multivariate Techniques- I
Course Code:	STAT-309
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the objectives and applications of Multivariate techniques.
2. Know the underlying theoretical framework of Multivariate techniques (multivariate normal distribution).
3. Acquire the knowledge of Wishart distribution.

Course Outline

Unit 1

1.1 Review of matrix algebra

1.2 Multivariate Distributions

Notions of multivariate distributions. The multivariate normal distribution and its properties. Linear compound and linear combinations. Estimation of the mean vector and the covariance matrix.

1.3 Wishart Distribution

Wishart distribution and its properties. The joint distribution of the sample mean vector and the sample covariance matrix.

- **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.

Text Book

1. Johnson, R.A., & Wichern, D.W. (2008). *Applied multivariate statistical analysis*. Pearson Education: Singapore.

Suggested Readings

1. Anderson, T.W. (2003). *An introduction to multivariate statistical analysis* (3rd ed.). John Wiley & Sons: New York.
2. Chatfield, C., & Collins, A.J. (1981). *Introduction to multivariate analysis*. Chapman and Hall: London.
3. Morrison, D.F. (2004). *Multivariate statistical methods* (4th ed.). McGraw Hill Publishing Co, New York.

Course Title:	Probability & Probability Distributions- II
Course Code:	STAT-310
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	Probability & Probability Distributions- I

Learning Outcomes

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

1. Learn the theoretical and mathematical basis of Bivariate distributions including Bivariate normal distribution.
2. Derive chi-square, t and F distributions along with their properties.
3. Grasp the concept of Order statistics and their distribution

Course Outline

Unit 1

1.1 Bivariate Distributions

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

1.2 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.

1.3 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.

Text Book

1. Ross, S.M. (2003). *Introduction to Probability Models*. Academic press.

Suggested Readings

1. Hirai, A.S. (2002). *A Course in Mathematical Statistic.* Ilmi Katab Khana, Lahore.
2. Hogg, R.M., McKean, J., and Craig, A.T. (2013). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey, USA.
3. Milton, J.S. and Arnold, J.C. (2003). *Introduction to probability and statistics*", McGraw Hill, 2003.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics.* McGraw Hill, New York, USA.

Course Title:	Categorical Data Analysis
Course Code:	STAT-311
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Know the nature of categorical variables and their measurement scales.
2. Ascertain the knowledge of sampling distributions for categorical variables and learn the methods of testing hypothesis with applications.
3. Learn various tools and techniques to analyze categorical data and their applications to the real world examples.

Course Outlines

Unit 1

1.1 Introduction

Historical background of categorical response data. Types of categorical variables, measurement scales distinction and sampling distributions. Testing goodness of fit and independence. Large sample confidence intervals and the idea of p-value.

1.2 Different Test statistics

Chi-square Test for Categorical Data, its Assumptions and Applications, 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. Cochran-Mantel-Haenszel Test, Matched Samples and McNemar Test. Meta-Analysis for (2x2xk) Tables.

Unit 2

2.1 Testing of Statistical Significance

Testing of Statistical Significance of Relative Risk and Odds Ratio with its Confidence Limits, Sensitivity, Specificity and Kappa Statistic.

2.2 Model building

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.

Text Book

1. Agresti, A. (2012). *Categorical data analysis* (3rd ed.). John Wiley & Sons.

Suggested Readings

1. Agresti, A. (2010) *Analysis of Ordinal Categorical Data.* (2nd ed.). John Wiley & Sons.
2. Lloyd, C. J. (1999). *Statistical analysis of categorical data* (1st ed.). John Wiley & Sons.
3. Powers D. A., & Xie, Y. (2008). *Statistical Methods for Categorical Data Analysis* (2nd ed.). Emerald Group Publishing.

Course Title:	Advanced Computer Languages
Course Code:	STAT-312
Semester:	VI
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Get familiar with the interface of R along with the objects required for the purpose of data analysis.
2. Learn the basic programming skills including logical statements, looping and graphical functions.
3. Generate random numbers and simulate data from different distributions.
4. Estimate Regression and Time Series models based on Monte Carlo Simulations and Bootstrapping.

Course Outline

Unit 1

1.1 Introduction to R and its Framework

Downloading, Installing and Starting R and associate libraries. Calculating environment of R, Types of R objects, Vector, Matrix, Data frame, Array etc. Writing Scripts, Basic programming skills, Logical statements, Looping, Programming flow and basic debugging. Using built-in functions, Input and Output files, Programming with functions, Graphics.

Unit 2

2.1 Empirical Study of Sampling Distributions

Probability and probability distributions, Generating random numbers, Selecting random samples, Empirical study of the sampling distribution of estimators.

2.2 Data Simulation

Simulation of data from a probability distribution, Simulation of data for a regression model, Simulation of data for time series model, Monte Carlo simulation, Bootstrapping.

- **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.

Text Book

1. Purohit, S. G., Gore, S. G., & Deshmukh, S. R. (2008). *Statistics Using R.* Narosa Publishing House

Suggested Readings:

1. Fischetti, A. (2018). *Data Analysis with R: A comprehensive guide to manipulating, analyzing and visualizing data in R*. Packt Publishing Ltd.
2. Jones, O., Maillardet, R., & Robinson, A. (2014). *Introduction to scientific programming and simulation using R*. Chapman and Hall/CRC.

COURSE OUTLINES
FOR
SEMESTER – VII

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

Learning Outcomes

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

1. Have vast knowledge about point estimation and properties of a good estimator.
2. Tackle the problems related to Cramer-Rao inequality and Minimum variance bound estimators.
3. Get an insight on Bayes estimation with examples.

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.

Text Books

1. Casella, G., & Berger, R.L. (2008). *Statistical Inference*. Cengage Learning, New York, USA.
2. Hogg, R.V., & Tanis E.A. (2009). *Probability and Statistical Inference* (7th ed.). Macmillan Publishing Company, New York.

Suggested Readings

1. Hoel, P.G. (1984). *Introductions to Mathematical Statistics* (5th ed.). John Wiley and Sons, New York.
2. Hogg, R.M., McKean, J., & Craig, A.T. (2013). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey, USA.
3. Lehman, E.L. (2003). *Theory of Point Estimation* (2nd ed.). John Wiley, New York.
4. Mood, A.M., Graybill, F.A., & Boes, D.C. (2007). *Introduction to the Theory of Statistics.* McGraw Hill, New York, USA.
5. Rao, C.R. (2001). *Linear Statistical Inference and its Applications* (2nd ed.). Wiley.

Course Title:	Time Series Analysis-I
Course Code:	STAT- 402
Semester:	VII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Get the key concepts of time series, its objectives, components and special features.
2. Learn the descriptive techniques of transforming, differencing and analyzing the seasonal and irregular variations.
3. Develop the probability models of time series along with their theoretical framework.

Course Outline

Unit 1

1.1 Introduction to time series

Introduction and objectives of time series analysis. Components of time series, time series plots, time series and stochastic processes, special features of time series data, means, variance, auto-covariance, auto-correlation and partial auto-correlation for sample time series data.

1.2 Simple Descriptive Techniques

Stationary time series, transformations, Analyzing the secular trend, Filtering, Differencing, Analyzing Seasonal Variations, Analyzing Cyclical Variations, Analyzing Irregular Variations, Auto-correlation (correlogram) and other tests of randomness.

Unit 2

2.1 Probability Models for Time Series

Stochastic processes and stationary processes, useful stochastic processes, purely random process, random walk, moving average process, Stationarity and Invertibility of moving average models, auto-regressive process, Stationarity and invertibility of auto-regressive models, Duality between moving average and auto-regressive models, Principle of parsimony, Recursion rule for ACVF and ACF of auto-regressive process, Yule-Walker equations for auto-regressive process, Mixed ARMA models, moving average and auto-regressive representations of mixed ARMA models. Models for non-stationary time series. Box-Jenkins Integrated ARIMA models: Stationarity through differencing, other transformations. General linear processes and continuous processes.

- **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.

Text Book

1. Chatfield, C. (2003). *The analysis of time series: An introduction* (6th ed.). Chapman & Hall, London.

Suggested Readings

1. Box, G.E.P., Jenkins, G.M., & Reinsel, G.C. (2008). *Time series analysis: Forecasting and control* (4th ed.). Holden-dayk, San Francisco.
2. Brockwell, P.J. & Davis, R.A. (2010). *Introduction to time series and forecasting* (2nd ed.). Springer, New York.
3. Wei, W. (2005). *Time series analysis: Univariate and multivariate methods* (2nd ed.). Addison-Wesley publishing company, Inc.

Course Title:	Research Methodology
Course Code:	STAT-403
Semester:	VII
Credit Hours:	3 Credit Hours
Pre-requisites:	

Learning Outcomes

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

1. Learn the key concepts of a research and its various types.
2. Know the different kinds of survey and how to conduct them.
3. Acquire the knowledge of sample selection with the help of examples.
4. Develop a questionnaire for a real world problem.

Course Outline

Unit 1

1.1 Introduction to Research

Definition of Research, Types and Methods of Conducting Research, Census and Survey, Sampling frame, Types of errors in surveys (coverage, non-response, measurement, errors etc.) and methods of control of such errors, Steps for successful surveys.

1.2 Types of Surveys and Methods for Conducting a Survey

Qualitative and Quantitative survey, Assessments survey, Marketing survey, Evaluation of a survey. Mail surveys, telephone surveys, face to face surveys, and drop off surveys.

Unit 2

2.1 Sample Size Selection and Construction of Questionnaire

Various methods of sample selection. Sample size and its practical difficulties. Constructing a questionnaire for different types of surveys. Scaling Techniques.

2.2 Analysis and Report Writing

The analysis of data. Style and format of report writing. Preparing the report.

- **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.

Text Books

1. Daniel, P.S., & Sam, A.G. (2011). *Research Methodology*. Kalpaz Publications, Delhi.
2. Singh, Y.K. (2011). *Fundamental of Research Methodology and Statistics.* New Age International.

Suggested Readings

1. Creswell, J.W. (2002). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches.* Sage Publications.
2. Salkind, N.J. (2010). *Encyclopedia of Research Design.* Sage Publications, Inc
3. Saris, W.E., & Gallhoffer, I.N. (2014). *Design, Evaluation, and Analysis of Questionnaires for Survey Research* (2nd ed.). John Wiley & Sons, Inc, Hoboken, New Jersey.
4. Panneerselvam, R. (2013). *Research Methodology*. Prentice Hall India.

COURSE OUTLINES
FOR
SEMESTER – VIII

Course Title:	Statistical Inference-II
Course Code:	STAT-404
Semester:	VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	Statistical Inference-I

Learning Outcomes

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

1. Learn different methods of estimation and their properties.
2. Get detailed insight on Interval estimation and its various methods.
3. Have sufficient knowledge of testing hypotheses under varied circumstances.

Course Outline

Unit 1

1.1 Methods of Estimation

Method of moments, Maximum likelihood method and its properties. Method of least squares and its properties. Ordered least squares estimation of location and scale parameters. Minimum chi-square method.

1.1 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 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. Monotone likelihood ratio tests of hypotheses. Sequential probability ratio test. Approximate sequential probability ratio test. Average sample number.

- **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.

Text Books

1. Casella, G., & Berger, R.L. (2008). *Statistical Inference*. Cengage Learning, New York, USA.
2. Hogg, R.V., & Tanis E.A. (2009). *Probability and Statistical Inference* (7th ed.). Macmillan Publishing Company, New York.

Suggested Readings

1. Hoel, P.G. (1984). *Introductions to Mathematical Statistics* (5th ed.). John Wiley and Sons, New York.
2. Hogg, R.M., McKean, J., & Craig, A.T. (2013). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey, USA
3. Lehman, E.L. (2003). *Theory of Point Estimation* (2nd ed.). John Wiley and Sons, N.Y
4. Mood, A.M., Graybill, F.A., & Boes, D.C. (2007). *Introduction to the Theory of Statistic.* McGraw Hill, New York, USA.
5. Rao, C.R. (2001). *Linear Statistical Inference and its Applications* (2nd ed.). John Wiley and Sons, New York.

Course Title:	Econometrics
Course Code:	STAT-405
Semester:	VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Research with econometrics
2. Explain econometrics concepts and results intuitively
3. Derive econometric results mathematically

Course Contents

Unit 1

1.1 Review of Mathematical Tools

Probability Distributions and Statistical Inference. Basic mathematical tools, Probability distribution, Point and interval estimation, Large sample properties of estimators, Hypothesis testing and confidence intervals, Matrices.

1.2 Linear Regression Analysis

Economic Data, Simple linear regression and ordinary least squares (OLS) estimation, Multiple linear regression, The properties, expected value and the variance of the OLS estimator. Issues in Multiple Regression Analysis, Inference and hypothesis testing, Large sample properties of the OLS estimator, Other functional form, Goodness of fit, Qualitative data (Binary variables).

Unit 2

2.1 Heteroskedasticity

Heteroskedasticity-robust inference, Testing for heteroskedasticity, Weighted least squares estimation. Specification and Data Issues, Functional form misspecification, Proxy variables, Measurement errors

2.2 Subject to time availability, one or more of the following topics will be covered: Panel Data, Fixed effects estimation, Random effects estimation, Limited Dependent Variable Models and Sample Selection Corrections, Logit and probit models, Tobit models, Poisson regression model, Models with censored and truncated data, Sample selection. Instrumental Variables Estimation and Simultaneous Equations Model, Instrumental variables, Two-state least squares estimation, Simultaneity bias in OLS

- **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.

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Text Book

Gujrati, D. (2003). *Basic Econometrics* (4th ed.). McGraw Hill Book Company.

Suggested Readings

1. Gunst, R. F. (2018). *Regression analysis and its application: A data-oriented approach*. New York: Routledge.
2. Peck, E. A., Vining, G., & Montgomery, D. C. (2012). *Introduction to Linear Regression Analysis* (5th ed.). Wiley.
3. Wooldridge, J. (2013). *Introductory Econometrics: A Modern Approach* (5th ed.). South-Western Cengage Learning.

Course Title:	Stochastic Processes
Course Code:	STAT-406
Semester:	VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn stochastic processes in detail along with their various dimensions.
2. Gain knowledge about Markov, Poisson, Pure Death and Pure Birth processes.
3. Understand Queuing theory and characteristics of queuing system

Course Outlines

Unit 1

1.1 Introduction

Markov chains, Transition and absolute probability, Calculation of K-step transition probabilities. Chapman-Kolmogorov equations. Classification of states. Classification of Markov chains. The ergodic property. The random walk. Gambler's ruin and expected duration of game.

1.2 Stochastic processes

Markov process. Poisson process. Pure death process. Pure birth process. Renewal process. Branching process. The Winer process. Non-Markovian process. Stationary process.

Unit 2

2.1 Queuing theory

Characteristics of queuing system. Simple queues. Multiple service channels. 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.

Text Book

Lawler, G. F. (2006). *Introduction to Stochastic Processes* (2nd ed.). Chapman & Hall/CRC.

Suggested Readings

1. Bailey, N.T.J. (1964). *The Elements of Stochastic Processes with Applications to Natural Science*. John Wiley and Sons, New York, 1964.
2. Karlin A.S. (1975). *A First Course in Stochastic Processes* (2nd Edition). Academic Press, London.
3. Srinivasan, S.K. and Mehata, K.M. (1997). *Stochastic Processes* (2nd Edition). Tata McGraw Hill Publishing Company, New Delhi, India.

COURSE OUTLINES FOR ELECTIVES – GROUP I (BIOSTATISTICS)

Course Title:	Multivariate Analysis– II
Course Code:	STAT-409
Semester:	VII
Credit Hours:	3 Credit Hours
Pre-requisites:	Multivariate Analysis– I

Learning Outcomes

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

1. Develop a thorough understanding of multivariate data analysis
2. Master basic techniques of reproducible research
3. understand the link between multivariate techniques and corresponding univariate techniques,
4. Use multivariate techniques appropriately, undertake multivariate hypothesis tests, and draw appropriate conclusions.

Course Outline

Unit 1

1.1 Multivariate Statistical Inference

The Hotelling's T^2 distribution. The linear discriminant function, Mahalanobis distances. Tests of hypotheses and confidence intervals for mean vectors: One sample and two-sample procedures.

Unit 2

2.1 Multivariate statistical procedures

Discriminant analysis, Principal component analysis, Factor analysis, and Canonical correlation 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.
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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.

Text Books

1. Chatfield, C., & Collins, A.J. (1980). *Introduction to multivariate analysis*. Chapman and Hall: London.
2. Johnson, R.A., & Wichern, D.W. (2008). *Applied multivariate statistical analysis.* Pearson Education: Singapore.

Books Recommended

1. Anderson, T.W. (2003). *An introduction to multivariate statistical analysis* (3rd ed.). John Wiley & Sons: New York.
2. Bhuyan, K.C. (2008). *Multivariate analysis and its applications*. New Central Book Agency: Kolkata.
3. Rencher, A.C. (2002). *Methods of multivariate analysis* (2nd ed.). John Wiley & Sons: New York.
4. Tabachnick, B.G., & Fidell, L.S. (2006). *Using multivariate statistics* (5th ed.). Allyn & Bacon: Boston.

Course Title:	Time Series Analysis-II
Course Code:	STAT-410
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	Time Series Analysis-I

Learning Outcomes

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

1. Demonstrate advanced understanding of the concepts of time series and their application to health, climate, finance and other areas.
2. Demonstrate familiarity with a range of examples for the different topics covered in the course.
3. Demonstrate an advanced understanding the underlying concepts in the time series and frequency domains.

Course Outline

Unit 1

1.1 Model Building

Various stages of model building, Identification of model from sample time series, steps for model identification, estimating the auto-covariance, auto-correlation function and partial auto-correlation function, pattern of theoretical ACF and PACF as a tool of model identification.

Unit 2

2.1 Parameter Estimation

Estimating the parameters of an auto-regressive model, estimating the parameters of moving average, Back casting, dual estimation, mixed ARMA model and integrated model. The Box-Jenkins seasonal model. Model diagnostics; Residual analysis, over fitting and parameter redundancy, portmanteau tests. Model selection criteria, AIC, BIC.

2.2 Forecasting

Univariate procedures, Minimum mean square estimate of forecast, forecast weights, mean, variance and forecast limits for forecast, forecast error, minimum mean square forecast error, structure of minimum mean square forecast error. Multivariate procedures, comparison of forecasting procedures. Prediction theory.

- **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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Text Book

Brockwell, P.J., & Davis, R.A. (2002). *Introduction to time series and forecasting*. (2nd ed.). Springer: New York.

Suggested Readings

1. Box, G.E.P., Jenkins, G.M., & Reinsel, G.C. (2004). *Time series analysis: Forecasting and control* (3rd ed.). Holden-dayk: San Francisco.
2. Chatfield, C. (2003). *The analysis of time series: An introduction* (6th ed.). Chapman & Hall: London.
3. Wei, W. (1990). *Time series analysis: Univariate and multivariate methods*. Addison-Wesley publishing company, Inc.

Course Title:	Demography
Course Code:	BIOS-401
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

After completion of this course, the student will be able to:

1. Identify appropriate sources of data.
2. Perform basic demographic analyses using various techniques and ensure their comparability across populations.
3. Produce population projections and interpret the information gathered by the different demographic methods.

Course Outline

Unit 1

1.1 Introduction to Demography and its Sources

Define and differentiate the demographic concepts, terminology and formulas. Discuss the key assumptions underlying techniques and tools. Identify and compare the advantages and disadvantages of the different sources of demographic data. Present appropriate techniques to ensure comparability of the measures across population.

1.2 Demographic Indicators

Describe basic demographic indicators and elaborate on their computation and interpretation. Introduce population projection calculations and analysis.

Unit 2

2.1 Distribution and Methods of Standardization

Describe the distribution of a population using various demographic characteristics. Construct a Lexis diagram. Perform direct and indirect methods of standardization.

2.2 Life Tables

Construct and analyze simple and abridged life-tables. Describe the relations and calculate indicators in a stationary population. Derive the mathematical relationships in a cohort life table.

2.3 Population Projections and Analysis

Estimate the rate of change in a population. Project a population using appropriate equations and assumptions. Recognize and analyze typical demographic patterns arising from the data

- **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.

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Text Book

Preston, S., Heuveline, P., & Guillot, M. (2000). *Demography: Measuring and Modeling Population Processes* (1st ed.). Willey-Blackwell.

Suggested Readings

Shyrock, S., Siegel, J.S., & Stockwell, E.G. (1976). *The Methods and Materials of Demography*. Academic Press.

Course Title:	Analysis of Repeated Measurements
Course Code:	BIOS-402
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Identify clusters and potential dependency by inspecting the design and/or viewing the resulting data set
2. Understand the principles of experimental design in which experimental factors vary both between and within clusters
3. Perform simple, descriptive analyses such as obtaining sample covariance and correlation, and corresponding graphical plots such as scatter plots, to illuminate key features of data with clustered and/or repeated observations

Course Outlines

Unit 1

1.1 Introduction

Repeated Measurements, Advantages and Disadvantages of Repeated, Measurements Designs, Sample Size Estimation. Univariate Analysis for one Sample and Multiple Samples. Multivariate Normal Distribution Theory, One Sample repeated measurements, Two sample repeated measurements.

1.2 Inferential Analysis

The Multivariate General Linear Model, Parameter Estimation, Hypothesis Testing, Comparisons of Test Statistics / Profile Analysis, Growth Curve Analysis.

Repeated Measures ANOVA Model, The Fundamental Model, One Sample and Multiple Samples Cases. The Linear Mixed Model.

- **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.

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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.

Text Book

Davis, C. S. (2002). *Statistical methods for the analysis of repeated measurements*. Springer Science & Business Media.

Suggested Readings

1. Dupont, W. D., & Dupont, W. D. (2009). *Statistical modeling for biomedical researchers: a simple introduction to the analysis of complex data*. Cambridge University Press.
2. Goldstein, H. (1995). *Multilevel Statistical Models* (2nd ed.). Arnold, London.
3. Munro, B. H. (2001). *Statistical methods for health care research* (4th ed.). Lippincott Williams & Wilkins.

Course Title:	Bioinformatics
Course Code:	BIOS-403
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the major sources of 'big-data' in Biology and the scale and nature of the data.
2. Perform fundamental operations (data input/output, statistics, data visualization).
3. Use common bioinformatics tools using the Unix command line, R, and Python.
4. Understand the importance of reproducibility and open access for data and computer code in bioinformatics.

Course Outline

Unit 1

1.1 Introduction

History of Bioinformatics, Central Dogma & Protein structures, bioinformatics applications

1.2 Protein structures

Cell, Molecule, Gene, Chromosom, DNA, RNA, Protein, Connection DNA-RNA-Protein, Protein structures, Protein functions, Bio-chemical properties of amino acids, Motif, Domain, Protein Families, Evolution, Similarity, Homology. Means-Ends Analysis, Problem Reduction,

Unit 2

2.1 Genetic Algorithm

Goal Tree, DepthFSearch, BreadthFSearch, BestFSearch, Optimal Search, Branch and Bound, Dynamic Programming Principle, (Minimax-procedure, Alpha-Beta pruning). PAM-Matrices (Dayhoff), BLOSUM (Henikoff and Henikoff), Scoring systems based on amino acid classifications. Cost (measure) of multiple alignment, Dynamic programming, Progressive alignment (CLUSTAL), Use of local multiple alignment. Methods for finding relative positions of DNA sequences on a chromosome. (Small and Large scale). Construction by the use of character states, construction by the use of distance matrices. Statistical significance, Dot matrix methods,

2.2 Bioinformatics Databases:

Dynamic programming (MPSearch), FASTA, BLAST, Search with profiles. The PROSITE-database, sequence driven methods, pattern driven methods. Introduction to the RNA secondary structure prediction and protein folding problems.

- **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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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.

Text Book

Baxevanis, A., & Ouellette, B. F. F. (1998*). Bioinformatics: A Practical Guide to Analysis of Genes and Proteins*. John Wiley and Sons Inc.

Suggested Readings

1. Gibas, C., Jambeck, P., & Fenton, J. (2001). *Developing bioinformatics computer skills*. O'Reilly Media, Inc.
2. Gu, J., & Bourne, P. E. (Eds.). (2011). *Structural bioinformatics* (2nd ed.). Wiley – Black Well.

Course Title:	Hospital Management
Course Code:	BIOS-404
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Apply theoretical ideas and materials from this course to resolve problems and develop opportunities in healthcare organizations.
2. Develop their leadership and teambuilding abilities.
3. Apply modern change and innovation management concepts to optimize healthcare structures, processes and outcomes.
4. Enhance their alignment within the local and national context.

Course Outline

Unit 1

1.1 Introduction to hospital administration

Understanding of the role and functions of hospitals and their health care context, vision, mission and goals of a hospital.

1.2 Hospital Service management

Structure and organization, planning and managing resources, reviewing and evaluating services and understanding the local and national context in a developing health system.

1.3 Hospital Ethical concerns teaching methodology

The foundation of international health, the principles of hospital management.

- **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.
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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.

Text Book

Ramani, K.V. (2014). *Hospital Management*. Pearson India.

Suggested Readings

1. Kunders, G. D. (2004). *Hospitals: facilities planning and management* .Tata McGraw-Hill Education.
2. Srinivasan, A. V. (2008). *Managing a modern hospital* (2nd ed.). SAGE Publications, India.

Course Title:	Design &Analysis of Medical Studies
Course Code:	BIOS-405
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Explain methods of study design used in a clinical or population setting, and knows how these studies are performed.
2. Show the ability to perform a comprehensive literature search for the design of a biomedical study by following reproducible methodology
3. Translate a clinical problem into a research question and design a biomedical study in an efficient way.
4. Choose, apply and interpret statistical analyses.

Course Outline

Unit 1

1.1 Key features of probability sample designs

Rrandom sampling, stratification, clustering, multistage sampling. Understand potential limitations of purposive sampling designs, and techniques to reduce the potential bias from such designs.

1.2 Design Review

Review the main study designs for the comparison of treatments and potential risk factors for a health outcome, including randomized clinical trials, prospective and retrospective longitudinal studies, case-control studies, analyses of clinical data bases.

1.3 Analysis

Statistical methods to analyses data from these studies including univariate and multivariate linear regression, logistic regression, survival analysis (Kaplan Meier survival curves and Cox regression), and linear mixed models.

1.4 Interpretation and validation:

Analyze research data and interpret these results from a population health or clinical-translational perspective. Validation of the methods using model checks, the reliability of measurements (inter- and intraobserver variation, kappa), the evaluation of diagnostic systems (ROC curves), and recognition of the principles of bias and confounding.

- **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.

Text Book

1. Machin, D., & Campbell, M.J. (2005). *Design of Studies for Medical Research*. John Wiley & Sons, Ltd.

Suggested Readings

1. Petrie, A., & Sabin, C. (2019). *Medical statistics at a glance*. John Wiley & Sons.

Course Title:	Epidemiology
Course Code:	BIOS-406
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes
Students will be able to

1 Understand the major concepts and tools of epidemiology, the study of health in populations.
2 They should be able to judge the quality of evidence in health-related research literature.

Course Outline
Unit 1
1.1 Introduction to Epidemiology
Concepts of health and disease, Introduction to Public Health, Ethical issues in epidemiologic research, Ratios, proportions, rates, Measures of health status: Prevalence and Incidence, National and International causes of mortality: Overview, Measures of health status: mortality rates, Sources of information on mortality, Rate adjustment, Major dimensions of descriptive epidemiology: person, place and time.
Unit 2
2.1 Introduction to analytic epidemiology
Analytic study designs, Measures of association, Evaluating valid statistical associations, Evaluating causal associations, Interpretation of literature abstracts, Issues in the design of Cohort studies, Measures of Public Health impact, Attributable Risk, Population Attributable Risk, Confounding, Techniques to control for confounding, Introduction to effect modification , Intervention studies, Epidemiology in disease control: Introduction to the epidemiology of infectious diseases, Disease outbreak investigation, Public Health Surveillance.

- **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.
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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.

Text Book

1. Ahrens,W., & Pigeot, I. (2005). *An introduction to epidemiology*. Springer.

Suggested Readings

1. Page, R. M., Cole, G. E., & Timmreck, T. C. (1995). *Basic epidemiological methods and biostatistics: A practical guidebook*. Jones & Bartlett Learning.

Course Title:	Clinical Trials
Course Code:	BIOS-407
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes
Students will be able to

1. Explain key concepts in the design of clinical trials.
2. Identify key issues in data management for clinical trials.
3. Describe the roles of Regulatory Affairs in clinical trials.

Course Outline
Unit 1
1.1 Introduction to clinical trials
Historical examples and ethics.
1.2Types of trial designs
Parallel, crossover, group allocation, factorial, large simple, equivalency, non-inferiority, and adaptive designs.
Unit 2
2.1 Randomization and Masking
Key design features of randomized clinical trials used to protect against bias, randomization and masking. Outcomes and 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.

Text Book

1. Piantadosi, S. (2017). *Clinical Trials: A Methodologic Perspective*. (3rd ed.). Wiley, USA.

Suggested Readings

1. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., & Granger, C. B. (2015). *Fundamentals of clinical trials*. Springer.

Course Title:	Survival Analysis
Course Code:	BIOS-408
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Build and apply different types of survival models along with their applications.
2. Know in detail about the Markov jump process as well its practical framework.
3. Learn about different graduation methods and census formulae for various variables.

Course Outline

Unit 1

1.1 Survival Models and their Principles

Principles of actuarial modeling, estimating the lifetime distribution function-the Kaplan-Meier and Nelson-Aalen Models. The Cox regression model, the two stat Markov Model, concept of survival model, two stat model of a single decrement and compare its assumption with random lifetime model, Derivation of maximum likelihood estimators for the transition intensities in the model of transfers between states with piecewise constant transitions intensities.

1.2 Markov jump Process

Essential features of a Markov process model, Poisson process and derive the distribution of the number of events in a given interval, drive Kolmogorov equations for a Markov process with time independent and time/age dependent transition intensities. Simple survival model, sickness model, and marriage model in term of Markov processes.

Unit 2

2.1 Methods of graduation

Methods of graduation for parametric formula, standard table, graphical, Binomial and Poisson models, Graduation and statistical test, Exposed to risk: homogeneous classes including subdivision by age and sex, calculation of central exposed to risk, Assumptions underlying the census approximation of waiting time, concept of rate interval, census formula for age birthday, age at specific calendar date, age at a specified policy anniversary.

- **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.

Text Book

1. Marubini, E., & Valsecchi, M.G. (1995). *Analyzing survival data from clinical trials and observational studies*. John Wiley and Sons, New York.

Suggested Readings

1. Gerber, H.U. (1997). *Life insurance mathematics* (3rd ed.). Springer Swiss Association of Actuaries.
2. Haberman, S., & Pitacco, E. (1999). *Actuarial models for disability insurance*. Chapman & Hall.

COURSE OUTLINES
FOR ELECTIVES –
GROUP II
(OPERATIONS RESEARCH)

Course Title:	Metaheuristic Algorithms
Course Code:	COMP-401
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the concepts of metaheuristics
2. Learn basic properties and structure of metaheuristic optimization methods.

Course Outline

Unit 1

1.1 Concepts of Metaheuristics

Optimization Models, Optimization Methods, Representation, Objective Function, Constraint Handling, Parameter Tuning, Performance Analyses of Metaheuristics. Random walk and Levy flights.

1.2 Single Solution Based Metaheuristics

Neighborhood, Initial Solution, Fitness Landscape Analysis, Local Search.

Unit 2

2.1 Population Based Metaheuristics

Initial Population, Stopping Criteria. Differential evolution, Ant and Bee algorithms. Firefly algorithm, Bat algorithm, Cuckoo search. Metaheuristics for Multiobjective Optimization.

2.2 Hybrid Metaheuristics

Design Issues, Implementation Issues. Combining Metaheuristics with Mathematical Programming. Hybrid Metaheuristics with Machine Learning and Data Mining. Hybrid Metaheuristics for Multiobjective Optimization.

- **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.

Text Book

1. Bozor, O., Solgi, M., & Loaiciga, H. A. (2017). *Meta-heuristic and evolutionary algorithms for engineering optimization*. John Wiley & Sons, Inc.

Suggested Readings

1. Blum, C., Roli, A., & Sampels, M. (2008). *Hybrid metaheuristics: an emerging approach to optimization*. Springer.
2. Yang, X. S. (2010). *Nature-inspired metaheuristic algorithms*. Luniver press.

Course Title:	Nonlinear and Dynamic Programming
Course Code:	OPRS-401
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Describe non-linear programming problems.
2. Understand the non-linear programming problems.
3. Distinguishes non-linear programming and linear programming problems.
4. Classifies the non-linear programming problems.

Course Outline

Unit 1

1.1 Thoeratical

Q-learning and Temporal-Difference Learning. Rollout, limited look ahead and model predictive control. Optimal control in continuous time and space. LQR for linear optimal control. Kalman filters for linear state estimation. The Pontryagin minimum principle. Eikonal equation for shortest path in continuous state space and the Fast Marching Method for solving it.

Unit 2

2.1 Practical

DP for financial portfolio selection and optimal stopping for pricing derivatives. Exploration vs exploitation in learning. Approximate linear programming and Tetris. Constraint sampling and/or factored MDPs for approximate linear programming. Policy search method PEGASUS, reinforcement learning and helicopter control. Neural networks and/or SVMs for value function approximation. Lyapunov functions for proving convergence. Viterbi algorithm for decoding, speech recognition, bioinformatics, etc. Extended and/or unscented Kalman filters and the information filter.

- **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.

Text Book

1. Himmelblau, D. M. (2018). *Applied nonlinear programming*. McGraw-Hill.

Suggested Readings

1. Denardo, E. V. (2012). *Dynamic programming: models and applications*. Courier Corporation.
2. Dreyfus, S. E., SE, D., & Law, A. M. (1977). *The Art and Theory of Dynamic Programming*. Academic Press.
3. Ravindran, A., Ragsdell, K. M., & Reklaitis, G. V. (2006). *Engineering optimization: Methods and applications* .Wiley, New York.

Course Title:	Sequential Optimization
Course Code:	OPRS-402
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand how to translate a real-world problem, given in words, into a mathematical formulation.
2. Better understand design and analysis of algorithms: specifically through complexity analysis.
3. Write and apply computer code to problems, including (a) mathematical optimisation techniques; (b) using existing optimisation toolkits; (c) writing computer programs to implement algorithms, and solve problem; and (d) methods to deal with ingesting data.
4. Critically analyse and interpret results and present this in both oral and written form.

Course Outline

Unit 1

1.1 Introduction

Optimality conditions and its importance.

1.2 Methods for unconstrained minimizations

Line-search methods for unconstrained minimization. Trust-region methods for unconstrained minimization. Active-set methods for linearly-constrained minimization.

1.3 Methods for constrained minimizations

Penalty and augmented Lagrangian methods for constrained minimization. Interior-point methods for constrained minimization. Sequential quadratic programming (SQP) methods for constrained minimization.

- **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.

Text Book

1. Nocedal, J., & Wright, S. J. (1999). *Numerical Optimization*. Springer, New York.

Suggested Readings

1. Fletcher, R. (1987). *Practical Methods of Optimization* (2nd Edition). Wiley.

Course Title:	Inventory Systems and Modeling
Course Code:	OPRS-403
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Comprehend the dynamics of inventory management's principles, concepts, and techniques as they relate to the entire supply chain (customer demand, distribution, and product transformation processes),
2. Understand the methods used by organizations to obtain the right quantities of stock or inventory,
3. Familiarize themselves with inventory management practices.

Course Outline

Unit 1

1.1 Deterministic Models

Inventory policies Deterministic Inventory Models in Supply Chain, Echelon Based Inventory Models in Supply Chain, Roundy's 98 Percent Approximation, Echelon Based Time Varying Demand.

1.2 Stochastic Models

Guaranteed Service Model Approach, Coordination and Contracts in Supply Chain, Multi-Period Models, Bivariate Periodic/Continues Review Models.

Unit 2

2.1 Multi-Echelon Systems

The Concept of Echelon, Propositions on Echelon Stock, The Clark-Scarf Approach, An Introduction to METRIC Approach, The Optimization Techniques for METRIC Approach.

2.2 Perishable Inventory Systems

Deterministic Models with Perishability, Shelf Life Optimization Models, Probabilistic Perishable Inventory Models, Multi-Period Perishable Inventory Models, Inventory Systems with Supply Disruptions, Inventory Systems with Manufacturing Disruptions, Inventory Systems with Demand Disruptions, Environmental Performance and Returns in Inventory Models, A Green Inventory Model.

2.3 Coordinated Based Inventory Systems

The Basic Concept of VMI, Coordinated Based Inventory Models, VMI Modeling Framework, VMI Sensitivity Analyses.

Unit 3

3.1 Palms' Theorem and Performance Measures

Palms' Theorem, Performance Measures, Convexity and Concavity of Measures Optimization Models of Performance Measures.

3.2 METRIC System

The LRU Concept, The LRU Optimization Models, The SRU Concept (Multi-Indenture Systems), Lateral Resupply Systems, Multi-Echelon Systems With Pooling Environment, The Concept of Shortfall, Multi-Echelon Systems with Capacity-Limited, Systems Optimization with Capacity-Limited, Real-time Execution Concept, The Stock Allocation Model (SAM), The Extensions of Stock Allocation Model (ESAM, ESAMR).

- **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.

Text Books

1. Axsäter, S. (2015). *Inventory Control* (3rd ed.). Springer, New York.
2. Muckstadt, J.A., & Sapra, A. (2010). *Principles of Inventory Management*. Springer, New York.

Suggested Readings

1. Agrawal, N., & Smith, S.A. (2015). *Retail Supply Chain Management: Quantitative Models and Empirical Studies* (2nd ed.). Springer, New York.
2. Albrecht, M. (2010). *Supply Chain Coordination Mechanisms: New Approaches for Collaborative Planning*, Springer, Berlin.
3. Altay, N., & Litteral, L.A. (2011). *Service Parts Management: Demand Forecasting and Inventory Control*. Springer, New York.
4. Davis, R.A. (2016). *Demand-Driven Inventory Optimization and Replenishment: Creating a More Efficient Supply Chain* (2nd ed.). Wiley, New Jersey.
5. Hillier, F.S., & Lieberman, G.J. (2015). *Introduction to Operations Research* (10th ed.). McGraw-Hill, New York.
6. Nahmias, S. (2011). *Perishable Inventory Systems*, Springer, New York.

Course Title:	Queuing Theory
Course Code:	OPRS-404
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. To develop the modeling and mathematical skills to analytically determine computer systems and analytically determine computer systems and communication network performance.
2. Students should be able to read and understand the current performance analysis and queueing theory literature upon completion of the course
3. Understand strengths and weaknesses of Queueing Models

Course Outline

Unit 1

1.1 Introduction to Queueing Theory

Basic Components of a Queue, Kendall Notation A/S/m/B/K/SD, Exponential/Erlang/Hyper-Exponential Distribution, Group Arrivals/Service, Rules for All Queues, Little's Law, Stochastic Processes, Discrete/Continuous State Processes, Markov Processes, Birth-Death Processes, Poisson Distribution, Poisson Processes, PASTA Property, Relationship Among Stochastic Processes.

1.2 Analysis of A Single Queue

Birth-Death Processes, M/M/1 Queue, M/M/m Queue, M/M/m/B Queue, Other Queues.

Unit 2

2.1 Queueing Networks

Open Queueing Networks, Closed Queueing Networks, Mixed Queueing Networks, Product-Form Network, General Open Network of Queues, Closed Product-Form Networks, Machine Repairman Model, Central Server Model, Types of Service Centers.

2.2 Operational Laws

Utilization Law, Forced Flow Law, Bottleneck Device, Transition Probabilities, Little's Law, General Response Time Law, Interactive Response Time Law, Bottleneck Analysis, Asymptotic Bounds.

2.3 Mean Value Analysis and Related Techniques

MVA Steps, MVA Assumptions.

- **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.

Text Books

1. Chen, H., & Yao, D. D. (2013). *Fundamentals of queueing networks: Performance, asymptotics, and optimization* (Vol. 46). Springer Science & Business Media.
2. Kleinrock, L. (1975). *Queueing systems*. John Wiley & Sons.

Suggested Readings

1. Bose, S. K. (2013). *An introduction to queueing systems*. Springer Science & Business Media.
2. Jain, R. (1990). *The art of computer systems performance analysis: techniques for experimental design, measurement, simulation, and modeling*. John Wiley & Sons.
3. Wolff, R. W. (1989). *Stochastic modeling and the theory of queues*. Pearson College Division.

Course Title:	Network Analysis
Course Code:	OPRS-405
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the fundamental concepts and theories about networks.
2. Apply this knowledge to solve real-world, network-centric problems.
3. Use advanced network analysis methods and tools to visualize and analyze networks.
4. Interpret the results with respect to exploratory, quantitative and substantive questions.

Course Outline

Unit 1

1.1 Introduction to Network analysis

Graph Theory Concepts (basic definitions; graph types; graph examples; graph representations, classical graph algorithms), Basic metrics (diameter, clustering coefficient, shortest paths, centralities).

1.2 Network visualization and Graph models

Graph formats; graph drawing; graph layout methods and algorithms; software experimentation, Erd¨os-R´enyi random models; small-world and Watts-Strogatz model; scalefree networks, preferential attachment and Barab´asi-Albert model; other models.

Unit 2

2.1 Graph mining and patterns discovery

Subgraph mining, communities, network characterization and comparison, large scale network analysis.

2.2 Information networks and the World Wide Web

Information retrieval overview, web crawling and link analysis, information extraction, applications

- **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.

Text Book

1. Easley, D., & Kleinberg, J. (2012). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge University Press.

Suggested Readings

1. Hansen, D., Shneiderman, B., & Smith, M. A. (2010). *Analyzing social media networks with NodeXL: Insights from a connected world*. Morgan Kaufmann.
2. Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* (Vol. 8). Cambridge university press.

Course Title:	Simulation and Modeling
Course Code:	OPRS-406
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the techniques of modeling in the context of hierarchy of knowledge about a system.
2. Develop the capability to apply the same to study systems through available software.
3. Learn different types of simulation techniques.
4. Simulate the models for the purpose of optimum control by using software.

Course Outline

Unit 1

1.1 Introduction

Course overview, Modeling and simulation concepts, application domains, and tools.

1.2 Model development, simulation execution, and experimentation

Fundamental simulation modeling concepts and frameworks. System-theoretic model development principles and methods. Component-based simulation and modeling tools. Simulation protocol concepts, designs, and implementations. Simulation experimentation and analysis. Network system simulation modeling. Multi-resolution, multi-aspect modeling. Parallel simulation modeling concepts and methods.

Unit 2

2.1 Heterogeneous modeling and verification & validation

Simulation model verification and validation. Model composability and simulation interoperability

- **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.

Text Books

1. Chung, C. A. (2003). *Simulation modeling handbook: a practical approach*. CRC press.
2. Fishwick, P. A. (1995). *Simulation model design and execution: building digital worlds*. Prentice Hall PTR.

Suggested Readings

1. Bellman, K. L., Landauer, C., Cloud, D., & Rainey, L. (1998). *Designing Models in Applied Modeling and Simulation: An Integrated Approach to Development and Operation*. US Air Force Academy, McGraw-Hill.
2. Fujimoto, R. M. (2000). *Parallel and distributed simulation systems* (Vol. 300). New York: Wiley.
3. Law, A. M., Kelton, W. D., & Kelton, W. D. (2000). *Simulation modeling and analysis* (Vol. 3). New York: McGraw-Hill.
4. Singh, L. P. (2006). *Advanced power system analysis and dynamics*. New Age International.
5. Wymore, A. W. (2018). *Model-based systems engineering* (Vol. 3). CRC press.
6. Zeigler, B. P., & Sarjoughian, H. S. (2005). *Introduction to DEVS modeling and simulation with java: Developing component-based simulation models*. ACIMS

Course Title:	Game Theory
Course Code:	OPRS-407
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Define the basics of a "game"
2. Translate the basic of a "game" into a wide range of conflicts
3. Analyze conflict dynamics from the standpoint of rationality
4. Evaluate conflict dynamics from the standpoint of the self interests of the "Players".

Course Outline

Unit 1

1.1 Decision Theory

Utility representations of preferences, Probability and expectations, von Neumann and Morgenstern expected utility representation, Paradoxes.

Unit 2

2.1 Game Theory

Basics and canonical models: Dominance, Equilibrium: Pure strategies, Equilibrium: Mixed Strategies, Basic games: Prisoner's Dilemma, Matching Pennies, Stag Hunt, Dove-Hawk, Continuous Games: Cournot & Bertrand; Public Goods.

Unit 3

3.1 Extensive-Form Games

Game trees and information, Sub-game perfection, Forgetful driver game, Stackelberg & other illustrations, Refinements.

Unit 4

4.1 Repeated Games

Finitely repeated games, Rubinstein bargaining, Infinitely repeated games, Folk theorems.

Unit 5

5.1 Incomplete Information

Bayesian games, Auctions, Signaling, Voting, Cheap talk & strategic communication. Rationalizability and Evolutionary Game Theory.

- **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.

Text Book

1 Myerson, R. B. (2013). *Game theory*. Harvard university press.

Suggested Readings

1. Binmore, K. (2007). *Game theory: a very short introduction*. OUP Oxford.
2. Dixit, A. K. and Skeath, S. (2004). *Games of Strategy*. Norton & Company.
3. Osborne, M. J. (2004). *An introduction to game theory*. Oxford university press, New York.

Course Title:	Integer Programming
Course Code:	OPRS-408
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Be able to read, digest, and understand scholarly journal articles on integer programming.
2. Become acquainted with "off the shelf" solvers for integer programs, learn what the algorithmic parameters mean, how to tune them for improved performance, and how to customize them for specialized algorithms.
3. Understand how integer variables are used for formulating complex mathematical models, and in particular, what makes one valid model "better" than another.

Course Outline

Unit 1

1.1 Integer programming basics

Integer programming modeling concepts. Branch-and-bound for solving integer programs. An introduction to software for solving integer programs.

1.2 Theoretical underpinnings

Complexity Theory: Basic complexity classes P, NP, and NP-Complete. The concept of problem reduction to determine complexity. Polyhedral Theory: Concepts of dimension, faces, facets, polyhedral representations, and polarity. The equivalence of separation and optimization.

Unit 2

2.1 Techniques in Branching-based algorithms

Preprocessing and probing in integer programs. Primal heuristics for integer programs. Advanced branching and node selection rules for integer programs. Techniques for obtaining valid inequalities, Gomory's cutting planes, mixed integer rounding, lifting, cover inequalities.

- **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.

Text Book

1. Wolsey, L. A. (1998). *Integer programming* (Vol. 52). John Wiley & Sons.

Suggested Readings

1. Schrijver, A. (1998). *Theory of linear and integer programming*. John Wiley & Sons.

Course Title:	Decision Analysis
Course Code:	OPRS-409
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes
Students will be able to

1. Develop an understanding of how quantitative tools and analysis may lead to improved decision-making.
2. Improve your quantitative reasoning ability.
3. Increase your facility with spreadsheets.

Course Outline
Unit 1
1.1 Introduction and classical techniques:
Decision structuring, decision under uncertainty, risk attitudes and the value of information. Value of information (NPV, IRR), Decision Trees.
Unit 2
2.1 Monte Carlo Simulation and Group Decisions
Both analytical and psychological. Risk Attitude aspects.

- **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.

Text Book

1. Clemen, R. T. (1996). *Making hard decisions: an introduction to decision analysis*. Brooks/Cole Publishing Company.

Suggested Readings

1. Albright, S.C., Winston, W.L., & Zappe, C. (2006). *Data Analysis & Decision Making – With Microsoft Excel*, Thomson, South-Western.
2. Powell, S. G., & Baker, K. R. (2009). *Management science: The art of modeling with spreadsheets*. Wiley.

COURSE OUTLINES FOR ELECTIVES – GROUP III (ACTUARIAL SCIENCE)

Course Title:	Financial Mathematics
Course Code:	ACTS-401
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn about the different types of cash flow models.
2. Compute interest rates with respect to different terms.
3. Know in detail about the discounted cash flow techniques.

Course Outline

Unit 1

1.1 Cash flow models

Generalized cash flow model, cash flow process, cash inflow and cash out flow for fixed and uncertain amounts, cash flow in zero coupon bond, fixed interest securities, index linked securities, cash on deposit, an equity, interest only loan, repayment loan, an annuity certain, Accumulation with simple and compound interest, present value, simple discount rate.

1.2 Interest rates

Interest rates in different terms, yearly, p^{th} interest rates, effective and nominal interest rates, equivalent annual rate of interest over a specified period. Real and money interest rates.

Unit 2

2.1 Discounting and accumulating

Constant and variable interest or discount rates, force of interest, present values of equal and unequal payments, deferred and not deferred payments, Annuities.

2.2 Loan schedules Project appraisal

Discounted cash flow techniques in investment projects, net present value and accumulated profits of receipt and payments, internal rate of return, payback period and discounting payback periods, money weighted rate of returns, the time weighted rate of returns, linked internal rate of return on investment or fund.

- **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.

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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.

Text Books

1. Bowers, N. L., Gerber, H. U., & Hickman, J. C. *Actuarial mathematics* (2nd ed.). Institute of Actuaries.
2. Garrett, S. (2013). *An introduction to the mathematics of finance: a deterministic approach* (2nd ed.).

Suggested Readings

1. Butcher, M.V., & Nesbitt, C.J. (1971). *Mathematics of compound interest*. Ulrich's Books.
2. Gerber, H. U. (1986). *Life insurance mathematics* (3rd ed.). Springer; Swiss Association of Actuaries.
3. Kellison, S.G. (2008). *The Theory of interest* (3rd ed.). Irwin.

Course Title:	Advanced Financial Mathematics
Course Code:	ACTS-402
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn about investments and problems of elementary compound interest.
2. Calculate different types of yields and taxes.
3. Know the practical aspects of arbitrage and forward contracts.

Course Outline

Unit 1

1.1 Investments

Risk characteristics in investment, fixed interest government borrowings, fixed interest borrowing by other bodies, shares and other equity-type financing, derivatives

1.2 Elementary compound interest problems

Calculate the present value of payments from fixed interest securities with constant coupon rate and fixed term, calculation of upper and lower bounds for present value of fixed interest securities.

1.3 Calculation of Yields

Calculation of running yield and redemption yield, yield from ordinary shares, properties investments with the growth assumption of dividend and rent, Real yield from an indexed bond with the assumption of rate of inflation, price of, or yield from a fixed interest securities.

Unit 2

2.1 Types of Taxes

Deduction of income tax on coupon payments and redemption payments, deduction of capital gain taxes, value of investment under the assumption of capital gain tax in simple situation with constant tax and indexation, allowances for specified index movement and allowance for the case where an investor can offset capital losses against capital gains.

2.2 Arbitrage and Forward contracts

Define arbitrage, price of forward contract in the absence of arbitrage assuming: no income or expenditure associated with underlying assets during the term of contract, fixed income from assets during term, fixed dividend from assets during the term, hedging and forward contract, and value of forward contract in the absences of arbitrage.

2.3 Term structure of interest rates

Main factors influencing the term structure of interest rate, Par yield and yield to maturity, discrete spot rates and forward rates, continuous spot and forward rates, duration and convexity of cash flow sequence, sensitivity of the value of cash flow, evaluation of duration and convexity of cash flows sequence used in immunization of a portfolio of liabilities. Stochastic interest rates.

- **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.

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Text Books

1. Garrett, S. (2013). *An introduction to the mathematics of finance: a deterministic approach* (2nd ed.).
2. Promislow, S. D. (2015). *Fundamentals of Actuarial mathematics* (3rd ed.). Wiley.

Suggested Readings

1. Butcher, M.V., & Nesbitt, C.J. (1971). *Mathematics of compound interest*. Ulrich's Books.
2. Gerber, H. U. (1986). *Life insurance mathematics* (3rd ed.). Springer; Swiss Association of Actuaries.
3. Kellison, S.G. (2008). *The Theory of interest* (3rd ed.). Irwin.

Course Title:	Life Contingencies and Life Tables
Course Code:	ACTS-403
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Have deep insight about life insurance contracts and different types of assurances.
2. Acquire knowledge about various annuity contracts along with its practical aspects.
3. Express life table probabilities in term of the actuarial related functions.
4. Learn about the net premiums and provisions.

Course Outline

Unit 1

1.1 Life Insurance Contracts

Define simple insurance contracts and devolve the formulae for mean and variance of the present values of the payments under these contracts, Whole life assurance, Term assurance, Pure endowment assurance, endowment assurance and critical ill-health assurance including assurances where the benefits are deferred also derive their mean and variances Define the symbols $A_x, A_{x:\overline{n}|}, A_{x:\sqrt{n}}^{1}, A_{x:\sqrt{n}}$ and their select and continuous equivalents.

1.2 Life annuity contracts

Simple annuity contracts and derive their formulae, premium and benefits including annuity contracts where the benefits are deferred, integrals of mean and variances of these benefits, more frequently more than annually for these benefits, define the actuarial symbols related to these annuities and their continuous equivalent, derive the relation between level annuities payable in advance and arrears and between level temporary, deferred and whole life annuities.

Unit 2

2.1 The life table

Describe the life table functions, express life table probabilities in term of the actuarial related functions used both in assurances and annuities. Evaluation of assurances and annuities: derive the relations between assurance and annuities and their select and continuous equivalents.

2.2 Net premiums and provisions

Ultimate and select mortality; net premiums and net premium provisions, random future loss, prospective and retrospective provisions, Derive Thiele's equation, Death strain at risk, expected death strain, actual death strain, mortality benefits. Simple annuities and assurances involving two lives.

- **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.

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Text Books

1. Neill, A.H. (1977). *Life contingencies*. Society of Actuaries.

Suggested Readings

1. Benjamin, B. (1980). *The analysis of mortality and other actuarial statistics* (2nd ed.). William Heinemann.
2. Booth, P.M. (1999). *Modern actuarial theory and practice*. Chapman & Hall.
3. Bowers, N.L. (1997). *Actuarial mathematics* (2nd Edition). Society of Actuaries.
4. Gerber, H.U. (2011). *Life insurance mathematics* (3rd ed.). Springer.

Course Title:	Mortality Data Analysis
Course Code:	ACTS-404
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Know how to compute the premiums for mortalities with respect to the type of the contracts.
2. Calculate the gross premiums.
3. Describe the techniques of discounting emerging cost for use in pricing, reserving and assessing profitability.
4. Construct and use of a multiple decrement service tables for pension's calculations.

Course Outline

Unit 1

1.1 Variable benefits and with profit policies

Calculations for select and ultimate mortalities of net premiums and net premium provisions for increasing and decreasing benefits and annuities, with profit contracts, list the type of bonus that may be given to with profits contract, calculation of net premiums and net premiums provision for with profit contracts.

1.2 Gross Premiums

Gross premiums and provisions for fixed and variable benefits contracts: Calculation of gross premiums and provisions of assurance and annuity contracts, calculation of gross premium using loss random variable for benefits and annuities with the help of equivalence principle and other than equivalence principle, calculation of gross premium prospective and retrospective provisions using random loss variable and their conditions of equivalent. Derivation of a recursive relation between successive annual provisions for an annual premium contracts with allowance for expenses for standard fixed benefit contracts.

Unit 2

2.1 Profit Testing and Competing Risks

Describe the techniques of discounting emerging cost for use in pricing, reserving and assessing profitability, unit linked contracts, cash flows related to whole life, endowment and term assurance with unit linked contracts, profit testing signature, the net present value and profit margins and its use in to price a product. Determine provisions and profit testing, profit test to be used to determine provisions,: Describe methods which can be used to model cash flows contingent upon competing risks.

2.2 Multiple decrement tables

Describe the construction and use of a multiple decrement service tables for pension's calculations, including the relationships with associated single decrement tables, Pension Fund, Mortality, Selection and standardization.

- **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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Text Book

1. Benjamin, B. (1980). *The analysis of mortality and other actuarial statistics* (2nd ed.). William Heinemann.

Suggested Readings

1. Bowers, N.L. (1997). *Actuarial mathematics* (2nd Edition). Society of Actuaries.
2. Booth, P.M. (1999). *Modern actuarial theory and practice*. Chapman & Hall.
3. Gerber, H.U. (1997). *Life insurance mathematics* (3rd Edition). Springer.
4. Neill, A.H. (1977). *Life contingencies*. Society of Actuaries.

Course Title:	Employee Benefit Management
Course Code:	ACTS-405
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the economic basis of old-age problems.
2. Learn about the basic features of a pension plan and its various types.

Course Outline

Unit 1

1.1 Introduction

Underlying forces: Economic basis of the old-age problems, Population trend, Employment opportunities for aged, Capacity to save for old age, changed concept of filial Responsibility.

1.2 Public pension Program

Federal Old-Age and survivors Insurance, Federal staff retirement Plans, noncontributory pension program. The private Pension Movement: Rationale, Forces influencing the growth of private pension plans.

Unit 2

2.1 Basic Features of a Pension Plan and its types

Coverage, benefit structure, retirement benefits, termination benefits, sources of financing. Types of Formal pension Plans: Individual contract plan, group plan. Types of Formal pension Plans: self-administrated trusteed plan, combination Plan. Method of Financing: Disbursement approach, advance funding. Choice of funding Medium: Cost, Security benefits, Flexibility, service.

- **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.

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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.

Text Book

1. Butler, R.J. (1999). *The Economics of Social Insurance and Employee Benefit.* Kluwer Academic Publishers.

Suggested Readings

1. McGill, D., Brown, K.N., Haley, J.J., Schieber, S. & Warshawsky, M.J. (2010). *Fundamentals of Private Pensions* (9th ed.). Oxford University Press.
2. Rosenbloom, J. (2011). *The Handbook of Employee Benefits: Health and Group Benefits* (7th ed.). McGraw-Hill Education.

Course Title:	Life and Health Insurance
Course Code:	ACTS-406
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

On completion of this course the candidate will be able to:

1. Define the principal terms used in health and care.
2. Describe and understand the main types of contract and their purpose for the customer.
3. Describe the principles by which health and care insurance contracts are designed and the interests of the various stakeholders in the process.
4. Understand the operating environments in which health and care insurance products and services are traded.
5. Understand and apply the techniques used in pricing health and care insurance.

Course Outline

Unit 1

1.1 Introduction

Critical illness insurance, income protection insurance, long term care insurance, health cash plans, major medical expenses, private medical insurance, group and individual covers. Distribution channels, regulatory and taxation regimes. Professional guidance, economic and political influences.

1.2 Role of the State in the provision of alternative health and care protection

Objectives of State healthcare provision, methods of State healthcare provision and funding approaches.

1.3 Techniques used in pricing health and care insurance products

Techniques used in pricing health and care insurance products in terms of data availability, assumptions used, equation of value / formula approach, cash flow techniques, group risk assessments, options and guarantees, external influences.

Unit 2

2.1 Nature of the risks facing the insurer

Data, claim rates, claim amounts, investment performance, expenses and inflation, persistency, mix of new business, volume of new business, guarantees and options, competition, actions of management , counterparties, legal, regulatory and tax developments, reputation, internal audit failures/fraud, physical risks, aggregation and concentration of risk, catastrophes, non-disclosure and anti-selection.

2.2 Use of reinsurance to manage the risks and the reinsurance products involved

Reasons for reinsurance, types of reinsurance and determination of the retention level. Other ways in which insurers manage their risks: underwriting, claims management, data checks, product design, managing the distribution process and customer relationship, managing other counterparties, other internal processes.

2.3 Principal modeling techniques appropriate to health and care insurance

Asset-liability modeling, objectives and basic features of a health insurance model, uses of models, multi-state modeling, comparison of formula and cash flow approach, sensitivity analysis, deterministic and stochastic models. Assumptions that are crucial to pricing and valuation, including profit requirements.

Unit 3

3.1 Purposes of reserves, solvency capital requirements and embedded values

The methodologies by which these are calculated for a health and care insurer, including: role of statistical and individual case estimates, setting assumptions, including a comparison with those used in pricing, market consistent valuation, the interplay between the strength of the supervisory reserves and the level of solvency capital required.

3.2 Value at Risk (VaR) capital assessment

Comparison of passive and active valuation approaches. Principles of investment and how they apply to health and care insurance and the principles by which the experience from a health insurance operation is used to refocus business planning: reasons for monitoring experience, data required, analysis of mortality, morbidity, claim amounts and persistency rates, analysis of expenses, new business and investment experience • reasons for analysis of surplus and analysis of embedded value profit, use of results to revise the models and assumptions used.

- **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.

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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.

Text Book

1. Lombardi, L. (2006). *Valuation of Life Insurance Liabilities* (4th ed.).

Suggested Readings

2. Zultowski, B. (2014). *The Art and Science of Life Insurance Distribution.*

Course Title:	Investment and Portfolio Management
Course Code:	ACTS-407
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn in detail about Investment, its objectives and characteristics.
2. Acquire the knowledge of Portfolio Management in depth.
3. Conduct Fundamental analysis along with the practical applications.

Course Outline

Unit 1

1.1 Introduction to Investment and its various dimensions

The nature and Meaning of Investments, Financial in Economic Concept of investment, Characteristics of Investment, Objectives of Investment, Investment Vs. Speculation, Investment Vs. Gambling. Types of Investors: Individual and Industrial Investor,

1.2 Introduction to portfolio Management

Phases of portfolio Management, Security Analysis, Portfolio analysis, Portfolio Selection. Portfolio Evaluation, Evolution of portfolio Management, Historical Facts. Phases of Evolution: Speculative Phase, Phase of Professionalize, Scientific Phase, role of Portfolio Management. Investment and Risk: Meaning of Risk, Elements of Risk, Systematic Rate of risk, Market Risk, Purchasing Power Risk.

Unit 2

2.1 Fundamental Analysis

Unsystematic Risk: Business Risk, Financial Risk, Fundamental Analysis: the concept of fundamental analysis, Economy-Industry-Company analysis frame work, Economy Analysis: Growth rate of National Income, Interest rate, Government revenue, expenditure and deficit, Exchange rates, Infrastructure, Economic and political stability, economic forecasting.

2.2 Procedure of dealing on stock Exchange

Broker, Order, contract, communication, settlement. Buyer and seller of Securities: Types of Speculators, Causes of Fluctuation in Security prices, Types of Orders, Pakistan's Stock Market

- **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.

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Text Book

1. Elton, E.J., Gruber, M.J., Brown, S.J. and Goetzmann, W.N. (2014). *Modern Portfolio Theory and Investment Analysis* (9th ed.). Wiley and Sons.

Suggested Readings

1. Kevin, S. (2006). *Portfolio Management* (2nd ed.). Prentice Hall of India.

Course Title:	Pension Models
Course Code:	ACTS-408
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Define the principal terms used in the provision of pensions.
2. Describe the role that each of the following parties may play in the provision of pensions and other benefits.
3. Compare alternative systems of social security, mandatory individual accounts, occupational pension schemes and personal pensions.

Course Outline

Unit 1

1.1 Providers of pension and other benefits

Principal terms used in the provision of pensions. Role of the State, employers or groups of employers and individuals or groups of individuals.

1.2 Alternative systems of benefit provision

Alternative systems of social security and their comparison, mandatory individual accounts, occupational pension schemes and personal pensions. The ways in which the State and employers may meet their needs in relation to the forms and levels of benefits that may be needed by individuals, the financing and non-finance related needs of different sponsors and the regulation of non-State provision.

Unit 2

2.1 Environment in which benefits provided

Discuss the implications of the environment in which benefits are provided in terms of the effect o different presentation and reporting of benefits and contributions any professional guidance for actuaries or other professionals.

2.2 Financing benefits and Sponsor covenant

Ways in which providers may be able to finance the benefits to be provided in terms of the alternatives that may exist relating to the timing of contributions relative to benefit payments, the forms and characteristics of investment that may be available if contributions are made before benefits are due for payment. The issues surrounding sponsor covenant in terms of what is meant by sponsor covenant, how to measure the willingness of the sponsor to contribute, how to measure the ability of the sponsor to contribute and when the other parties involved should consider the sponsor covenant.

Unit 3

3.1 Scheme design – general/ specific

Factors to consider in determining a suitable design for a defined benefit scheme, in terms of benefits and contributions, in relation to, the level and form of benefits to be provided, the method of financing the benefits to be provided, the choice of assets when benefits are to be funded

3.2 Risks and uncertainties

Describe the risks and uncertainties affecting the level and incidence of benefits, the level and incidence of contributions, the level and incidence of return on assets when benefits are funded and the overall security of 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.

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Text Book

1. Gill, M. (2010). *Fundamentals of Private Pensions* (9th ed.). Oxford University Press.

Suggested Readings

1. Yamamoto, D.H. (2015). *Fundamentals of Retiree Group Benefits* (2nd ed.). ACTEX.

Course Title:	General Insurance
Course Code:	ACTS-409
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Define the principal terms in use in general insurance.
2. Describe the main types of general insurance products
3. Learn the main types of general reinsurance products and the purposes for which they may be used.
4. Know the implications of the general business environment.

Course Outline

Unit 1

1.1 Introduction

Define the principal terms in use in general insurance. Describe the main types of general insurance products in terms of: the needs of customers, the financial and other risks they pose for the general insurer including their capital requirements and possible effect on solvency.

1.2 Types and purposes

Describe the main types of general reinsurance products and the purposes for which they may be used. Describe the implications of the general business environment in terms of: the main features of the general insurance market, the effect of different marketing strategies , the effect of the regulatory and fiscal regimes, the effect of inflation and economic factors, the effect of legal, political and social factors, the effect of the climate and environmental factors, the general effect of professional guidance, the impact of technological change.

1.3 Risk and Uncertainty in general insurance

Describe the major areas of risk and uncertainty in general insurance business with respect to pricing, in particular those that might threaten profitability or solvency. With regard to the use of data in pricing: (i) describe the types of data that are used. (ii) Describe the main uses of data. (iii) Describe the requirements for a good information system. (iv) Outline the possible causes of data errors. (v) Understand the effects of inadequate data.

Unit 2

2.1 Actuarial valuation models in general insurance

Outline the major actuarial investigations and analyses of experience undertaken with regard to pricing for general insurers, including the monitoring of business being written. (i) Describe the Individual Risk Model and its applications in a general insurance environment. (ii) Describe the Collective Risk Model and its applications in a general insurance environment. (iii) Understand the derivation of the Aggregate Claim Distribution for the Collective Risk Model, and its approximations using stochastic simulation. Understand the various components of a general insurance premium. (ii) Describe the basic methodology used in rating general insurance business. (iii) Appreciate the various factors to consider when setting rates. (j) Develop appropriate rating bases for general insurance contracts, having regard to: return on capital, underwriting considerations, reinsurance considerations, investment, policy conditions such as self-retention limits, the renewal process and expenses.

2.2 Cost and loss measurement

Describe the burning cost approach to rating. (ii) Understand the assumptions required when using this approach. (iii) Outline the practical considerations when using this approach. (l) (i)

Describe the frequency / severity approach to rating. (ii) Understand the assumptions required when using this approach. (iii) Outline the practical considerations when using this approach. Describe how Original Loss Curves can be used in rating. (ii) Understand the assumptions required when using this approach. (iii) Outline the practical considerations when using this approach. (n) Understand the applications of Generalised Linear Models to the rating of personal lines business and small commercial risks.

2.3 Models used in general insurance

Understand the uses of multivariate models in pricing. (ii) Outline the different types of multivariate models. (i) Outline the fundamental concepts of credibility theory. (ii) Describe and compare the Classical and Bayes credibility models. (iii) Describe the practical uses of credibility models in a general insurance environment. Outline the similarities and differences between pricing direct and reinsurance business. (ii) Describe how to determine appropriate premiums for each of the following types of reinsurance: proportional reinsurance, non-proportional reinsurance, property catastrophe reinsurance, stop losses (iii) Describe the data required to determine appropriate premiums for each of the above types of reinsurance. Outline the basic structure of a catastrophe model. (ii) Describe the key perils that can be modeled.

- **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.

Text Book

1. Friedland, J. (2013). *Fundamentals of General Insurance Actuarial Analysis*. Society of Actuaries.

Suggested Readings

1. Grossi, P., & Kunreuther, H. (2005). *Catastrophe Modeling: A New Approach to Managing Risk*. Springer Science.

Course Title:	Takaful and Insurance Practices
Course Code:	ACTS-410
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn in detail the system of Takaful and its framework.
2. Explore the legal issues in Takaful.
3. Build Takaful business models along with knowledge of risk management in Takaful.

Course Outline

Unit 1

1.1 Takaful and its products

Relationship between risk, insurance(Takaful), Sharia and regulatory framework, Corporate Governance and stakeholder rights, Legal issues in Takaful, Takaful business models, Takaful products, Underwriting and claim management, Distribution and Servicing

1.2 Takaful and Actuarial concepts

Actuarial concept and Actuarial control cycle, Product design and pricing.

Unit 2

2.1 Portfolios

Investment portfolios of Takaful Undertaking, Valuation of Liabilities, Surplus distribution, Financial and capital management, Retakaful arrangements, Risk management of takaful operations, Solvency and Capital Adequacy in Takaful, Reinsurance and takaful, Issues in Rating Takaful Companies, Transparency and Financial reporting in Islamic Insurance

- **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.
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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.

Text Book

Ismail, E. (2011). *Takaful Actuarial Practices* (2nd ed.). International Centre for Education in Islamic Economics.

Suggested Readings

1- Archer, S., Karim, R.A.A., & Nienhaus, V. (2011). *Takaful Islamic Insurance; Concepts and Regulatory Issues*. John Wiley and Sons.
2- Sohail, J. (2007). *Islamic Insurance: Trends, Opportunities and the Future of Takaful*. Euromoney.

Course Title:	Islamic Mode of Finance
Course Code:	ACTS-411
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the theoretical framework of Islamic system of Finance.
2. Grasp the knowledge of Shariah-based Islamic instruments
3. Acquire the concept of Islamic Finance in terms of Pakistan's financial system.

Course Outline

Unit 1

1.1 Primary background and Theoretical Foundations of Islamic System of Finance

Islamic Economic System and Introduction, Macroeconomic theories from Islamic perspective, Islamic Banking and Finance in theory and practice, Financial intermediation in the framework of Shariah, The role of Shariah-based financial instruments in Islam,

1.2 Mechanism of Islamic Financial Markets and their Principles

The mechanism and operations of Islamic financial markets, Islamic modes of finance, Principles of Islamic Financing, External financing in Islam, Empirical Investigation on Islamic Development bank - its role and functioning and Contemporary experiences of Islamic Banks.

Unit 2

2.1 Islamic Finance and Pakistan's Financial System

Islamic Finance in Pakistan's Context, Supreme Court's Judgment on the issue, Interest-free Banking in Pakistan, Long-term Financing in Pakistan, Islamic Modes of Finance in Pakistan: A practical experience

- **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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Text Book

1. Manzar, K. (1978). *The Islamic Economy: An analytical study of the functioning of Islamic Economic System.* Muslim Students Association of U.S. and Canada.

Suggested Readings

1. Khurshid, A. (1976). *Studies in Islamic Economics*. The Islamic Foundation, Liecester, UK.

Course Title:	Financial Risk Management
Course Code:	ACTS-412
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn about different financial markets and their operations.
2. Acquire the knowledge regarding derivative securities and its related concepts.
3. Fit different types of financial models in practical settings.

Course Outline

Unit 1

1.1 Financial markets

Stock market, Money market, Bond market, General return model, Interest rates, risk and return, Insurance and annuities.

1.2 Derivative Securities

Forward, Future, Option, Swap, Caps and floors, Reinsurance, Securitization of assets, Interest rate and Immunization: Interest rate risk, , Equilibrium pricing, No-Arbitrage Pricing theory, Option and other derivatives.

Unit 2

2.1 Financial Models

Term Structure models, Portfolio selections, Investment return Models, Financial models, Econometric models, Actuarial stochastic Investment models, Insurance and pension Applications, A Model for the stock price process, Self- portfolios, The Markowitz Model and its properties, The asset liability models, Shortfall Constraints, Factor models, The price of a contingent Claims, The geometric Brownian Motion case, Option on two stocks, Dividend Models, Incomplete market model, American option, financing Forward and future prices.

- **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.

Text Book

1. Panjer, H.H. (1998). *Financial economics: with applications to investments, insurance and pensions*. The Actuarial Foundation.

Suggested Readings

1. Baxter, M., & Rennie, A. (1996). *Financial calculus; An introduction to derivative pricing* (17th ed.). Cambridge University Press.
2. Elton, J.E., Gruber, M.J., & Brown, S.J.G. (2009). *Modern portfolio theory and investment analysis* (8th ed.). William N.
3. Hull, J.C. (2002). *Options, futures and other derivatives* (5th ed.). Prentice Hall.

Course Title:	Trade Finance
Course Code:	ACTS-413
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn risk-free rate of return, and describe assets that may be assumed to be risk-free in practical work.
2. Understand ways in which investment returns are taxed along with the principles of fundamental analysis of equities and bonds.
3. Apply appropriate methods for the valuation of individual investments and demonstrate knowledge and understanding of the theory of finance along with the characteristics of specialist financial instruments.
4. Analyze the performance of an investment and Describe the construction of investment indices and the principal features of major investment indices

Course Outline

Unit 1

1.1 Concept of Risk-free Rate

Concept of risk-free rate of return and assets that may be assumed to be risk-free in practical work. The typical ways in which investment returns are taxed and the effect of the taxation is based on investor's behavior.

1.2 Commercial and Economic Environment

Knowledge of the influences over the commercial and economic environment from central banks, main investor classes and government policy. Principles of fundamental analysis of equities and bonds.

Unit 2

2.1 Methods of Valuation

Appropriate methods for the valuation of individual investments and an understanding of their appropriateness in different situations. Fixed income analytics and valuation (including interest rate swaps and futures). Arbitrage pricing and the concept of hedging, empirical characteristics of asset prices, introduction into fixed income option pricing, evaluating a securitisation (including CBO's and MBS's) and evaluation of a credit derivative.

2.2 Methods controlling the exposure to different types of risk

Asset / liability mismatching risk, market risk, credit risk (including counterparty risk), operational risk, liquidity risk, relative performance risk and explain in the context of mean-variance portfolio theory what is meant by opportunity set, efficient frontier, indifference curves and the optimum portfolio

2.3 Principles and aims of market conduct regulatory regimes

Knowledge of the principles underlying the legislative and regulatory framework for investment management and the securities industry. Demonstrate how these principles can be applied in the areas of: trust law, corporate governance, role of the listings authority, environmental and ethical issues, competition and fair trading controls, monopolies regulators, investment restrictions in investment agreements, provision of financial services, institutional investment practices, EU legislation, role and responsibilities of directors and development of international accounting standards.

2.4 Theory of finance

Relationship between financial management and acting as an entrepreneur. Outline the possible motives for mergers and divestitures. Discuss the key findings in behavioural finance. Outline the main steps involved in financial planning. Demonstrate a knowledge and understanding of the characteristics of specialist financial instruments: financial instruments available for short-term lending and borrowing, corporate debt and credit derivatives, swaps and swaptions , private debt, asset-backed securities, securitization, venture capital, hedge funds, currency, infrastructure, commodities , structured products, new ways of investing in old asset classes. Main types of derivative contract, how they are traded, and define their payoffs. Actuarial techniques may be used to develop an appropriate investment strategy. Asset pricing models, asset / liability modelling , asset / liability mismatch reserving, credit rating an entity, liability hedging, dynamic liability benchmarks. Performance of an investment and discuss the limitations of such measurement techniques. Portfolio risk and return analysis, equity price, net present value, net asset value, return on capital.

Unit 3

3.1 Construction of investment indices and their principal features

Uses of investment indices. Describe the principal indices in the United Kingdom, United States, Japanese, German and French stock markets. Explain the problems encountered in constructing property indices.

3.2 Performance of an investment portfolio

Assess the performance of a portfolio relative to a published market index. Assess the performance of a portfolio relative to a predetermined benchmark portfolio. Analyse the performance of a portfolio into components relating to investment sector selection and individual stock selection. Discuss the relative merits of assessing portfolio performance relative to published indices, other portfolios or a predetermined benchmark portfolio. Discuss the uses of risk adjusted performance measures. Discuss the value of portfolio performance measurement and its limitations.

3.3 Principal techniques in portfolio management including risk control techniques

Principal active management “styles” (value, growth, momentum, rotational). Principal equity portfolio management techniques. Discuss the principal bond portfolio management techniques. Discuss the uses which an institutional investor might make of financial futures and options, including over the counter contracts. Discuss the uses which an institutional investor might make of interest rate and currency and inflation swaps. Discuss the uses which an institutional investor might make of forward foreign exchange contracts for currency hedging. Discuss the usefulness of multifactor models in practical investment management and risk control. Discuss the problems of making significant changes to the investment allocation of a substantial portfolio. Transition management and asset allocation techniques (including overlay strategies). Role of the custodian. Portfolio construction with attention to value at risk, tracking error, risk budgets. Measurement, comparison and attribution of risk

- **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.

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Text Book

1. Berk, J., & DeMarzo, P. (2014). *Corporate Finance* (3rd ed.). Pearson Publishers.

Suggested Readings

1. Dowd, K. (2005). *Measuring Market Risk* (2nd ed.). John Wiley & Sons
2. Sweeting, P. (2011). *Financial Enterprise Risk Management*. Cambridge University Press.

Course Title:	Advanced Risk Management
Course Code:	ACTS-414
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the concept of valuation of derivative securities and their associated risks.
2. Apply the binomial models.
3. Understand the technique of Black-Schole mode.

Course Outline

Unit 1

1.1 Introduction to the valuation of derivatives securities

Arbitrage, the principle of no arbitrage, Preliminary concepts, European call options, European put option, American options, intrinsic value, Factor affecting option prices, underlying share price, strike price, time to expiry, volatility of the underlying share, interest rates, income received on underlying shares, The Greeks and risk management. Pricing forward contracts, Bonds for option prices, lower bounds on option prices, upper bounds on option prices, put-call parity. The Greeks: portfolio risk management, delta, Gamma, Vega, Rho, Lamda, theta

1.2 The Binomial Model

The one-period model, Two-period binomial tree, n-period binomial tree, recombining binomial trees, the state-price deflator approach.

Unit 2

2.1 The Black-Scholes Option Pricing Formula

The assumptions underlying the Black-Scholes model, The Black-Scholes model, The PDE approach, The Black-Scholes model for dividend-paying shares, The Garman-Kohlhagen formula, The Greeks for a European call option on a dividend-paying share, how delta and gamma vary with the underlying asset price, the use of Greeks in risk management.

2.2 Arbitrage-free pricing and the 5-step models with the Black-Scholes mode

The 5- step method in continuous time, the state-price-deflator approach, the 5-step approach with dividends. The term structure of interest rate: relationship between interest rate and bond option, characteristics of a term structure model, the risk-neutral approach to pricing, the market price of the risk, the risk-neutral measures as a computational tool, Models for the term structure of interest rates, the Vasicek model, the Cox-Ingersoll-Ross model, the Hull and White model, limitation of one factor models, Multifactor models

- **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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Text Book

1. Elton, E.J., Gruber, M.J., Brown, S.J., & Goetzmann, W.N. (2003). *Modern portfolio theory and investment analysis*. (6th ed.). Wiley.

Suggested Readings

1. Hull, J.C. (2002). *Options, futures and other derivative*. (5th ed.). Prentice Hall.

COURSE OUTLINES FOR ELECTIVES – GROUP IV (DATA SCIENCE)

Course Title:	Data Mining
Course Code:	DTSC-401
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the key concepts of data mining along with classification trees and discriminant analysis.
2. Learn Multiple Linear regression in data mining.
3. Compare different data mining techniques.

Course Outline

Unit 1

1.1 Introduction

Data mining overview. Prediction and classification with k-Nearest Neighbors Classification and Bayes rule, Naïve Bayes.

1.2 Classification methods

Classification trees. Discriminant analysis. Logistic regression. Neural network.

Unit 2

2.1 Regression methods

Multiple regression review. Multiple linear regression in data mining. Regression trees. Comparison of data mining techniques.

2.2 Clustering methods

K mean clustering. Hierarchical clustering. Principal component. Association rules.

- **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.

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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.

Text Book

1. Zaki, M. J., Meira Jr, W., & Meira, W. (2014). *Data mining and analysis: fundamental concepts and algorithms*. Cambridge University Press

Suggested Readings

1. Rajaraman, A., & Ullman, J. D. (2011). *Mining of massive datasets*. Cambridge University Press
2. Zhou, Z. H. (2003). *Three perspectives of data mining*.

Course Title:	Big Data
Course Code:	DTSC-402
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the analytics of big data and its basic framework.
2. Learn about the Hadoop distributed file system and different types of interfaces.
3. Acquire knowledge about PIG and its related concepts.

Course Outline

Unit 1

1.1 Introduction to big data and hadoop

Types of digital data, introduction to big data, big data analytics, history of Hadoop, Apache Hadoop, analyzing data with unix tools, analysing data with Hadoop, Hadoop streaming, Hadoop echo system, IBM big data strategy, introduction to Infosphere, BigInsights, and Big Sheets.

1.2 HDFS (Hadoop distributed file system)

The design of HDFS, HDFS concepts, command Line interface, Hadoop file system interfaces, data flow, data ingest with flume and scoop and Hadoop archives, Hadoop I/O: compression, serialization, avro and file-based data structures.

Unit 2

2.1 Map Reduce

Anatomy of a map reduce Job run, failures, Job scheduling, shuffle and sort, task execution, map reduce types and formats, map reduce features.

2.2 Hadoop Eco System

Pig, introduction to PIG, execution modes of Pig, comparison of Pig with databases, grunt, Pig latin, user defined functions, data processing operators. Hive, hive Shell, hive services, and hive metastore, comparison with traditional databases, hiveQL, tables, querying data and user defined functions. Hbase, hbasics, concepts, clients, example, hbase versus RDBMS. Big SQL.

- **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.

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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.

Text Book

1. Zikopoulos, P., & Eaton, C. (2011). *Understanding big data: Analytics for enterprise class hadoop and streaming data*. McGraw-Hill Osborne Media.

Suggested Readings.

1. McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D. J., & Barton, D. (2012). *Big data: the management revolution*. Harvard business review. *90*(10), 60-68.
2. Prajapati, V. (2013). *Big data analytics with R and Hadoop*. Packt Publishing Ltd.

Course Title:	Machine Learning
Course Code:	DTSC-403
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn the basic concepts and techniques of Machine Learning.
2. Develop the skills of using recent machine learning software for solving practical problems.
3. Gain hands-on experience of doing independent study and research.

Course Outline

Unit 1

1.1 Introduction to machine learning

Machine learning and pattern recognition. Supervised learning: Linear and non-linear regression, Non-parametric methods, Support vector machines and large-margin classifiers, Kernel methods, Model/Feature selection.

Unit 2

2.1 Unsupervised Learning

Clustering algorithms, K-means, Expectation-maximization, Gaussian mixture models, Anomaly detection, artificial neural networks.

2.2 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
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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.

Text Book

1. Bishop, C. M. (2006). *Pattern recognition and machine learning.* Springer.

Suggested Readings

1. Alpaydin, E. (2014). *Introduction to machine learning*. MIT press.
2. Marsland, S. (2011). *Machine learning: an algorithmic perspective*. Chapman and Hall/CRC.

Course Title:	Neural Network
Course Code:	DTSC-404
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. To understand important concepts and theories of artificial neural networks (ANNs).
2. Know the main types of neural networks.
3. Know and apply the methods of training neural networks.
4. Know the application of artificial neural networks.
5. To be able to formalize the problem, to solve it by using a neural network.

Course Outline

Unit 1

1.1 Introduction to neural networks

What are artificial neural networks? The structure of an ANN. The artificial neuron. Nodes. The bias Putting together the structure. The notation The feed-forward pass. A feed-forward. Vectorisation in neural networks. Matrix multiplication.

Unit 2

2.1 Gradient descent and optimization

The cost function .Gradient descent in neural networks. A two dimensional gradient descent. Vectorisation of backpropagation. Implementing the gradient descent step. The final gradient descent algorithm. Scaling data. Creating test and training datasets. Setting up the output layer. Creating the neural network. Assessing the accuracy of the trained model.

- **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.
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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.

Text Book

1. Hagan, M.T., Demuth, H.B., Beale, M.H., & Jesus, O. (2014). *Neural Network Design* (2nd ed.). Martin Hagan.

Suggested Readings

1. Haykin, S.O. (2008). *Neural Networks and Learning Machines* (3rd ed.). Pearson.

Course Title:	Cloud Computing
Course Code:	DTSC-405
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Analyze the trade-offs between deploying applications in the cloud and over the local infrastructure.
2. Deploy applications over commercial cloud computing infrastructures such as Amazon Web Services, Windows Azure, and Google AppEngine.
3. Program data intensive parallel applications in the cloud.
4. Solve a real-world problem using cloud computing through group collaboration.

Course Outline

Unit 1

1.1 Introduction to cloud computing

Definition of Cloud computing, history, overview of cluster computing and grid computing.

1.2 Cloud Based Service Offerings

Service models and deployment models. Computer networks, Cloud computing platforms, parallel programming in the cloud, distributed storage systems.

Unit 2

2.1 Virtualization

Virtualization structure, virtualization of CPU, memory, and I/O devices, virtual clusters.

2.2 Cloud security

Traffic eavesdropping, malicious intermediator, denial of service, insufficient authorization, virtualization attack, overlapping trust boundaries. Multicore operating system. Roles and boundaries in Clouds.

2.3 Cloud infrastructure

Logical network, Cloud storage device, Cloud usage monitor, resource replication, ready-made environment.

- **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.
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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.

Text Book

1. Erl, T., Puttini, R., & Mahmood, Z. (2013). *Cloud computing: concepts, technology, & architecture*. Pearson Education.

Suggested Readings

1. Jamsa, K. (2012). *Cloud computing: SaaS, PaaS, IaaS, virtualization, business models, mobile, security and more*. Jones & Bartlett Publishers.

Course Title:	Bayesian Machine Learning
Course Code:	DTSC-406
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Discuss the basics of Bayesian methods: from how to define a probabilistic model to how to make predictions from it.
2. Understand the powerful, consistent framework for approaching many problems that arise in machine learning, including parameter estimation, model comparison, and decision making.

Course Outline

Unit 1

1.1 Bayesian inference concepts

Prior and posterior distributions, Bayes estimators, credible inter- vals, Bayes factors, Bayesian forecasting, Posterior Predictive distribution.

1.2 Linear models for regression

Linear basis function models, Bayesian linear regression, Bayesian model comparison. Probabilistic generative models, Probabilistic discriminative models, The Laplace approximation, Bayesian logistic regression. Variational inference, Variational linear and logistic regression.Bayesian networks, Conditional independence, Markov random fields.

Unit 2

2.1 Mixture models and Clustering

Clustering, Mixtures, The EM algorithm.

2.2 Sampling Algorithms and Models

Basic sampling algorithms, Markov chain Monte Carlo, Gibbs sampling, Markov models, Hidden Markov models, Linear dynamical systems.

2.3 Gaussian processes

Bayesian Non-Parametrics, Gaussian processes for regression 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.

Text Book

1. MacKay, D. J. (2003). *Information theory, inference and learning algorithms*. Cambridge university press.

Suggested Readings

1. Bishop, C. M. (2006). *Pattern recognition and machine learning*. springer.
2. Murphy, K. P. (2012). *Machine learning: a probabilistic perspective*. MIT press.
3. Rogers, S., & Girolami, M. (2016). *A first course in machine learning*. CRC Press.

Course Title:	Natural Language Processing
Course Code:	DTSC-407
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Learn about basic NLP problems, tasks and methods.
2. Master basic programming tools for NLP.
3. Implement a simple NLP system.
4. Define a NLP problem and find a suitable solution to it.

Course Outline

Unit 1

1.1 Introduction

Natural language and formal language, regular expressions and finite state automata. N-grams and language models.

1.2 Programming in Python

An introduction to programming in Python. Why Python? Variables, numbers, strings, arrays, dictionaries, conditionals, iteration. The NLTK (Natural Language Toolkit), with demonstrations. Part of speech tagging. Syntax parsing. Key word and phrase extraction. Vector space model and dimensionality reduction. Topic modeling. Distributional models. Text classification. Sequence labeling. Deep learning for NLP POS Tagging, HMMs and POS.

- **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.

Text Book

1. Bird, S., Klein, E., & Loper, E. (2009). *Natural language processing with Python: analyzing text with the natural language toolkit*. "O'Reilly Media, Inc.".

Suggested Readings

1. Jurafsky, D., & Martin, J. H. (1999). *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition.* Prentice Hall.

Course Title:	Computer Vision
Course Code:	DTSC-408
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Get familiar with both the theoretical and practical aspects of computing with images.
2. Have described the foundation of image formation, measurement, and analysis.
3. Have implemented common methods for robust image matching and alignment.
4. Understand the geometric relationships between 2D images and the 3D world.

Course Outline

Unit 1

1.1 Overview

AI, Computer Vision, and Robots, Sensing, seeing, and perceiving. What is the role of vision?

1.2 Image Analysis

Sources of imagery, The physics of imaging, Representing, acquiring, and displaying images, Grayscale, color, noise, lens distortion, and filtering, Image processing, preprocessing, and image correction. Practical linear algebra, linear models and optimization, neural networks.

Unit 2

2.1 Geometry

Single-view geometry, multi-view geometry and application.

- **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.

Text Book

1. Szeliski, R. (2010). *Computer vision: algorithms and applications*. Springer Science & Business Media.

Suggested Readings

1. Forsyth, D. A., & Ponce, J. (2003). *Computer vision: a modern approach*, *17*, 21-48.
2. Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The elements of statistical learning: data mining, inference, and prediction*. Springer Science & Business Media.

Course Title:	Artificial Intelligence
Course Code:	DTSC-409
Semester:	VII & VIII
Credit Hours:	3 Credit Hours
Pre-requisites:	N / A

Learning Outcomes

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

1. Understand the opportunities that machine learning offers in data science and artificial intelligence.
2. List the objectives and functions of modern Artificial Intelligence.
3. Categorize an AI problem based on its characteristics and its constraints.
4. Understand and implement search and adversarial (game) algorithms.

Course Outline

Unit 1

1.1 Introduction

Problem Solving, Agents, Blind Search (BFS, DFS, IDA), Heuristic Search, Game Playing (Minimax, Alpha Beta, Expectimax)

1.2 Logic

Propositional logic, CNF, Resolution First Order Logic, Logic Programing, online resources, Constraint satisfactory problems, Probabilistic reasoning,

Unit 2

2.1 Machine learning for classification algorithms

Naive Bayes + SVM, Neural networks for classification online resources, Deep Learning, Language Understanding online resources.

- **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.
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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.

Text Book

1. Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A modern approach* (3rd ed.). Perason.

Suggested Readings

1. Fritz, S., & Foreword By-Brooks, R. (2002). *Understanding artificial intelligence*. Warner Books, Inc.
2. Graubard, S. R. (1988). *The artificial intelligence debate*. Cambridge (Ma): MIT press.
3. Schalkoff, R. J. (1990). *Artificial intelligence: an engineering approach* (pp. 529-533). New York: McGraw-Hill.