SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF STATISTICS

Curriculum BS Statistics
2023 & onwards

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Department of Statistics

This Curriculum has been approved by the 2nd Board of Studies (by circulation), 12th Meeting of Board of Faculties (Science), 19th meeting of Academic council and is placed before Syndicate for approval.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF STATISTICS

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   (Lecturer)

3. Ms. Ghazala Sahib
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Affiliation and Monitoring, SBBWU

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Dean Faculty of Sciences & Social Science,
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VISION STATEMENT OF THE DEPARTMENT OF STATISTICS

The vision of the department of statistics is to provide education and research facilities in the field of statistics, also to provide a platform for statistical collaboration with researchers from other fields of knowledge and encourage participation of female segment of population in the development of the society.

MISSION STATEMENT OF DEPARTMENT OF STATISTICS

The Department of Statistics aims:

- To provide quality graduates in the field of Statistics.
- To create awareness among the students about virtues and ethics.
- To educate females to be able to apply their knowledge in research

BS (4 YEARS) STATISTICS

PROGRAM OBJECTIVES

- To provide students with sound background of statistical knowledge and skills, so that they can pursue higher degrees and research in the field of statistics and to compete in the job market.
- To prepare the students to provide help and consultation in data analysis to researchers, working in various fields.
- To enable the students to link theory with practice while using Statistical techniques and to highlight the role of Statistics and its importance in Research.
- To enable the students to implement statistical packages for data analysis and research.
- To involve the students in project-based activities.

INTENDED OUTCOMES OF THE PROGRAM

Upon successfully completing the study program the students will be able to:

- Apply statistical techniques to solve the survey and research problems in various areas.
- Analyze and interpret the data in conducting researches
- Communicate effectively the results with researchers in their professional dealings.
- Work as a part of organization and take optimal decisions in improving the productivity and utilization of the resources of the organization.
- Demonstrate best standards of professional and ethical practices and responsibilities.

ELIGIBILITY CRITERIA

- Intermediate, with at least 45 % marks in aggregate

Structure of BS Statistics as per HEC New UEP 2023

Sr.	Categories	Credit Hours Min – Max
1.	General Education (Gen Edu) Requirements: Mandatory Courses of General Education.	30 – 30
2.	Major (Disciplinary) Requirements: Area of Study in Which the Degree is offered	*72 ≥
3.	Interdisciplinary/Allied Requirements (To Support Horizon of the Major)	**12 ≥
4.	Field Experience/Internship (Practical Work Experience related to a Student's Field of Study or Career interest)	03 – 03
5.	Capstone Project or Capstone Research Project	03 – 06
	Total	**120 – 144**

*The Credit Hours for the courses of Major Disciplines may vary but not less than 72 Credit Hours.
**The Credit Hours for Interdisciplinary/Allied Courses may vary but not less than 12 Credit Hours.

- Total number of Credit hours   120-144
- Duration   4 years
- Semester duration   16-18 weeks
- Semesters   8
- Course Load per Semester   15-18 Cr hr
- Number of courses per semester   4-6 (not more than 3 lab / practical courses)

SCHEME OF STUDIES OF BS STATISTICS 4-YEAR PROGRAM
(SESSION 2023 & Onwards)

Semester	Category	Course Codes	Course Title	Lectures	Lab	Cr.Hrs
Semester 1	Art & Humanities	AH-301	Art & Humanities	2	0	2
	Islamic Studies/Religious Studies/Ethics	ISL-301	Islamic Studies/Religious Studies	2	0	2
	Interdisciplinary/Allied	ECO-302	Fundamentals of Economics	3	0	3
	Functional English	ENG-303	Functional English	3	0	3
	Major I	STAT-306	Introduction to Statistics	3	0	3
	Major II	STAT-308	Basic Statistical Methods	3	0	3
			Total			**16**
Semester 2	Social Sciences	000	Social Science	2	0	2
	Expository Writing	ENG-304	Expository Writing	3	0	3
	Interdisciplinary/Allied	MTH-301	Calculus & Analytical Geometry	3	0	3
	Ideology and Constitution of Pakistan	PST-313	Ideology and Constitution of Pakistan	2	0	2
	Major III	STAT-307	Fundamentals of Probability and Probability Distributions	3	0	3
	Major IV	STAT-309	Linear Algebra and Numerical Analysis	3	0	3
			Total			**16**
Semester 3	Quantitative Reasoning (QR I)	MTH-401	Quantitative Reasoning (QR-I)	3	0	3
	Application of Information and Communication Technologies.	CSC-308	Applications of Information and Communication Technologies(ICT)	2	1	3
	Natural Science	000	Natural Science	2	1	3
	Entrepreneurship	MS-309	Introduction to Entrepreneurship	2	0	2
	Major V	STAT-405	Exploratory data analysis and visualization	3	0	3
	Major VI	STAT-406	Basic Statistical Inference	3	0	3
			Total			**17**
Semester 4	Civic and Community Engagement	PSC-418	Civic and Community Engagement	2	0	2
	Quantitative Reasoning (QR II)	MTH-402	Quantitative Reasoning(QR II)	3	0	3
	Major VII	STAT-407	Introduction to Regression and Analysis of Variance	3	0	3
	Major VIII	STAT-408	Applied Statistics	3	0	3
	Major IX	STAT-410	Non-parametric techniques	3	0	3
	Major X	STAT-411	Bio-Statistics and Epidemiology	3	0	3

				Total			17
Semester 5	Interdisciplinary/Allied Course	MTH-302	Advanced Calculus	3	0	3
	Major XI	STAT-511	Random Variables and Probability Distributions	3	0	3
	Major XII	STAT-512	Sampling Fundamentals and Techniques	3	0	3
	Major XIII	STAT-513	Experimental Designs	3	0	3
	Major XIV	STAT-514	Regression Analysis	3	0	3
				Total			15
Semester 6	Interdisciplinary/Allied Course	MTH-501	Differential Equations	3	0	3
	Major XV	STAT-521	Continuous Probability Distributions	3	0	3
	Major XVI	STAT-522	Sampling Techniques and Survey Methods	3	0	3
	Major XVII	STAT-523	Experimental Designs and Analysis of Experiments	3	0	3
	Major XVIII	STAT-524	Econometrics	3	0	3
	Major XIX	STAT-507	Population Studies	3	0	3
				Total			18
Semester 7	Internship (Mandatory)	STAT-698	Internship (Mandatory)	3	0	3
	Major XX	STAT-611	Statistical Inference: Estimation of Parameters	3	0	3
	Major XXI	STAT-612	Multivariate Methods	3	0	3
	Major XXII	STAT-606	Statistical Packages	3	0	3
	Major XXIII(Elective)	STAT-614	Survey and Research Methods (Elective)	3	0	3
	*Capstone Research Project OR Capstone Project + Optional Course	STAT-699 OR STAT-697	Capstone Research Project OR Capstone Project + Optional Course	3	0	3
				Total Cr.Hrs.			18
Semester 8	Major XXIV	STAT-621	Statistical Inference : Hypothesis Testing	3	0	3
	Major XXV	STAT-622	Applied Multivariate Analysis	3	0	3
	Major XXVI	STAT-624	Time Series Analysis	3	0	3
	Major XXVII (Elective)	STAT-627	Survival Analysis (Elective)	3	0	3
	*Capstone Research Project OR Capstone Project + Optional Course	STAT-699 OR STAT-697	Capstone Research Project OR Capstone Project + Optional Course	3	0	3
				Total Cr.Hrs.			15

*Students who are not opting Capstone Research project of 6 credit hours, will have to take one optional course and Capstone Project each of 3 credit hours.

List of Major Elective/Optional Courses (offered in 7th and 8th semester)

S.No	Course Code	Course Title	Credit Hours
1	STAT-613	Statistical Quality Control	3
2	STAT-614	Survey and Research Methods	3
3	STAT-615	Robust Methods	3
4	STAT-616	Operation Research	3
5	STAT-617	Statistical Practicum	3
6	STAT-618	Applied Bio Statistical Analysis	3
7	STAT-619	Official Statistics	3
8	STAT-620	Applied Categorical Data Analysis	3
9	STAT-623	Stochastic Process	3
10	STAT-625	Decision Theory	3
11	STAT-626	Reliability Analysis	3
12	STAT-627	Survival Analysis	3
13	STAT-628	Data Mining	3
14	STAT-629	Actuarial Statistics	3
15	STAT-630	Mathematical Modeling & Simulation	3
16	STAT-631	Bayesian Analysis	3

DETAILS OF THE COURSES:

First Semester:

Course Title: Art & Humanities	Course Code: 000
Course Structure: Lectures: 2, Labs: 0	Credit Hours: 2
Prerequisites: Nil	
Course Objective:	
Course Outline: **The Course contents will be taken from the booklet of mandatory and general courses.**	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Islamic Studies	Course Code: ISL-301
Course Structure: Lectures: 2, Labs: 0	Credit Hours: 2
Prerequisites: Nil	
Course Objective: This course is designed to provide students with a comprehensive overview of the fundamental aspect of Islam, its beliefs practices History and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course students will have and enhanced understating of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's Historical and contemporary role fostering empathy respect and informed dialogue.	
Course Outline: **Introduction to Islam:** Definition of Islam and its core beliefs The Holy Qur'an (Introduction,	

Revelation and compilation, Hadith and Sunnah (Compilation Classification and Significance) Key theological concepts and themes (Tawhid , Prophet hood Akhirah etc., **Seerat of Holy Prophet (S.A.W)** Life and legacy of the Holy prophet **(S.A.W** Diverse role of the Holy Prophet (as an individual, educator, peace maker, leader etc.**), Islamic History and civilization** World Before Islam Rashidun Caliphate and expansion of Islamic rule, Contribution of Muslim scientists and philosophers in shaping world civilization,

Islamic Jurisprudence: (Fiqh) Fundamental Sources of Islamic Jurisprudence Pillars of Islam and their significance Major Schools of Islamic Jurisprudence**,** Significance and principles of Ijtihad,

Family and Society in Islam Status and rights of woman in Islamic Teachings, Marriage, Family, and gender roles in Muslim society, Family structure and values Muslim society, **I**slam & the Modern World.

Course Outcomes: After completing the course, the students will be able to

1. Demonstrate enhanced knowledge of Islamic foundational beliefs, practices historical development spiritual values and ethical principles
2. Describe basic source of Islamic law and their application in daily life

Identify and discuss contemporary issue being faced by the Muslims world including social challenges, gender role and interfaith interactions

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Recommended Books: Latest Edition of the Following Books.

Suggested Instructional Materials

1. The five Pillars of Islam: A journey thought the Divene Acts of Worship by Muhammad Mustafa Al Azami
2. The Five Pillars of Islam: A Framework for Islamic Values and Character Building by Musharraf Hussain
3. Towards Understanding Islam By Abul, A' la Mawdudi
4. Islami Nazria e Hayat by Khurshid Ahmad
5. An Introduction to Islamic theology by John Rearard
6. Islamic Civilization Foundations Belief and Principles by Abul A la Mawdudi
7. Women and Social Justices an Islamic Paradigm by Dr Anis Ahmad
8. Islam its Meaning and Message "By Khushid Ahmad

Course Title: Fundamentals of Economics	**Course Code: ECO-302**

Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:
This course provides students with a brief introduction to, and overview of, introductory economics, covering both microeconomics and macroeconomics. The course will enable the students to explain and apply basic economic terminology.

Course Outline:
Introduction to economics**:** Definitions of Economics Classical (Adam Smith), Neo Classical (Alfered Marshall) Modern (Robins Definition)**,** Branches of economics (Micro & Macro)**,** Demand & Supply**:** Demand**,** Supply**,** Price & Output determination**,** Elasticity**,** Utility Analysis: Concept of utility**,** Theory of Diminishing Marginal utility**,** Theory of Equi Marginal Utility**,** Concept of Indifference curve, Consumer equilibrium with indifference curve, Revenue & Cost funcstions: total cost (TC), Marginal Cost (MC), & Average Cost (AC)**.** Total Revenue TR, Marginal Revenue (MR), & Average Revenue (AR) under Perfect and imperfect competition (only basics and definitions)**,** Profit maximization (TR-TC approach)**.** Macroeconomic Issues: The Scope of Macroeconomics, Inflation (definition & types), unemployment (Definition & types). National income accounts: National income accounts (concepts and measurements of national income), Circular flow of income.

Course Outcomes:
At the end of this course the student will be able to define what is economics, and the basic economic problem, and distinguish between microeconomics and macroeconomics.

Recommended Books: Latest Edition of the Following Books.
1. Sloman, John (Latest edition), Economics, New York: Pearson, Prentice Hall.   2. Robert Frank and Ben S Bernanke, (Latest edition)   3. Principles of Economics,McGraw- Hill (Latest edition).   4. Paul A. Samuelson, (latest ed), Economics. Tata McGraw-Hill Education   5. Mankiw, N.G. and Taylor, Mark, (Latest edition), Economics, Cengage Learning   6. Michael Parkin, Melanie Powell and Kent Matthews, (Latest edition), Economics, Addison-Wesley, Pearson Education

Course Title: Functional English	**Course Code: ENG-303**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:

This course will familiarize students with the essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language and usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp subtle messages and tailor their communication effectively through the application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking and everyday conversation ensuring that students are equipped for both academic and professional spheres.

Course Outline:

1. Vocabulary Building (contextual usage, synonyms, antonyms, and idiomatic expressions) Communicative Grammar (subject-verb agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes etc.) Word Formation (affixation, compounding, clipping, back formation etc.) Sentence Structure (simple, compound, complex and compound-complex). Comprehension and Analysis.**2**. Understanding Purpose, audience and context a. (reading for meaning, descriptive texts versus narrative texts, argumentative texts versus persuasive texts) **3**. Contextual Interpretation (tones, biases, stereotypes, assumptions, inferences etc) **4**. Reading Strategies (skimming, scanning, SQ4R, critical reading) **5**. Active Listening (overcoming listening barriers, focused listening). Effective Communication Principles of Communication (clarity, coherence, correctness and courteousness). Structuring Documents (introduction, body, conclusion and formatting). Inclusivity in Communication (gender-neutral language and cross-cultural communication). Public Speaking (Speech/presentation: extemporaneous and prepared, public announcements and overcoming stage fright) Presentation Skills: a. (the elements of an effective presentation, using visual displays to present key facts, figures, charts, and graphs, steps to preparing an effective presentation, one-minute presentations and evaluate presentations, Informal Communication (small talk and networking), Professional Writing (business e-mails, memos, reports, formal letters etc.)

Course Outcomes:

By the end of the course the students will be able to apply the enhanced English skills, comprehend a variety of literary and non-literary texts, and express effectively in spoken and written English in diverse social and cultural contexts

Recommended Books: Latest Edition of the Following Books.

1. Murphy, Raymond. Grammar in Use Intermediate Student's Book without Answers. Cambridge University Press, 2018.

2. Kaufman, Lester, and Jane Straus. The Blue Book of Grammar and Punctuation. 2021.

3. Axelrod, Rise B., and Charles R. Cooper. The St. Martin's Guide to Writing [with Access Code]. 2016.

4. Johnson-Sheehan, Richard, and Charles Paine. Writing Today. Pearson, 2019.

5. https://www.hec.gov.pk/english/services/universities/RevisedCurricula/Documents/2011-2012/Education/English2_Sept13.pdf

Course Title: Introduction to Statistics	**Course Code: STAT-306**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:
- To have introduction of statistics as a field of knowledge and its scope and relevance to other disciplines of natural and social sciences.
- To equipped and prepare students for advance courses in the field of statistics.
- To achieve the capability of critical thinking about data and its sources; have idea about variables and their types and scale measures.
- Be able to calculate and interpret descriptive statistics (able to classify, tabulate, describe and display data using software).

Course Outline:
The nature and scope of Statistics. Organizing of Data, classification of data, Graphs and Charts: Stem-and leaf diagram, Box and Whisker plots and their interpretation. Measures of Central Tendency and Dispersion: Their properties, usage, limitations and comparison. Calculations for the ungrouped and grouped data. Measures of Skewness and Kurtosis and Distribution shapes.

Introduction to Sampling, advantages of sampling. Probability and non-probability sampling. Sampling and non-sampling errors. Sample surveys. Introduction to different sampling techniques.

Probability Concepts, Addition and Multiplication rules, bivariate frequency tables, joint and

marginal probabilities, Conditional probability and independence, Bayes' rule.

Course Outcomes: After completing the course, the students will be able to

- Organize and display the data through tables and graphs.
- Understand and differentiate between the types of data and variables.
- Evaluate and interpret basic descriptive statistics.

Recommended Books: Latest Edition of the Following Books.
1. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
2. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Clark, G.M and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
4. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th ed.Prentice Hall, New Jersey.
5. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
6. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.
7. Weiss, N,A. (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub. Company, Inc.
8. Wilcox, R. R. (2009). Basic statistics: understanding conventional methods and modern insights. Oxford University Press.
9. Mendenhall, W.,Beaver,R. J.,& Beaver, B. M. (2012) Introduction to probability and Statistics. Cengage Learning.

Course Title: Basic Statistical Methods	Course Code: STAT-308
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: Nil	

Course Objective:
- To have introduction of statistics as a field of knowledge and its scope and relevance to other disciplines of natural and social sciences.
- To equipped and prepare students for advance courses in the field of statistics.
- To achieve the capability of critical thinking about data and its sources; have idea about variables and their types and scale measures.

Course Outline:
Statistical population and its types, Sampling, importance of sampling, Statistic vs. parameters, Sampling errors, Probability and non-probability sampling. Sampling and non-sampling errors.

Basic data collection techniques, Census, registration system and Sample surveys. Introduction to different sampling techniques. proportion, difference between standard error and standard deviation; Point and interval estimate, properties of good point estimator.

Probability and set theory, Venn diagram, Addition and Multiplication rules, tree diagram, Conditional probability and independence, Chebyshev's inequality, empirical rule.

Course Outcomes: After completing the course, the students will be able to

- Evaluate and interpret basic descriptive statistics.
- Understand different data collection Techniques.
- Understand the basics of Probability theory.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Mclave, J.T. Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th Prentice Hall New Jersey.
3. Walpole, P.E. Myers, RH., Myers S.L. (1998), "Probability and Statistics for Engineers and Scientists", Prentice Hall.
4. Chaudhry, S.M. and S. Kamal, (1996), "introduction to Statistical Theory" Part I, II, 6th Ed, llmi Kitab Khana, Lahore, Pakistan.
5. Cochran, W.G. "Sampling Techniques".3rd Ed.
6. Pollard, A.H. Yousuf, F. and Pollard G.M. (1982), "Demographic Techniques", Pergamon Press, Sydney.
7. Mann, P. S. (2007). Introductory statistics. John Wiley & Sons.
8. Finkelstein, M. O. (2009). Basic concepts of probability and statistics in the law. New York, NY, USA: Springer.
9. Heumann, C., & Shalabh, M. S. (2016). Introduction to statistics and data analysis. Springer International Publishing Switzerland.

2ⁿᵈ Semester Courses

Course Title: Social Science	Course Code: 000
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: Nil	
Course Objective:	
Course Outline: The course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Expository Writing	Course Code: ENG-304
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective:	
Course Outline: The course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Calculus & Analytical Geometry	Course Code: MTH-301
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective: To provide foundation and basic ground for calculus and analytical geometry background.
Course Outline:
Functions and graphs, limits and continuity, differential calculus; (concept and idea of differentiation geometrical and physical meaning of derivative, rules for differentiation, techniques of differentiation, chain rule, implicit differentiation, linear approximation, applications of differentiation, extrema of functions, mean value theorem, maximum and minima, concavity , integral calculus; concept and idea of integration, indefinite, techniques of integration, Riemann sums and definite integrals, applications of integrals, physical interpretation as areas, mean value theorem, areas between curves, finding volumes by slicing, volumes and surface of revolution, Geometry in Two Dimensions: Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line. Circle; Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions. Conic Sections*;* Parabola, ellipse, hyperbola.
Course Outcomes: After completing the course, the students will be able to to solve problem using calculus concepts of limits, derivations, integration analytically and graphically, use calculus concepts in computer applications.
Recommended Books: Latest Edition of the Following Books.
1. Edwars, C.H., Penney, D.E.,.(2002).Calculus.Prentice hall,Inc.. 2. Anton, H.., Bivens, I., Devis, S. (7[th]edition).(2002). Calculus. Newyork: John Wiley and sons, Inc. 3. Thomas, G.B.(1992).Calculus and analytical geometry .Addison Welsey Longman, Inc.

Course Title: Fundamentals of Probability and Probability Distributions	**Course Code: STAT- 307**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	
Course Objective: • Understand basic concepts of probability, conditional probability, independence etc. • Be familiar with some of the more commonly encountered random variables, particularly the Binomial and Normal random variable. • Be able to calculate first two moments of common random variables i.e. means and variances. • Be able to apply the concepts of random variables to scientific applications. Computation of uncertainty using probability techniques	

Course Outline:
Discrete Random Variables, Probability Disstribution, Mean and Variance of a discrete random variable Bernoulli trials. Properties, applications and fitting of Binomial, Poisson, Hyper geometric. Negative Binomial and Geometric distributions. Continuous Random Variable, probability density function and its properties. Normal Distribution and its properties, Standard Normal Curve, Normal approximation to Binomial and Poisson distributions.

Course Outcomes: After completing the course, the students will be able to

- Demonstrate the basic knowledge of probability and probability distribution.
- Explain the concepts of basic techniques of measuring the uncertainty problem.
- Analyze and apply probability techniques

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Chaudhry. S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9t ed, Prentice Hall, New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
5. Walpole, RE., Myers, R.H and Myers, S.L. (1998), 'Probability and Statistics for Engineers   and Scientist" 6th edition, Prentice Hall, NY.
6. Weiss, N.A.(1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub. Company, Inc

Course Title: Linear Algebra and Numerical Analysis	Course Code: STAT- 309
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: Nil	

Course Objective:
- To develop the ability to solve problems using the techniques of linear algebra

- To Understand Euclidean vector spaces, their inherent arithmetic and algebraic structure, and the accompanying geometry that arises.

- To analyse the structure of real-world problems and plan solution strategies. Solve the Problems using appropriate tools.

Course Outline:

Introduction to Vectors. Vector spaces and subspaces. Vector spaces: linear independence, Norms, Inner products, and Orthogonality: Vector norms and inner products, orthogonal vectors, Gram-Schmidt procedure, Matrices, Matrices operations, Echelon Forms: Row echelon form and rank, The reduced row echelon form, Consistency of linear systems, Homogeneous systems, Nonhomogeneous systems. Matrix Algebra: Addition, scalar multiplication and transposition, linearity, matrix multiplication, properties of matrix multiplication, matrix inversion, inverses, elementary matrices and equivalence Determinants and their properties. Eigen value and Eigen vectors, Introduction to interpolation. Finite and central difference operators. Factorial polynomial, finite and divided differences. Newton-Gregory, Newton divided differences and Newton-gauss formulas for interpolation. Introduction to numerical integration and summation. Approximation to a definite integral. Euler-McLaurin formula and its application to summation of series and the sum of power of the whole numbers. Trapezoidal, Simpson's one –third and Simpson**.**

Course Outcomes: After completing the course, the students will be able to

- Apply mathematical concepts in problem-solving through integration of new material and modelling
- Analyses /interpret quantitative data verbally, graphically, symbolically and numerically.
- To provide students with concepts of interpolation and extrapolation.
- To enable the students to apply numerical techniques in problem solving.

Recommended Books: Latest Edition of the Following Books.

1. Anton, H. (2013). Elementary Linear Algebra, John Wisely publisher, 10th edition,
2. David C. L. (2014). Linear Algebra and its Applications, 5th edition.
3. Lay, D.C. (2006) "Linear Algebra and its applications" 3rd Edition, Addison- Wesley.
4. Leon, J. S. (2015). Linear Algebra with Applications, 9th edition.
5. Seymour, L and Marc, L. (2006), Linear Algebra, Schaum's Outline Series, McGraw-Hill.
6. Strang, G. (2016). Introduction to Linear Algebra, 5th edition.
7. Scheid, F. (1983). "Numerical Analysis".Shaum's outline series. Mc Graw-Hill book Co. New York.
8. Watson, W.A, Phlipson, T.and Oates, P.J (1981). "Numerical Analysis".2nd Edition. Edward Arnold limited, London.
9. Chaudhary's, M,and Kamal,S.An Appendex to "Statistical Theory" Finite differences   and

Interpolation.

10. Trefethen, L. N. (2022). Numerical Linear Algebra: Twenty-Fifth Anniversary Edition. United States: SIAM, Society for Industrial and Applied Mathematics.

11. Lyche, T. (2020). Numerical Linear Algebra and Matrix Factorizations. Germany: Springer International Publishing.

12. Lyche, T. (2021). Numerical Linear Algebra and Matrix Factorizations. Switzerland: Springer International Publishing

3rd Semester Courses

Course Title: Quantitative Reasoning (QR-1)	Course Code: MTH-401
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: Nil	
Course Objective:	
Course Outline: The course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Application of Information and communication technologies (ICT)	Course Code: CSC-308
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: Nil	
Course Objective:	

| **Course Outline:** |
| The course contents will be taken from the booklet of mandatory and general courses. |

| **Course Outcomes:** |
| |

| **Recommended Books: Latest Edition of the Following Books.** |
| |

Course Title: Natural Science	**Course Code: 000**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective:	

| **Course Outline:** |
| The course contents will be taken from the booklet of mandatory and general courses. |

| **Course Outcomes:** |
| |

| **Recommended Books: Latest Edition of the Following Books.** |
| |

Course Title: Introduction to Entrepreneurship	**Course Code: MS-309**
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: Nil	

Course Objective:
This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, abilities, enabling them to seize the identified opportunities for initiating ventures and successfully navigating the challenges that come with starting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business, market research, opportunity identification, business Lanning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation.

Course Outline:

Introduction to Entrepreneurship, Entrepreneurial Skills, . Opportunity Recognition and Idea Generation, Opportunity identification, evaluation and exploitation, Innovative idea generation techniques for entrepreneurial ventures, Marketing and Sales, Financial Literacy, Team Building for Startups & Regulatory Requirements to Establish Enterprises in Pakista**n**

Course Outcomes:

Upon successful completion of the course participants will:

- Have a basic understanding of the Islamic World and Muslim beliefs.
- Know the origins of the Islamic Banking and Finance.
- Appreciate the rationale behind the development of the Islamic finance industry.
- Be able to assess the nature and scope of the Islamic finance industry in relation to its conventional counterpart.
- ·Develop an appropriate level of understanding of the main principles of Islamic banking and finance.
- ·Acquire essential knowledge about the key Islamic financial contracts, as used by the industry.
- ·Know about Murabaha and Musharaka contracts, Ijara and Istisna'a financing methods,as well as Salam and Takaful insurance.
- Be familiarized with the Islamic financial infrastructure, international financial institutions, and regulatory bodies.

Recommended Books: Latest Edition of the Following Books.

1. Barringer, B. R., & Ireland, R. D. (2012). Entrepreneurship: Successfully Launching New Ventures. Pearson.
2. Kuratko, Donald F. (2017). Entrepreneurship : Theory, Process, Practice (ed.10). United State of America: Cengage Learning. Timmons, J. A., & Spinelli, S. (2003). New venture creation/entrepreneurship for the 21st century. Singapore City: McGraw-Hill.
3. Abrams, R. (2017). Entrepreneurship: A Real-World Approach (2nd ed., illustrated). Planning Shop.
4. Read, S., Sarasvathy, S., Dew, N., & Wiltbank, R. (2016). Effectual Entrepreneurship (2nd ed.). Routledge. https://doi.org/10.4324/9781315684826
5. Ries, E. (2011).The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.

Course Title: Exploratory Data Analysis and Visualization (EDAV)	Course Code: STAT-405
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	
Course Objective:	

- to provide solid understanding of the process of Exploratory Data Analysis
- to educate students in data exploration, analysis, and visualization
- to train students in industry standard tools for data analysis and visualization

Course Title: Basic Statistical Inference	Course Code: STAT-406
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Exploratory Data Analysis: Explore, Visualize, Analyse, Repeat. Selective data collective and data exploration.

Prerequisites: STAT- 306

Data sources, Data types, Data structures, Merging datasets, Samples and sampling bias, Data dictionaries and meta-data. Start Exploring:

Course Objective:
- To understanding of basic techniques of sampling and estimation, their properties and application.

Principles of Analytic Graphics, Exploratory Graphs, The base plotting system. The ggplot2 plotting system Data visualization and Data analysis (using Excel/Tableau/R/STATA/SPSS etc).
- To select a sample from a given population and use it to make inferences about the population and its parameter

Course Outcomes: After completing the course, the students will be able to
- To test, deduce and infer the validity of different types of hypotheses and models built on the basis of the raw data collected in diverse problem situations.
- describe exploratory data analysis and visualization concepts
- describe data analysis and visualization models and algorithms

Course Outline:
Distribution of sample mean and central limit theorem. Estimation. Point Estimation. Desirable
- describe applicability of different data analysis and visualization models' techniques to solve real-world problems
Properties of a Good Estimator. Interval Estimation. lnterval Estimation of population mean. Large
- pre-process data and apply exploratory data analysis to some real data sets and provide
and small sample confidence intervals for Population Mean. Nature of Hypothesis Testing and Types
interpretations via relevant visualization
of errors. Hypothesis Testing for Population Mean and variance. Inferences for Two Population
Means. Large-sample inferences for Two Populations using Independent Samples. Inferences for the

Recommended Books: Latest Edition of the Following Books.
Mean of Two Normal Populations using Independent Samples (variances are assumed Equal/Not
1. Cook, D., Swayne, D. F. (2007). lnteractive and Dynamic Graphics for Data Analysis: With
Equal). Inference for Two Populations Mean using Paired Samples. Inferences for Population
R and GGobi. Germany: Springer.
Proportion. Inferences for a single Population Proportion. Inferences for
2. Peng, R. (2015). Exploratory Data Analysis with R. http://leanpub.com/exdata.
Two Population Proportions using Independent Samples. Estimation of sample size. Chi-Square
3. Chang, W. (2013). R Graphics Cookbook. O'Reilly. http://www.cookbook-r.com/
Procedure. Chi-Square Goodness of fit Test. Chi-Square Independence Test.
4. Wickham. (2006). ggplot2: Elegant Graphics for Data Analysis. F(2nd edition Springer.
http://ggplot2.org/book/; http://hadley.nz/

Course Outcomes: After completing the course, the students will be able to
- The knowledge of the sampling distributions and their properties.
- Derive the appropriate estimators for parameters using best estimation procedure.
- Use appropriate sampling distributions for interval estimation and hypotheses testing.
- Apply appropriate inferential procedures to handle the practical situations.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998). A Basic Course in Statistics. 4th ed, Arnold, London.
2. DeGroot, M. Schervish, M. (2017). Probability and Statistics. 4th edition. Pearson Education Limited.
3. Mclave, J.T., Benson P.G. and Sincich, T. (2014). Statistics for Business and Economics. 12th Edition. Pearson Education Ltd, U.K.
4. Ross, S. (2017). A first course in Probability. 9th edition. Pearson Education Limited.
5. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2015). Probability and Statistics. 3rd edition. Schaums Outlines Series. McGraw-Hill. NY.
6. Srivastava, M.K., Khan, A.H. and Srivastava, N. (2014). Statistical Inference: Theory of

Estimation. Prentice-Hall of India Pvt. Ltd

7. Heumann, C., & Shalabh, M. S. (2016). *Introduction to statistics and data analysis*. Springer International Publishing Switzerland.
8. Rivera, R. (2020). *Principles of managerial statistics and data science*. John Wiley & Sons.
9. Ramachandran, K. M., & Tsokos, C. P. (2020). *Mathematical statistics with applications in R*. Academic Press.
10. Montgomery, D. C., & Runger, G. C. (2020). *Applied statistics and probability for engineers*. John wiley & sons.

4th Semester Courses

Course Title: Civic & Community Engagement	Course Code: PSC-418
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: Nil	
Course Objective:	
Course Outline: The course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Quantitative Reasoning (QR-II)	Course Code: MTH-402
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective:	
Course Outline: The course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

Course Title: Introduction to Regression and Analysis of	Course Code: STAT-407

Variance	
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Course Title: Applied Statistics	**Course Code: STAT-408**
Prerequisites: STAT-306	
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Course Objective:	
Prerequisites: NIL	

- To provide foundations of regression analysis and experimental designs and their uses in different disciplines.

Course Objective: To provide basic knowledge and art of statistical data analysis and planning and designing of
- To learn basic sampling Techniques.
- To enable the students to of index numbers. inference about the parameters of the population.
- To learn basic fertility and mortality rates.

Course Outline:

Concepts of Regression and Correlation, Simple linear regression model, Estimation of parameters by method of least squares and corresponding Sampling and testing and confidence intervals for least square estimators, mean prediction and individual prediction. (Multiple linear regression, average of relatives price index number, Weighted index number and Laspyers, Paasches and Fishers ideal index number of consumer price index (CPI), Sensitive price, Analysis of Variance for Analysis: Classifications of two-way classification Deion vital Statistics Meaning of squared, Multiple registrations of Births and death in Pakistan. Uses of vital statistics, stage counting of vital statistics, significant difference test sex ratio, child women ratio, birth and death ratio, population growth rate, classification of natal rates, death rates or mortality rates, crude death rate, specific death rate, infant mortality rate, case fatality rate, fertility rates, crude birth rate, specific birth rate, standardized death rate, reproduction rates, gross reproduction rate, net reproduction rate, morbidity or sickness rates, marriage rates, divorce rates etc. general: fertility rate, total fertility rate.)

Course Outcomes: After completing the course, the students will be able to
- Explore more adequately the connection between theories of regression and understand the basic concepts and applications of experimental design
- Perform analysis of real-world problems and decide appropriate design for given scenario.
- Provide prediction of dependent variable and interpret the results.

Course Outcomes: After completing the course, the students will be able to
- Understand the basic sampling techniques and their use in different scenarios.
- Learn basic concepts of Index Numbers.
- Learn the concepts and use of mortality and fertility rates.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G. M. and Kempson, R. E. (1997), "Introduction to the Design & Analysis of Experiment" Arnold London.
2. Chaudhry, S.M., and Kamal, S., (1996), "Introduction to Statistical Theory" Part I, II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Montgomery, D.C. (2012), Design and Analysis of Experiments, John Wiley & Sons, New York, USA.
4. Oehlert, G.W. (2000), A first course in design and analysis of experiments, W.H. Freeman, New York, USA.
5. Steel, R.G.D, Torrie , J.H. and Dickey, D.A. (2008), Principles and Procedures of Statistics: A Biometrical Approach, McGraw-Hill, Michigan, USA.
6. Walpole, P.E, Myers, R.H., Myers, S.L., (1998), "Probability and Statistics for Engineers and Scientists", 7th ed.Prentice Hall.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Mclave, J.T. Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th Prentice Hall New Jersey.
3. Walpole, P.E. Myers, RH., Myers S.L. (1998), "Probability and Statistics for Engineers and Scientists", Prentice Hall.
4. Chaudhry, S.M. and S. Kamal, (1996), "Introduction to Statistical Theory" Part I, II, 6th Ed, Ilmi Kitab Khana, Lahore, Pakistan.
5. Cochran, W.G. "Sampling Techniques" 3rd Ed.
6. Pollard, A.H., Yousuf, F. and Pollard G.M. (1982), "Demographic Techniques", Pergamon Press, Sydney.
7. Weiss, N.A. (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub.Company, Inc.

7. Daniel, J. (2011). Sampling Essentials: Practical Guidelines for Making Sampling Choices. Italy: SAGE Publications.
8. Thompson, S. K. (2012). Sampling. United Kingdom: Wiley.
9. Shumway, R. H., Stoffer, D. S. (2000). Time Series Analysis and Its Applications. With R Examples, Germany: Springer New York. Lutz, W. (2021)
10. Advanced Introduction to Demography. United Kingdom: Edward Elgar Publishing.

Course Title: Non-Parametric Techniques	Course Code: STAT-410
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: NIL	

Course Objective:
- The course is designed to give students knowledge about the basic concepts of nonparametric methods.
- This course provides the fundamentals of different non-parametric methods.
- This course helps in understanding of applications of non-parametric methods.

Course Outline:
Nonparametric vs. Parametric statistical tests, Applications in count, score, and rank data, Fundamental differences, appropriate situations for use of nonparametric methods vs. parametric methods, advantages and disadvantages of parametric tests, power-efficiency of nonparametric tests relative to similar parametric tests, The one-sample case (binomial test, Chi-Square test for goodness of fit, Kolmogorov Smirnov test, runs test), The case of two related samples (McNemar, Sign, Wilcoxon, Walsh tests), The case of two independent samples (fisher exact-probability test, Chi-Square test for independent samples, The Siegel – Tukey test , Median test, Mann-Whitney U-test, Kolmogorov-Smirnov test, Wald-Wol fowitz test), The case of k related samples (Cochrane Q test, Friedman two-way analysis of variance by ranks), The case of k independent samples (Chi-Square test for k independent samples, Kruskal Wallis one-way analysis of variance by ranks), Nonparametric correlation (the contingency coefficient C, Spearman rank correlation, Kendall rank correlation, Cox proportional hazard model.

Course Outcomes: After completing the course, the students will be able to
- Will have knowledge of elementary non-parametric methods.
- They will be able to use these nonparametric procedures for analyzing real data.
- Will know application of an appropriate nonparametric test for a specific scenario.

Recommended Books: Latest Edition of the Following Books.
1. Conover, W.J. (1999), "Practical Nonparametric Statistics", 3rd Edition, John Wiley and Sons, New York.
2. Gibbons, J.D. and Chakraborti, S. (1992), "Nonparametric Statistical Inference", Marcel Decker, New York.
3. Maritz, J.S. (1995). "Distribution-Free Statistical Methods". Chapman & Hall London.
4. Sprint, P. (2007). Applied Nonparametric Statistical Methods, 4th edition, Chapman & Hall London
5. Sprint, P. (1989). "Applied Nonparametric Statistical Methods". Chapman & Hall London.
6. Corder, G. W., & Foreman, D. I. (2014). Nonparametric statistics: A step-by-step approach.

John Wiley & Sons.
7. Wasserman, L. (2006). All of nonparametric statistics. Springer Science & Business Media.
8. Kraska-Miller, M. (2013). Nonparametric statistics for social and behavioral sciences.

Course Title: Bio-Statistics and Epidemiology	Course Code: STAT-411
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

~~7. CRC Press.~~
~~10. Manoukian, E. B. (2022). Mathematical nonparametric statistics. Taylor & Francis.~~

Prerequisites: NIL

Course Objective:
- To discuss and explain what biostatistics is and how it is used in Biological Sciences
- To recognize and give examples of different types of data arising in Biological Sciences
- To use statistical techniques to summarize the biological data
- To apply statistical software to analyze and evaluate biological data

Course Outline:

Epidemiology, epidemic and the role of epidemiologist, Sources of Demographic data, Definition of Biostatistics, type of variables and observations in biological, health and medical sciences, vital statistics, Categorical, numerical and censored data; Prospective and retrospective study; sample size determination, Proportions, rates and ratios; incidence, prevalence and odds, Diagnostic odds ratio (DOR), Relative Risk., sensitivity, specificity, false positive and false negative, Predictive values, Logistic regression, log-linear models.

Course Outcomes: After completing the course, the students will be able to
- Understand the diverse applications of statistical tools in biological science
- Demonstrate an understanding of the central concepts of modern statistical theory in Biological Sciences
- Acquire the understanding of the appropriate usage of software for biological sciences.
- Analyze and communicate the results of statistical analysis accurately and effectively.

Recommended Books: Latest Edition of the Following Books.
1. Alfassi Z. B., Boger, Z. and Ronen, Y. (2005): *Statistical Treatment of Analytical Data*. Blackwell Science, USA.
2. Antonisamy, B. Premkumar, P. and Christopher, S. (2017). *Principles and Practice of Biostatistics*. 1st edition. Elsevier, India.
3. Daniel, W.W. (2010). *Biostatistics: A Foundation for the Health Sciences*. 6th edition. John Wiley, New York. NY, USA.
4. Dunn, G. and Everit, B. (1995). *Clinical Biostatistics*. Edward Arnold, London, UK.
5. Sullivan, M.L. (2018). *Essentials of Biostatistics in Public Health*. 3rd edition. Jones and Bartlett Learning, Burlington, MA, USA.
6. Zar, J. (2000). *Biostatistical Analysis*. 5th Edition. John Wiley & Sons, New York, NY, USA.

Course Title: Advanced Calculus	Course Code: MTH-302

Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Calculus

Course Objective:
1. This course will familiarize students with the basic principles of calculus and their application to problem solving.

2. To enable the students about practical applications of the course in different fields.

3. Make the students to polish their analytical skills.

Course Outline:
Introduction to Limits: Theorems of limits and their application to functions: Introduction to Continuity, Derivatives: Introduction to derivatives, Partial derivatives and their geometrical significance Application problems (rate of change, marginal analysis) Higher derivatives: Mean value theorem, Applications of derivatives: Curvature and radius of curvature, maxima and minima of a function. Application partial derivatives: Integral calculus: Vector differentiation, vector integration and their application. Laplace transforms, Fourier series, Z-Transform.

Course Outcomes:

Recommended Books: Latest Edition of the Following Books.
1. Calculus by Thomas Finney, 11th Edition, Dec 26, 2010.

2. Brief Calculus and its applications by Doniel D. Benice, 5th Edition, 1997.

3. Applied Calculus by Raymond A. Barnett, 5th Edition, 08/28/1996

4. Calculus by Gerald L. Bradley, 2nd Edition, 2002.

Course Title: **Random Variables and Probability Distributions**	**Course Code: STAT-511**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3Cr.Hrs**

Prerequisites: STAT-307

Course Objective:
• This course is designed to give students a conceptual knowledge of discrete random variables and probability theory.
• This course provides the fundamentals of probability theory in different disciplines.
• This course helps to model the uncertain behaviour from the real-life scenario.

Course Outline:
Probability as a set function. Conditional probability and Bayes' theorem. Random variables, Distribution function, Probability mass function and probability density function. Location, scale, and shape parameters. Joint and conditional distributions for two and more random variables. Marginal and conditional distributions, stochastic independence. Mathematical expectation and its properties, Conditional expectation, variance and moments. Probability generating function. Moment generating and characteristic functions and their properties. Relation between moments and cummulants. Probability distributions: Bernoulli, Binomial, Hypergeometric, Poisson, Negative binomial, Geometric, discrete uniform, Multinomial distribution. Normal approximation to binomial, Poisson and Hypergeometric distribution.

Course Outcomes: After completing the course, the students will be able to
• Understand the basic concepts and applications of probability.
• Investigate the nature of stochastic process and apply suitable probability distributions for the random variable generated from such process.
• Find probabilities using probability distributions.
• Use probability concepts and laws in decision analysis

Recommended Books: Latest Edition of the Following Books.
1. Haq, M. (1984). Foundation of Probability and Statistics, Tahir sons, Urdu Bazar, Karachi
2. Hirai, A.S. (2002), A Course in Mathematical Statistics, Ilmi Katab Khana, Lahore.
3. Hogg, R.M., McKean, J. and Craig, A.T. (2013). Introduction to Mathematical Statistics. Prentice Hall, New Jersey, USA.
4. Khan, M. K., (1996). "Probability with Applications", Maktiba Ilmi, Lahore.
5. Mood, AM; Graybill, F.A. and Boss, D.C. (1997), "Introduction to the Theory of Statistics", McGraw Hill, New York.
6. Stirzaker, D. (1999), "Probability and Random Variables", Cambridge University Press, Cambridge

Course Title: Sampling Fundamentals and Techniques	Course Code: STAT- 512
Course Structure: Lectures: 3, Labs:.0	Credit Hours: 3
Prerequisites: NIL	

Course Objective:
• To introduce the concept and scope of sampling.
• To determine the sample size for conducting a survey.
• To learn ratio and regression estimations
• To understand the concept of simple and stratified random sampling techniques

Course Outline;
Introduction to Sampling, advantages of sampling, requirements of a good sample, bias, sampling and non-sampling errors. Steps and problems involved in planning and conduct of census and their Surveys/Sample surveys, Selection and estimation procedures. Description and properties of simple random sampling, Sampling for proportion and percentages, Estimation of variance, standard errors and confidence limits, Sample size determination under different conditions, Description and properties of stratified random sampling, Formation of strata, Different methods of allocation of sample size.

Course Outcomes: After completing the course, the students will be able to

• Use and implement of sampling designs.
• Apply the simple random sampling and the stratified random sampling appropriately in rea world problems.
• Estimate the population parameters by using simple and stratified random sampling techniques.

Recommended Books: Latest Edition of the Following Books.
1. Bethelem, J. (2009). Applied Survey Methods: A Statistical Perspective. Wiley.
2. Cochran, W.G. (1977), "Sampling Techniques' 3rd ed, John Wiley and Sons, New York.
3. Ferguson, T.S. (1996), "A Course in large Sample theory, Chapman & Hall, London.
4. Kish, L. (1992). "Survey Sampling", John Wiley, New York.
5. Raj, D. (1971) "Design of Sample Survey". McGraw Hill, New York.
6. Raj, D. & Chandhok, P. (1998), "Sample Survey Theory". Narosa Publishing House, New

Delhi.
7. Singh, R. and Singh N, (1996), "Elements of Survey Sampling", Kuiwar Academic Publisher, Dodrecht.
8. Sukhatme, P.V, Sukhatme, B., Sukhatme, S., and Asok, A. (1985), "Sampling Theory of Survey with Application". Iowa State University Press.

Course Title: Experimental Designs	Course Code: STAT-513
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: NIL	

Course Objective:
- This course provides the fundamentals of experimental designs and their uses in different Disciplines.
- To provide basic and advanced learning of investigation for conclusions through planning and designing of experiments.
- To train students through innovative instruction in design theory and methodology that will help them in addressing the significance of experimental design in statistics and across the Universal disciplines.

Course Outline:
Introduction to experimental design and its terminology; Planning and designing of experiment and research; Aspects of experimental design, basic principles of experimental design, fixed and random effects. Analysis of variance, estimation of model parameters. Checking model adequacy, Inference beyond ANOVA multiple comparisons, Contrast analysis, orthogonal polynomial contrasts and trend analysis. Basic experimental designs; completely randomized design, randomized complete block design and Latin square design. Relative efficiency of these designs. Missing values, Incomplete block designs (IBD), balanced incomplete block designs (BIBD) and partially balanced incomplete block designs (PBIBD). Intra-block and Inter-block analysis of IBD

Course Outcomes: After completing the course, the students will be able to

- Understand the basic concepts and applications of experimental design.
- Decide an appropriate design for a given scenario.
- Analyse the data generated from different designs and interpret the results.

Recommended Books: Latest Edition of the Following Books. Books Recommended:
1. Boniface, DR. (1995). "Experiment Design & Statistical Methods", Chapman & Hall.
2. Clarke, G.M., and Kempton, RE. (1997), "Introduction to the Design & Analysis of Experiments", Edward Arnold.
3. Kehul, R.O. (2000). Design of Experiments: Statistical Principles of Research Design and Analysis, Duxbury/ Thomson Learning, New York, USA.
4. Montgomery, D.C. (2000). "Design and Analysis of Experiments", John Wiley, New York.

5. Montgomery, D.C. (2012). Design and Analysis of Experiments, John Wiley & Sons, New York, USA.
6. Oehlert, G.W. (2000). A first course in design and analysis of experiments, W.H. Freeman, New York, USA.

Course Title: Regression Analysis	Course Code: STAT-514
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: STAT-406

Course Objective:
- To understand the basic assumptions of regression analysis.
- To handle the problems arising from the violation of assumptions.
- To understand the estimation techniques of parameters.
- To give the concept of nonlinear regression analysis

Course Outline:
Linear regression and its assumptions, least squares estimators, Maximum Likelihood Estimator, tests of significance for regression model and regression parameters. Confidence interval for regression parameters, Test of linearity of regression, Use of extraneous information in linear regression model. Residual analysis, Detection and study of outliers and influential observations, Polynomial regression, orthogonal polynomial, orthogonal regression analysis and Specification of models, Multicollinearity

Course Outcomes: After completing the course, the students will be able to

- Students would have enough knowledge of regression analysis.
- Students will be able to understand the concept of basic
- Students will know the assumption of regression.
- Developed the skills of students to analyze the real phenomena of regression models.

Recommended Books: Latest Edition of the Following Books.
1. Dielman, T. E. (2001). Applied regression analysis for business and economics. Pacific Grove, CA: Duxbury Thomson Learning.
2. Guttmann, I, (1980); "Linear Models: An Introduction", John Wiley, New York.
3. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to linear regression analysis (Vol. 821). John Wiley and Sons.
4. Montgomery, D.C., and Peck E.A. (1992). "Introduction to linear Regression Analysis", 2nd Edition, John Wiley and sons Inc. New York.
5. Rawlings, J. O., Panthula, S. G., and Dickey, D. A. (2001). Applied regression analysis: a research tool. Springer Science & Business Media.
6. Ryan, P. T. (1996) "Modern Regression Methods", John Wiley and sons Inc. New York.

7. Yan, X. and Zu, X. G. (2009) Linear Regression Analysis: Theory and Computing. World Scientific Publications.

6th Semester Courses

Course Title: Differential Equations	Course Code: MTH-501
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Calculus and Analytical Geometry

Course Objective:
Develop fundamental skills of solving ordinary differential equations, and developing differential equations for real-world problems

Course Outline:
Ordinary Differential Equations of the First Order: Geometrical Considerations, Isoclines, Separable Equations, Equations Reducible to Separable Form, Exact Differential Equations, Integrating Factors, Linear First-Order Differential Equations, Variation of Parameters. Ordinary Linear Differential Equations; Homogeneous Linear Equations of the Second Order, Homogeneous Second-Order Equations with Constant Coefficients, General Solution, Real Roots, Complex Roots, Double Root of the Characteristic Equation, Differential Operators, Cauchy Equation, Homogeneous Linear Equations of Arbitrary Order, Homogeneous Linear Equations of Arbitrary Order with Constant Coefficients, Non-homogeneous Linear Equations. Modeling of Electrical Circuits. Systems of Differential Equations. Series Solutions of Differential Equations. Partial Differential Equations: Method of Separation of variables, wave, Heat & Laplace equations and their solutions by Fourier series method.

Course Outcomes:
Students will be able to solve 1st and 2nd order ODES, able to apply ODES in computer applications, solve ODES such as Laplace, heat and wave equations using separation of variables.

Recommended Books: Latest Edition of the Following Books.
1. Greenberg,M.D.(*1996).Advanced Engineering Mathematics.* Prentice Hall publishers.
2. Kreyszig,E. (7th ed.).(1993). *Advanced Engineering Mathematics.* John Wiley & Sons Inc.
3. Zill,D.G.,Prindle,Weber,Schmidt.(1996).*A First Course in Differential Equation.* Brooks/Cole Publishing,
4. Zill,D.G., Cullen,M.R. (1996). *Differential Equations with Boundary-Value Problems*, , Brooks/Cole Publishing,

5. Edwards,C.H., Penney., David, E. (1993). Penney. *Elementary Differential Equations With Applications,* Prentice Hall.

Course Title: **Continuous Probability Distributions**	Course Code: **STAT-521**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: STAT- 511	

Course Objective: • This course is designed to give students a conceptual knowledge of continuous random variables and probability theory. • This course provides the fundamentals of probability theory in different disciplines. • This course helps to model the uncertain behavior from the real-life scenario
Course Outline: Overview of the continuous random variables, Uniform, Beta, Lognormal, Exponential, Gamma, Laplace, Rayleigh and Weibull distributions with moments and cumulates Distributions of functions of random variables; Bivariate Normal distribution and its properties, Distributions of functions of random variables: Chi-square, t and F distributions, their derivations and properties. Central limit and Chebyshev's theorems, Weak and Strong Laws of large numbers and their applications, Order statistics, Distributions of r-th and s-th order statistics**.**
Course Outcomes: After completing the course, the students will be able to • Understand the basic concepts and applications of probability. • Investigate the nature of stochastic process and apply suitable probability Distributions for the random variable generated from such process. • Find probabilities using probability distributions. • Use probability concepts and laws in decision analysis.
Recommended Books: Latest Edition of the Following Books. 1. Casella, G. and Berger, R.L. (2008). Statistical Inference, Cengage Learning, New York, USA. 2. Hirai, A.S. (2002), A Course in Mathematical Statistics, Ilmi Katab Khana, Lahore. 3. Hogg, R.M., McKean, J. and Craig, A.T. (2013). Introduction to Mathematical Statistics. Prentice Hall, New Jersey, USA. 4. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994). Continuous Univariate istributions, John Wiley & Sons, New York, USA. 5. Johnson, N.L., Kotz, S. and Kemp, A.W. (1993). Univariate Discrete Distributions, John Wiley & Sons, New York, USA.

6. Mood, A.M, Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, McGraw Hill, New York, USA.

Course Title: Sampling Techniques and Survey Methods	Course Code: STAT-522
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: STAT-512

Course Objective:
• To understand the concept of systematic, cluster, multistage and multiphase sampling techniques.
• Comparison among different sampling techniques.
• To learn ratio and regression estimations.
• To understand the non-response, their sources, and randomized response technique.

Course Outline:
Systematic sampling, Cluster Sampling. Ratio and regression estimate in simple and stratified random sampling, Efficiency of systematic sampling compared with simple random sampling, stratified random sampling and cluster sampling. Sub sampling, proportion to size (PPS)-Sampling, Double Sampling, Multistage and Multiphase sampling, Thomson Hurwitz estimator, Comparison of different sample designs. Sampling and non-sampling errors and their sources. Non-response, their sources and bias. Randomized response. Critical study of National sample surveys conducted in Pakistan: Census of Agriculture, Household Income and Expenditure Survey (HIES), Pakistan Demographic Survey (PDS) and National Population and Housing Census and Surveys (NPHCS).

Course Outcomes: After completing the course the students will be able to
By completing this course the students will be able to:
• Use and implement of systematic and cluster sampling designs.
• Apply the multistage and multiphase sampling appropriately in real world problems.
• Estimate the population parameters by using systematic and cluster sampling techniques.

Recommended Books: Latest Edition of the Following Books.
1. Bethelem, J. (2009). Applied Survey Methods: A Statistical Perspective. Wiley.
2. Cochran, W.G. (1977). Sampling Techniques. John Wiley and Sons, 3rd ed, New York.
3. Des Raj and Chandhok P. (1998). Sample Survey Theory. Narosa Publishing House, New Delhi.
4. Kish, L. (1992). Survey Sampling. John Wiley, New York.
5. Singh, R. and Singh N, (1996). Elements of Survey Sampling. Kulwar, Dodrecht.
*Various publications of Pakistan Bureau of Statistics (PBS).

Course Title: Experimental Designs and Analysis of Experiments	**Course Code: STAT-523**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: STAT-513

Course Objective:
- This course provides the advanced knowledge of experimental designs and their uses in different disciplines.
- To provide basic and advanced learning of investigation for conclusions through planning and designing of experiments.
- To train students through innovative instruction in design theory and methodology that will help them in addressing the significance of experimental design in statistics and across the universal disciplines

Course Outline:
Introduction to factorial experiments, simple, main and interaction effects. Hidden replication. 2k and 3k series and mixed level factorial experiments and their analysis. Analysis of Covariance (ANCOVA). Confounding in factorial experiments, complete and partial confounding; Single replication of factorial experiments. Fractional factorial experiments. Introduction of response surface methods; first and second order designs, central composite designs, fitting of response surface models and estimation of optimum response, split plot design and its variations

Course Outcomes: After completing the course, the students will be able to
- Understand the basic concepts and applications of experimental design.
- Decide appropriate design for given scenario.
- Analyze the data generated from different designs and interpret the results

Recommended Books: Latest Edition of the Following Books.
1. Kehul, R.O. (2000). Design of Experiments: Statistical Principles of Research Design and Analysis, Duxbury/ Thomson Learning, New York, USA.
2. Montgomery, D.C. (2012). Design and Analysis of Experiments, John Wiley & Sons, New York, USA
3. Montgomery, D.C. (2000). Design and Analysis of Experiments", John Wiley, New York.
4. Oehlert, G.W. (2000). A first course in design and analysis of experiments, W.H. Freeman, New York, USA.
5. Steel, R.G.D, Torrie, J.H. and Dickey D.A. (2008). Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, Michigan, USA.
6. Steel, G. D., Terrie, and Dickey A. (1997). "Principles and Procedures of Statistics: A Biometrical Approach" 3rd Edition, McGraw Hill, New York.
7. Boniface, DR. (1995). "Experimental Design & Statistical Methods", Chapman & Hall.
8. Myers, R.H. and Montgomery, D.C. (1995). "Response Surface Methodology; Process & Product Optimization Using Design", John Wiley.

Course Title: Econometrics	Course Code: STAT- 524
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: STAT-514	

Course Objective:
• The purpose of this course is to introduce students to the main concepts and tools used in econometrics.
• In particular, to learn when and how to apply regression analysis. Learn the basic assumptions and techniques used to run estimations and make inferences in the context of a linear equation framework.
• To learn to recognize specification and data problems. Also, additional tools to handle time series data.
• Each topic will be approached with a mix of intuitive explanations, theoretical characterization and proofs. And practical applications, including interpretation of regression output.

Course Outline:
Introduction to econometrics, Problems of autocorrelation, heteroscedasticity and their solution; Ridge regression, Lagged variables, Autoregressive models. Dummy variables, Errors in Variables, Instrumental variables, System of simultaneous linear equations, Identification-Estimation method, indirect and two-stage least squares methods, restricted least squares. Test of identifying restrictions; Estimation with stochastic repressor, generalized least squares estimators

Course Outcomes: After completing the course, the students will be able to
• Conduct basic statistical and econometric analysis. Explain and interpret econometric results.
• Explain econometric concepts and results intuitively, conduct independent data analysis and

Inquiry using the tools of statistics and econometrics.
- Conduct Research with econometrics, derive econometric results mathematically

Recommended Books: Latest Edition of the Following Books.
1. Baltagi, B. H. (1999). "Econometrics", 2nd Edition, Springer Varlog.
2. Draper, N.R. and Smith, H. (2004). "Applied Regression Analysis", John Wiley, New York.
3. Draper, N.R. and Smith, H. (2004). "Applied Regression Analysis", John Wiley, New York.
4. Gujrati, D. (2004). "Basic Econometrics", John Wiley, New York.
5. Gujrati, D. (1998). "Econometrics", John Wiley, New York.
6. Montgomery, D.C., and Peck E.A. (1992). "Introduction to Linear Regression Analysis", 2nd Edition, John Wiley and sons Inc. New York.
7. Maddela, G.S. (1977). 'Econometrics", McGraw Hill. New York.

Course Title: Population Studies	Course Code: STAT- 507
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
1. Gain a sound command over the basic tenets of demography as well as key demographic issues and illustrations in the context of a large and diverse country like India.
2. Grasp a clear understanding of the inter-relationship between demography and the process of Economic development.
3. Comprehend the basic components of population (fertility, mortality, migration)
4. To study established theories of population
5. To explore various aspects of the population policy and to study its impact on socio economic issues

Course Outline:
Meaning of vital statistics, registrations of Birth and death in Pakistan. Uses of vital statistics, short comings of vital statistics, rates and ratios (Sex ratio, child women ratio, birth and death ratio, population growth rate, classification of natal rates, death rates or mortality rates, crude death rate, specific death rate, infant mortality rate, case fatality rate, fertility rates, crude birth rate, specific birth rate, standardized death rate, reproduction rates, morbidity or sickness rates, marriage rates, divorce rates etc. general; fertility rate, total fertility rate.)

Basic concepts of demography, Sources of demographic data: The population and housing census, Registration of vital events. Demographic surveys, Components of population growth, composition of population and vital events, Types and sources of errors, Data quality testing procedures, testing the accuracy of age and sex distribution, Fertility and mortality measures, Estimation from incomplete Data. Consequences of world population growth & population explosion. State of Population in Pakistan. Development of demographic profile in Pakistan. Recent demographic

parameters. Current and future demographic activities in Pakistan.
Construction of complete and abridged life tables, Different types of life tables, Graphs of lx, qx and ex, Description and uses of life table columns.

Course Outcomes: After completing the course the students will be able
- to introduced to different sources of population data in Pakistan.
- They will also be familiarized with different techniques of data analysis.

Recommended Books: Latest Edition of the Following Books.

1.   Jay Weinstein, Vijayan, K. Pillai, (2001) "Demography: The Science of Population". Allyn & Bacon.
2.   Govt. of Pakistan (1998), National, Provincial and District census reports and other supplementary reports with respect to 1996 census; PCO, Islamabad.
3.   United Nations (1996), "Added years of Life in Asia", ESCAP; U.N., Thailand.
4.   Palmore, J .A; Gardner, R.W. (1994), "Measuring Mortality Increase"; East West Centre, Honolulu.
5.   Impagliazo, J. (1993), Deterministic Aspects of Mathematical Demography, Springer Verlag New York.
6.   United Nations (1990), " World Population Monitoring 1989", UNFPA.
7.   Rukanuddin AR. and Farooqi, M.N.l.., (1988), "The State of Population in Pakistan — 1987", NIPS, lslamabad.
8.   Keyfitz, N. (1983) "Applied Mathematical Demography", Springer Verlag N.Y.
9.   Pollard, A.H., Yousaf, F & Pollard, G.M. (1982), "Demographic Techniques", Pergamon Press. Sydney.
10. Lundquist, J. H., Anderton, D. L., Yaukey, D. (2015). Demography: The Study of
11. Human Population. United States: Waveland Press, Incorporated.
12.   Lutz, W. (2021). Advanced Introduction to Demography. United Kingdom: Edward Elgar Publishing.
3.   Poston, Jr., D. L., Bouvier, L. F. (2010). Population and Society: An Introduction to Demography. United States: Cambridge University Press.

7th Semester:

Course Title: Statistical Inference: Estimation of Parameters	Course Code: STAT-611
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: STAT-406	
Course Objective:	

- To introduces students to the basic theory behind the development and assessment of statistical analysis.
- To understand the techniques in the areas of point and interval estimation, as well as hypothesis testing.
- To apply the statistical techniques to real data and draw conclusions.

Course Outline:

Estimation of Parameters. Properties of Estimators: unbiasedness, consistency, sufficiency, efficiency, completeness Cramer-Rao inequality, Rao-Blackwell and Lehmann - Scheffe Theorems. Methods of Estimation: Moments, Maximum likelihood, least-squares, minimum Chi- square and Bayes' method. Interval Estimation: Pivotal and other methods of finding confidence interval, confidence interval in large samples, shortest confidence interval, optimum confidence interval. Bayes' Interval estimation.

Course Outcomes: After completing the course, the students will be able to
- I Explain the notion of a parametric model and point and interval estimation of the parameters of those models.
- Apply approaches for estimation and hypothesis testing.
- Explain and apply the idea of non-parametric statistics, wherein estimation and analysis techniques are developed that are not heavily dependent on the specifications of an underlying parametric model.
- Understand the computational issues related to the implementation of various statistical inferential approaches.

Recommended Books: Latest Edition of the Following Books.

1. Lindgren, B.W. (1998). "Statistical Theory". Chapman and Hall, New York.
2. Mood, A.M., Graybill, F.A. and Boss, D.C. (1997). "Introduction to the Theory of Statistics". McGraw Hill, New York.
3. Rao, C.R., (2009). "Linear Statistical Inference and its Applications", John Wiley, New York.
4. Rohatgi, V. K. (1984) Statistical Inference. Courier Dover Publications.
5. Stuart, A. and Ord, J.K. (2009). Kendall's' "Advanced Theory of Statistics" Vol. II. Charles Griffin, London.

Course Title: Multivariate Methods	Course Code: STAT-612
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: Nil	

Course Objective:
- This course provides the fundamental knowledge of multivariate data and its applications in different fields of life.
- This course will introduce the student different multivariate techniques through real world problems.
- This course will develop the skill in students to estimate the parameters and drive inference in multivariate cases.

Course Outline:

Introduction to multivariate data and its graphical representation. Properties of Random Vectors, Data Matrix, Euclidean and statistical distance. Mahalanobis Distances and Angles Review of matrix algebra, quadratic form, Eigen analysis, spectral decomposition. Descriptive statistics for multivariate data, multivariate normal distribution and its properties, Distribution of Linear Combinations of Normally Distributed Variates. Basic Properties. Methods for testing multivariate normality, <u>Inference</u> about mean vector, Inference about covariance matrices, One-way multivariate analysis of variance (MANOVA), and profile analysis.

Maximum Likelihood Estimation (MLE) of the Mean Vector and the Covariance Matrix. MLE under Constraints. Properties of the Estimators. Basic Multivariate Sampling Distributions. Distribution of Quadratic Forms Cochran's Theorem. The Wishart Distribution and its properties. The Hotelling T^2 Distribution. Distributions of Sample, Partial and Multiple Correlation Coefficients (Extensive derivations not required). Inference for the Multivariate normal Distribution. One-Sample Hypotheses on the mean Vector and covariance Matrix. One Sample Hypotheses of Linear Constraint on the Mean Vectors. Two Sample Hypotheses on the Mean Vectors and Covariance Matrices. Test of Homogeneity of Covariance Matrices. Test of Independence (Extensive Derivations not desired). Confidence Regions for the Mean Vectors. Simultaneous Confidence Intervals.

Course Outcomes: After completing the course the students will be able to
- Understand the basic concepts and applications of multivariate techniques.
- Unable to decide which multivariate technique to be used for the given scenario.
- Analyze the multivariate data and interpret the results correctly.

Recommended Books: Latest Edition of the Following Books.

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, John Wiley & Sons, New York, USA.
2. Johnson, R. A. and Wichern, D. W. (2007). Applied Multivariate Statistical Analysis, Prentice Hall, New York, USA.
3. Kendall, M.G.(1975). "Multivariate Analysis" Charless Griffin and Co. Ltd. London.
4. Manly, B.F.J. (2004). Multivariate Statistical Methods: A Primer, Chapman and Hall/CRC, New York, USA.
5. Mardia, K. V., Kent, J. T. and Bibby, J. M. (1976). Multivariate Analysis, Academic Press, New York, USA.

6. Rencher, A.C. and Christensen, W.F. (2012). Methods of Multivariate Analysis, John Wiley & Sons, New York, USA.
7. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979). "Multivariate Analysis", Academic Press, London.

Course Title: Statistical Packages	Course Code: STAT-606
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:
- To understand basics of data analysis through SPSS and R.
- To learn visualization of data through Minitab, SPSS and R.
- To learn basic programming in R.

Course Outline:
Introduction to statistical packages and programming languages, Introduction to Minitab, data manipulation, graphical representation, qualitative and quantitative data analysis and programming. Introduction to SPSS, data manipulation, descriptive statistics, function related to probability distributions, SPSS modules, graphical representation of data, tabulation and transformation of variables.

Introduction to R, language essentials; expression and objects, functions and arguments, vectors, missing values, matrices and arrays, factors, data frames, indexing, conditional selection, indexing of data frames, sorting, Data entry; reading from text files, the data editor, interfacing to other programs. Descriptive statistics and graphics.

Note: Use of any other statistical package based upon the availability of the Software.

Course Outcomes: After completing the course the students will be able to
- Understand the data presentation and analysis using Minitab and SPSS.
- Learn basic programming in R for statistical data analysis.
- Describe concepts as they are implemented in real world data.

Recommended Books: Latest Edition of the Following Books.
1. Crawley, M. J. (2012). The R book. John Wiley & Sons.
2. Delwiche, Lora D. and Slaughter Susan J. (1998) The Little SAS Book A Primer, Seco.c Edton, SAS institute, North Carolina.
3. Marques do Sd, Joaquim P.(2003) Applied Statistics using SPSS, STATISTICA and MATLAB
4. Norusis. Marija (2006) SPSS 14.0 Guide to Data Analysis, Prentice Hall, New Jersey.
5. Pace, L. (2012). Beginning R: An introduction to statistical programming. Apress.

6. Ryan, Barbara F.: Joiner, Brian L. and Cryer, Jonathan D.(2005) MINITAB Handbook, 5th Edition, Duxbury Press, California.
7. SPSS (2006) SPSS 14.0 Base User's Guide, , Prentice Hall, New Jersey.
8. Zumel, N., & Mount, J. (2014). Practical data science with R. Manning Publications Co.

Course Title: Survey and Research Methods	Course Code: STAT-614
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:
- To understand some basic concepts of research and its methodologies
- To identify appropriate research problems.
- To organize and conduct research in more appropriate manner
- To understand the logical structure of arguments and develop the reasoning ability.

Course Outline:
Definition of Research, Types of Research, Selection of Problem, Search of References, Formation of Hypothesis and Procedure for its Testing, Research Methodology, Planning of Experiments to Test Hypothesis Objectivity, Principals of Experimental Design, Steps in Experimentation, Collection of Data, Data Analysis to Determine Functional Relationship Between Variables, Levels of Significance, Interpretation of Results, Components of Scientific Reports and Various Methods of Data Presentation, Preparation of Scientific Reports, Publication Procedures.

Practical:

Studying and reviewing standard survey questionnaires and preparation of a sample questionnaire and a scientific report. Literature survey on a Given Topic, References from Various Sources. Critical report on given articles.

Course Outcomes: After completing the course the students will be able to
- Knowledge of important aspects of critical thinking
- Understanding of research problems and questionnaire
- Understand general definition of research design
- Plan and conduct research using an appropriate research design, keeping in view the ethical issues in the research
- Critically review of research articles

Recommended Books: Latest Edition of the Following Books.

1. Blaxter, L., Hughes, C. and Tight, M. (2006) How to Research (third edition). Buckingham:

Open University Press.

1. Creswell, J.W. (2002). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. Sage Publications.
2. Daniel, P.S. and Sam, A.G. (2011). Research Methodology. Kalpaz Publications, Delhi. Salkind, N.J. (2010). Encyclopedia of Research Design. Sage Publications, Inc.

3. Gimbaled, J. and W.S. Acuter (1988) "MLA handbook for Writers of Research Papers", McGraw .The Modern Language Association of America.
4. Panneerselvam, R. (2013). Research Methodology. Prentice Hall India.
5. Singh, Y.K. (2011). Fundamental of Research Methodology and Statistics. New Age International limited.
6. Salmon, M. H. (2006). Introduction to Logic and Critical Thinking. 5th edition. Wadsworth Publishing.
7. Saris, W.E. and Gallhoffer, I.N. (2014). Design, Evaluation, and Analysis of Questionnaires for Survey Research. 2nd edition. John Wiley & Sons, Inc, Hoboken, New Jersey.

Course Title: Statistical Inference: Hypothesis Testing	Course Code: STAT-621
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: STAT-611

Course Objective:
- To develop an advanced-level understanding and working knowledge of statistical inference.
- To provide an introduction to the rudiments of statistical inference for population parameters based on a general decision theoretic framework covering estimation and test of hypothesis.
- To introduce some nonparametric methods and their applications.

Course Outline:
Tests of Hypotheses: Simple and composite hypotheses, critical regions. Neyman-Pearson Lemma, power functions, uniformly most powerful tests. Deriving tests of Hypothesis concerning parameters in normal, exponential, gamma and uniform distributions, Randomized Tests, Unbiased tests, Likelihood ratio tests and their asymptotic properties. Sequential Tests: SPRT and its properties, A.S.N. and O.C. functions.

Course Outcomes: After completing the course the students will be able to
- A foundation for understanding probability-based statistical inference material presented in other courses.
- The understanding of the concepts of testing, size and power of a test.
- The understanding of and derivation of the properties of tests based on different criterion functions.

Recommended Books: Latest Edition of the Following Books.
1. Hirai, A. S. (2012) Estimation of Parameters. Ilmi Kitab Khana Lahore.
2. Lehman, E.L. (2008). "Testing Statistical Hypotheses". Springler - Volga, New York.
3. Lindgren, B.W. (1998). "Statistical Theory". Chapman and Hall, New York.
4. Rao, C.R., (2009). "Linear Statistical Inference and its Applications", John Wiley, New York.
5. Stuart, A and Ord, J.K. (2009). Kendall's' "Advanced Theory of Statistics" Vol. II. Charles Griffin, London.
6. Welish, A. H. (2011) Aspects of Statistical Inference. Wiley.

8ᵗʰ Semester:

Course Title: Applied Multivariate Analysis	Course Code: STAT-622
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: STAT-612	

Course Objective:
- This course provides the fundamental knowledge of orthogonal transformation of correlated variables.
- The course enable the students to use exploratory and confirmatory multivariate statistical methods properly.
- To be able to carry out multivariate statistical techniques and methods efficiently and effectively.

Course Outline:
Principal Component Analysis. Introduction. Definition and Properties of Principal Components. Sampling Properties of Principal Components. Inference about Principal components. Discarding of Variables. Interpretation of the Results. Factor Analysis Introduction. The Factor Model. Principal Factor Analysis. Maximum Likelihood Factor Analysis. Goodness of Fit Test. Factors Scores. Relationship between Factor Analysis and Principal Component Analysis. Discriminant Analysis. Introduction. Discrimination When the Populations are known. Discrimination under Estimation. Fisher's Linear Discriminant Function. Probabilities of Misclassification. Cluster Analysis. Introduction. A Probabilistic Formulation. Hierarchical Methods. Distances and Similarities. Other Methods and Comparative Approach. Canonical Correlation Analysis, Multidimensional Scaling, Correspondence Analysis.

Course Outcomes: After completing the course the students will be able to
- Use principal component analysis effectively for data exploration and data dimension reduction.

- Use factor analysis effectively for exploratory and confirmatory data analysis.
- Discriminate between groups.
- Summarize, Analyse the multivariate data and interpret the results correctly

Recommended Books: Latest Edition of the Following Books.
1. Grimm. L.G. & Yarnold, P.R. (1995). "Reading and understanding multivariate statistics". Washington, DC: APA Books.
2. Grimm. L.G. & Yarnold, P.R. (2000). "Reading and understanding more multivariate statistics". Washington, DC: APA Books.
3. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2009). "Multivariate data analysis" (7th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
4. Everitt, B.S., Hothorn, T. (2011). "An introduction to Applied Multivariate Analysis with R", Springer.
5. Harlow, L. L. (2014). "The Essence of Multivariate Thinking: Basic Themes and Methods" (2nd ed.). New York: Routledge.
6. Johson, R. A., & Wichern, D. W. (2007). " Applied multivariate statistical analysis" (6th ed.). NJ: Pearson
7. Lattin, J., Carroll, D., and Green, P. (2003). "Analyzing Multivariate Data". Thomson Learning.

Course Title: Time Series Analysis	Course Code: STAT-624
Course Structure: Lectures: 3, Labs: 0	**Credit Hours:** 3

Prerequisites:

Course Objective:
- Learn basic analysis of time series data.
- Compute and interpret ACF/PACF and a sample spectrum.
- Derive the properties of ARIMA models and choose an appropriate ARIMA model for a given set of data and fit the model using an appropriate package
- Compute forecasts for a variety of linear methods and models.

Course Outline:
Time series analysis: concepts and components, Stochastic Process, Stationary Time-Series, Exponential smoothing techniques, auto-correlation and auto-covariance, estimation of auto-correlation function (ACF) and Partial autocorrelation function (PACF) and standard errors, Periodogram, spectral density functions, comparison with ACF, Linear stationary models: Auto Regressive Moving Average (ARMA) and mixed models, Non-stationary models, general ARIMA notation and models, minimum mean square forecasting. ARIMA Seasonal Models.

Course Outcomes: After completing the course the students will be able to
- Demonstrate understanding of the concepts of time series and their application to various

fields of sciences.

- Apply ideas to real time series data and interpret outcomes of analyses and forecast.
- Use various advanced time series econometric methods, estimation methods and related econometric theories.
- Interpret time series models' estimates and analyze the results.

Recommended Books: Latest Edition of the Following Books.

1. Anderson, T. W. (2011). *The statistical analysis of time series* (Vol. 19). John Wiley & Sons.
2. Box, G.E.P. and Jenkins, G.M., and Reinsel G. C. (2008) Time Series Analysis: Forecasting and Control, San Francisco.
3. Chatfield C. (2003): The Analysis of Time Series: An Introduction, Taylor & Francis, NY, USA.
4. Diggle, P.J. (1990), Time Series: A Bio statistical Introduction, Clarendon Press, Oxford.
5. Enders, W. (2004). Applied time series econometrics. *Hoboken: John Wiley and Sons*.
6. Jonathan D. C. and Kung-Sik C. (2008): Time Series Analysis with Applications in R, Springer, USA.
7. Peter J. B and Richard A. D (2002): Introduction to Time Series and Forecasting, Second Edition, Springer, USA.

Major Optional/Elective Courses

(For 7th and 8th semester)

Course Title: Statistical Quality Control	Course Code: STAT- 613
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3
Prerequisites: NIL	

Course Objective:
- This course is designed to provide a conceptual and practical knowledge of techniques for quality control.
- This course is structured to monitor the process control via control charts.
- This course is designed to determine most appropriate sample size needed to accept or reject a lot of material.

Course Outline: Concept of quality control and Quality assurance, Total Quality Management (TQM), Statistical Methods in Quality Improvement, Statistical Process Control (SPC). X-bar, R, S, Shewhart, CUSUM and moving average control charts. Six Sigma approach to control charts, Average Run Length (ARL); Standard deviation run length (SDRL). Process capability analysis: Process improvements using design of experiments. Acceptance sampling plans: Single, double, and multiple with their operatic characteristic curves. Introduction to ISO- 9000 and ISO-14000 series

Course Outcomes: On the successful completion of this course the students will be able to:

- Design attribute and variable acceptance sampling plans for the industrial purpose.
- To construct various types of attribute and variable sampling plans using statistical software.
- Draw attribute and variable control charts to be implemented in different scenarios exist in industry.
- To construct various types of attribute and variable control charts to be implemented in different scenarios exist in industry.

Recommended Books: Latest Edition of the Following Books.
1. Juran, J.M. and Godfrey, A.B. (1998). *Juan's Quality Control Handbook*. McGraw Hill, New York, USA.
2. Montgomery, D.C. (2013). *Introduction to Statistical Quality Control.* McGraw Hill, New York, USA.
3. Ryan, T.P. (2011). *Statistical Methods for Quality Improvement.* John Wiley & Sons, New York, USA.
4. Schilling, E.G. and Neubauer, D.V. (2008). *Acceptance Sampling in Quality Control*. Chapman & Hall, New York, USA.
5. Vardeman, S.B. and Jobe, J.M. (2016). *Statistical Methods for Quality Assurance: Basics, Measurement, Control, Capability, and Improvement*. Springer, New York, USA

Course Title: Survey and Research Methods	Course Code: STAT-614
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- To understand some basic concepts of research and its methodologies
- To identify appropriate research problems.
- To organize and conduct research in more appropriate manner
- To understand the logical structure of arguments and develop the reasoning ability.

Course Outline:
Definition of Research, Types of Research, Selection of Problem, Search of References, Formation of Hypothesis and Procedure for its Testing, Research Methodology, Planning of Experiments to Test Hypothesis Objectivity, Principals of Experimental Design, Steps in Experimentation, Collection of Data, Data Analysis to Determine Functional Relationship Between Variables, Levels of Significance, Interpretation of Results, Components of Scientific Reports and Various Methods of Data Presentation, Preparation of Scientific Reports, Publication Procedures.

Practical:

Studying and reviewing standard survey questionnaires and preparation of a sample questionnaire

and a scientific report. Literature survey on a Given Topic, References from Various Sources. Critical report on given articles.

Course Outcomes: After completing the course, the students will be able to

- Knowledge of important aspects of critical thinking
- Understanding of research problems and questionnaire
- Understand general definition of research design
- Plan and conduct research using an appropriate research design, keeping in view the ethical issues in the research
- Critically review of research articles

Recommended Books: Latest Edition of the Following Books.
1. Blaxter, L., Hughes, C. and Tight, M. (2006) How to Research (third edition). Buckingham: Open University Press.
2. Creswell, J.W. (2002). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. Sage Publications.
3. Daniel, P.S. and Sam, A.G. (2011). Research Methodology. Kalpaz Publications, Delhi. Salkind, N.J. (2010). Encyclopedia of Research Design. Sage Publications, Inc.

4. Gimbaled, J. and W.S. Acuter (1988) "MLA handbook for Writers of Research Papers", McGraw .The Modern Language Association of America.

5. Panneerselvam, R. (2013). Research Methodology. Prentice Hall India.

6. Singh, Y.K. (2011). Fundamental of Research Methodology and Statistics. New Age International limited.
7. Salmon, M. H. (2006). Introduction to Logic and Critical Thinking. 5th edition. Wadsworth Publishing.
8. Saris, W.E. and Gallhoffer, I.N. (2014). Design, Evaluation, and Analysis of Questionnaires for Survey Research. 2nd edition. John Wiley & Sons, Inc, Hoboken, New Jersey.

Course Title: Robust Methods	Course Code: STAT-615
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- The objectives of this course are to provide an introduction to both basic and advanced analytical tools for robust models. This course also aims to promote a critical perspective on the use of statistical information.

- Beginning with simple statistical methods, the course builds to more robust analytical

techniques such as multivariate linear regression and estimators.

- Emphasis is placed on theoretical understanding of concepts as well as the application of key methodologies used in different research fields.

Course Outline:
Introduction to Robustness, Objective function, M-estimator of location, E-estimator, R-estimator and W-estimator, Redescending M-estimator's The Breakdown point of Robust estimator Influence function. M-estimator for scale, Jackknife Resampling, Outliers and influential observations, Outliers in Regression analysis.

Course Outcomes: After completing the course, the students will be able to
- Explain the importance, techniques and biases of estimators in context
- Explain the concept of outliers in regression model and other influential observations
- Construct and interpret various statistical hypothesis tests.

Recommended Books: Latest Edition of the Following Books.
1. Hamper, T.R. Brochette, E. M., Rousseau, P.J. and Satchel, W.A. (1986). *Robust Statistics: The approach Based on Influence functions,* John Wiley & Sons, New York, USA.
2. Hosmer, D.W. and Lemeshow, S. (2008). *Applied Survival Analysis,* John Wiley & Sons, New York, USA.
3. Huber, P. J. and Ronchetti, E.M. (2009). *Robust Statistics,* John Wiley & Sons, New York, USA.
4. Maronna, R.A., Martin, D.R. and Yohai, V.J. (2006). *Robust Statistics: Theory and Methods,* John Wiley & Sons, New York, USA.
5. Rousseau, P.J. and Leroy, A.M. (1987). *Robust Regression and outlier detection*, John Wiley & Sons, New York, USA.

Course Title: Operations Research	Course Code: STAT- 616
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- To introduce students to the techniques of operations research.
- To provide students with basic skills and knowledge of operations research and its application in industry.
- To introduce students to practical application of operations research with emphasis on the industrial data.
- To effectively use relevant statistical software for data analysis.

Course Outline:
  History and definition of Operations Research (OR), Types of OR models, Introduction to linear

programming, Formulation of LP model, Graphical solution of two variables, Standard Form, Simplex method, Duality theory; Sensitivity Analysis, Primal and dual form, Transportation Problem, Assignment problem. Network Analysis, PERT/CPM techniques, Queuing Models.

Course Outcomes: After completing the course the students will be able to

- Identify and develop operations research models from the verbal description of the real system.
- Understand the mathematical tools that are needed to solve optimization problems.
- Apply operations research techniques to summarize the industrial data.
- Demonstrate the usage of statistical software for solving problem and analyzing the relevant data.

Recommended Books: Latest Edition of the Following Books.
1. Hillier, F.S. and Lieberman, G.J. (2014). *Introduction to Operations Research.* 10th edition. McGraw Hill.
2. Bazarra, N.M., Jarvis J.J. and Sherali, H.D. (2010). *Linear Programming and Network Flows*. 4th edition. John Wiley & Sons.
3. Taha, H.A. (2010). *Operations Research*. 9th edition, Pearsons.
4. Gross, D., Shortle, J.F., Thompson J.M. and Harris, C.M. (2008). *Fundamentals of Queueing Theory.* 4th edition. John Wiley & Sons, Hoboken, NJ.
5. Gupta, P.K. and Hira, D.S. (2008). *Operations Research*. 7th edition, S. Chand and Co., New Delhi.
6. Bronson, R. and Naadmuthu, G. (1997). *Operations Research – Schaums' Outline Series*. McGraw-Hill.

Course Title: Statistical Practicum	**Course Code: STAT-717**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- To discuss and explain application of the statistical techniques on real world problems.
- To use statistical software's to carry practical application of statistics.
- To apply statistical software to analyze and evaluate data by implementing appropriate statistical techniques.

Course Outline:
 This course enables students to gain professional work experience in the application of statistics. The students will carry practical on benchmark data sets using statistical software's/ programming packages. The numerical problems from regression analysis, sampling, experimental design, non-parametric technique.

Course Outcomes: After completing the course, the students will be able to
- Analyze a statistical question involving, sampling, design of experiments, regression using statistical simulation and real data sets.
- Apply various statistical techniques on benchmark data sets.
- To demonstrate an understanding of the concepts of statistical theory in application.
- To apply appropriate usage of software/programming languages.
- To analyze and communicate the results of statistical analysis accurately and effectively.

Recommended Books: Latest Edition of the Following Books.
1. Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical learning (Vol. 1, No. 10). New York: Springer series in statistics.
2. Crawley, M. J. (2012). The R book. John Wiley & Sons.
3. Little, R. J., & Rubin, D. B. (2019). Statistical analysis with missing data (Vol. 793). John Wiley & Sons.
4. Verzani, J. (2018). Using R for introductory statistics. Chapman and Hall/CRC.
5. Gandrud, C. (2016). Reproducible research with R and R studio. Chapman and Hall/CRC.
6. Finch, W. H., Bolin, J. E., & Kelley, K. (2016). Multilevel modeling using R. Crc Press.
7. Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2004). SPSS for introductory statistics: Use and interpretation. Psychology Press.

Course Title: Applied Bio-statistical Analysis	Course Code: STAT-618
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- To discuss and explain what biostatistics is and how it is used in Biological Sciences
- To recognize and give examples of different types of data arising in Biological Sciences
- To use statistical techniques to summarize the biological data
- To apply statistical software to analyze and evaluate biological data

Course Outline:
Definition of Biostatistics, type of variables and observations in biological, health and medical sciences, Uniqueness in terms of behavior of variables their domain, and units; Categorical, numerical and censored data. Populations, Target populations and samples; Role of sampling in biostatistics, Size of samples of various types of studies, Proportions, rates and ratios; incidence, prevalence and odds. Distributional behavior of biological variables (Binomial, Poisson and Normal), Role of transformation for analysis of biological variables. Probit and Logit transformations and their analysis, p values, its importance and role. Confidence Interval in simple and composite hypothesis testing.

Course Outcomes: After completing the course, the students will be able to

- Analyze the different type of data using appropriate statistical software

- Demonstrate a good understanding of descriptive statistics and graphical tools
- Explain fundamental concepts of estimation and hypothesis testing and be confident when interpreting P values and confidence intervals
- Produce some common statistical performance measures such as sensitivity, specificity, positive and negative predictive values, ROC curve and Area under the ROC curve
- Compute and interpret some common measures of association such as absolute risk, relative risk, odds and odds ratio

Recommended Books: Latest Edition of the Following Books.

1. Alfassi Z. B., Boger, Z. and Ronen, Y. (2005): *Statistical Treatment of Analytical Data*. Blackwell Science, USA.
2. Antonisamy, B. Premkumar, P. and Christopher, S. (2017). *Principles and Practice of Biostatistics*. 1st edition. Elsevier, India.
3. Daniel, W.W. (2010). *Biostatistics: A Foundation for the Health Sciences*. 6th edition. John Wiley, New York. NY, USA.
4. Dunn, G. and Everit, B. (1995). *Clinical Biostatistics*. Edward Arnold, London, UK.
5. Sullivan, M.L. (2018). *Essentials of Biostatistics in Public Health*. 3rd edition. Jones and Bartlett Learning, Burlington, MA, USA.
6. Zar, J. (2000). *Biostatistical Analysis.* 5th Edition. John Wiley & Sons, New York, NY, USA.

Course Title: Official Statistics	Course Code: STAT- 619
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: NIL

Course Objective:
- To understand the official, demographic and social statistics.
- To understand the scope and organization of official statistics,
- To understand the planning and administration statistics.

Course Outline:
Design and planning of a Statistical Investigation. Data collection-approach and operation; Role of sampling in generation of Statistics, Sampling plans and survey Designs. Sources of Errors, Types of Errors, methods of their control. Data processing, presentation, and publication of Statistics. Different modes of Data Dissemination. Official Statistics, Statistical systems and standards, Sources of official statistics, their role, working and publication. Role of Official Statistics, Official Publications. Setup of official organizations in Pakistan their role, working & publication, Statistics Division, Federal Bureau of Statistics, Agricultural Census Organization, Population Census Organization, Ministry of Food, Agriculture and Livestock; National Data Base and Registration Authority (NADRA). Provincial Bureaus of Statistics. Financial Statistics: Ministry of Finance, State Bank of Pakistan-Department of Statistics, their working, publications and responsibilities. Other Organization's Statistical output, National and International series, classification and standards. Use of Statistics in administration and planning. Concepts and evaluation of GDP, GNP, NNP, Balance of Trade and payments. Measurement of Income Distribution, use of Index Numbers and time series. Deflation and Inflation of series. National sample surveys and censuses conducted in Pakistan.

Assignment: Visit of major Statistical Organizations will be a part of the course. An assignment will have to be submitted on any topic given by the course In-charge.

Course Outcomes: After completing the course, the students will be able to
- The versatility to work effectively in a broad range of analytic, scientific, government, financial, technical and other positions.
- A broad overview of the fundamental issues underlying the organization of official statistics.
- To recognize the importance of statistical thinking.

Recommended Books: Latest Edition of the Following Books.
1. Hansen M.H. (1980). "Progress and Problems in Survey Methods and Theory". Illustrated by the work of U.S. Bureau of the Census, U.S. Department of Commerce; A Monograph.
2. Kish, L. (1992). "Survey Sampling", John Wiley, New York.
3. Murthy, MN. (1979). "Quality of Data, Country Course on Sample Surveys", Karachi.
4. Statistics Division, "Activity Report" (1988-89). Government of Pakistan, Islamabad.

5. Statistical Institute for Asia & Pacific SIAP (1984). "Training of Trainers in Statistical Operations and Procedures" Part-I, II UNDP, Tokyo.

Suggested Reports:

- Hansen M.H. (1980). Progress and Problems in Survey Methods and Theory. IIIustrated by the work of U.S. Bureau of the Census, U.S. Department of Commerce; A Monograph.
- NIPA (1962). Administrative uses of Statistics. NIPA Karachi.
- Statistical Institute for Asia and Pacific SIAP (1984). Training of Trainers in Statistical Operations and Procedures. Part-I, II UNDP, Tokyo.
- Statistics Division (1979). Retrospect, Perspective and Prospect. Islamabad.
- Statistics Division Activity Report (1988-89). Government of Pakistan, Islamabad.
  *Various Publications of PBS, State Bank of Pakistan, Ministry of Finance, etc.

Course Title: Applied Categorical Data Analysis	Course Code: STAT- 620
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- To understand the basic concepts of categorical data analysis
- To recognize different types of categorical data and use appropriate methodology for categorical data
- To conduct statistical analysis using existing software and properly interpret the computer output.

Course Outline:
 A brief history of categorical data analysis, Principles of likelihood-based inference, Sampling distributions for contingency tables, Measures of association for 2x2 tables, Testing independence in contingency tables, Exact inference for two-way tables, Inferences for three-way tables.

Introduction to generalized linear models: Log linear models, fitting Log linear and Logit models, building and applying Log linear models, Log linear Logit models for ordinal variables, multinomial response models for matched pairs, analyzing repeated categorical response data, logistic regression models and their analysis. Logistic regression, Model building, Alternative link functions for binary outcome, Diagnostics, Receiver Operating Characteristic (ROC) Curve Analysis. Exact methods and conditional logistic regression, Methods for analyzing matched case-control data, Multinomial response models for nominal data, Multinomial response models for ordinal data.

Course Outcomes: After completing the course, the students will be able to

- Implement basic categorical methods and combine them for the sampling estimation

- Obtain estimators, evaluate standard errors, construct confidence intervals and making statistical inference according to the categorical analysis techniques
- Apply the principles of lifelong learning to any new challenges arise with categorical data
- Demonstrate the knowledge to characterize, analyse and solve a wide range of problems related to the categorical data

Recommended Books: Latest Edition of the Following Books.
1. Agresti, A. (2012). *Categorical Data Analysis.* 3rd edition. John Wiley & Sons.
2. Agresti, A. (2007). *An Introduction to Categorical Data Analysis*. 2nd edition. John Wiley & Sons.
3. Collett D. (2003). *Modeling Binary Data*. Champman and Hall/CRC.
4. Hosmer D. W. and Lemeshow S. (2004). *Applied Logistic Regression.* John Wiley & Sons.
5. Lloyd C. J. (1999). *Statistical Analysis of Categorical Data.* John Wiley & Sons.
6. Powers D. A. and Xie, Y. (2008). *Statistical Methods for Categorical Data Analysis.* 2nd edition. Emerald Group publishing.

Course Title: Stochastic Process	Course Code: STAT- 623
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- This course aims to provide an understanding of stochastic processes and the ability to analyse certain aspects of these processes.
- Accordingly, the course starts by reviewing probability theory, conditional probability, independence and certain properties of random variables, and continues by examining stationary processes.
- Furthermore, Markov chains in discrete and continuous time as well as Possion processes are investigated in detail.

Course Outline:
Introduction. Generating Functions. Laplace Transforms. Difference Equations. Differential – Difference Equations. Introduction to Stochastic Processes. The Random Walk in one and two Dimensions. The Classical Gambler's Ruin Problem. Expected Duration of the Game. Markov Chains: Definition. Transition Probabilities, Higher Transition Probabilities. Classification of States and Chains. Markov processes with Discrete State Space. Poisson Process and its Generalization. Pure Birth and Death Processes. Markov Processes with Discrete State Space (Continuous Time Markov Chains). Markov Processes with Continuous State Space. Introduction to Brownian Motion. The Wiener Process. Diffusion Equations for the Wiener Process. Introduction to Brownian motion.

Course Outcomes: After completing the course, the students will be able to
- Compute probabilities of transition between states and return to the initial state
- Identify classes of states in Markov chains and characterize the classes.
- Determine limit probabilities in Markov chains after an infinitely long period.

Recommended Books: Latest Edition of the Following Books.
1. Durrett, R. (2001). *Probability: Theory and examples*, Cornel University, New York, USA.
2. Freedman, D. (1999). Brownian motion and Diffusion, Springer, New York, USA.
3. Karlin, S.A. and Taylor, H.M. (2011). *A first course in Stochastic Process*, Academic Press, London, USA.
4. Peter, W.J. and Smith, P. (2010). *Stochastic Process: An Introduction,* Chapman and Hall, New York, USA.
5. Resnick, S. I. (2002). *Adventure in Stochastic Process,* Birkhauser Boosters, New York, USA.
6. Ross, S.M. (2006). *Stochastic Process*, John Wiley & Sons, New York, USA.

Course Title: Decision Theory	Course Code: STAT-625
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- The course aims to make the statistical decision under uncertainty.
- on some statistical decision methods with or without data.
- Consider statistical inference (estimation and hypothesis testing) from the standpoint of statistical decision making.

Course Outline:
The nature and concept of loss functions, parameters, decisions and sample spaces. Risk and average loss. Admissibility and the class of admissible decisions. Minimax principle and its application to simple decision problems, linear and quadratic losses and their uses in problems of estimation and testing hypotheses. Asymptotically minimax procedure. A prior distributions and conjugate priors. Bayes' decision procedure, admissibility of Bayes' and minimax procedures.

Course Outcomes: After completing the course, the students will be able to

- Understand the elements of the decision problem under investigation.
- Use mathematics for making decision.
- Make the suitable type of decision and the analysis among various techniques in the field under uncertainty.
- Choosing the appropriate statistical methods for a particular application.
- Formulate significant research questions, use appropriate statistical decision method, and analyze and interpret the results.
- Read, evaluate, and interpret numerical, statistical information.

- Looking to any subject from different viewpoints.
- Comparing things should always be performed.
- Reaching the appropriate conclusions from the used analysis

Recommended Books: Latest Edition of the Following Books.
1. Berger, J. 0. (1985). "Statistical Decision Theory & Bayesian Analysis", Springer Verlag.
2. Blackwell, D. and Graphic, M.A. (1966). "Theory of Games and Statistical Decision", John Wiley. New York.
3. Joyce, J. M. (1999). The foundations of causal decision theory. Cambridge University Press.
4. Liese, F., & Miescke, K. J. (2007). Statistical decision theory. In Statistical Decision Theory (pp. 1-52). Springer, New York, NY.
5. Lindgren, B.W. (1971), "Elements of Decision Theory, Macmillan", New York.
6. Parmigiani, G., & Inoue, L. (2009). Decision theory: Principles and approaches (Vol. 812). John Wiley & Sons.
7. Winkler, R. L. (1972). An introduction to Bayesian inference and decision (pp. 493-524). New York: Holt, Rinehart and Winston.

Course Title: Reliability Analysis	Course Code: STAT-626
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- To learn to analyse complete and censored reliability data with and without covariates.
- To learn some key methods in reliability modelling.
- To learn the probability and statistical methods covered in the Reliability Analysis.
- To have the working knowledge to determine the reliability of a system and suggest approaches to enhancing system reliability.

Course Outline:
 Basic concepts of reliability. Structural reliability. Lifetime distributions (Failure models): Hazard rate; Gamma, Weibull, Gumball, Log-Normal and Inverse Gaussian Distribution. Stochastic fatigue-rate models. Point and interval estimation. Fatigue-life model. Testing reliability hypothesis. Monte-Carlo, distribution-free and Bayes' methods in reliability. System reliability, series and parallel systems. Failure models, (kout-of-rn) New-better-than used models. Inferences for these models. Accelerated life testing.

Course Outcomes: After completing the course, the students will be able to
- Analyse the interference between strength and stress, or life data for estimating reliability
- Apply the appropriate methodologies and tools for enhancing the inherent and actual reliability of components and systems, taking into consideration cost aspects.
- Specify life test plans for reliability validation.

Recommended Books: Latest Edition of the Following Books.
1. Achintya Haldar, Sankaran Mahadevan (2000). Reliability Assessment Using Stochastic Finite Element Analysis".
2. Crowder, M .J. (1994). "Statistical Analysis of Reliability Data".
3. Gertsbakh, lB. (1989). "Statistical Reliability Theory". Marcel Decker. New York.
4. Lee, J. Bain, Bain Bain, (1991). "Statistical Analysis of Reliability and Life-Testing Models".
5. Gertsbakh, lB. (1988). "Statistical Reliability Theory".
6. Lawless, J.F. (1982). "Statistical Model and Methods for Lifetime Data".
7. Mann, N.R., Scheefer, R.E. and Singapoor wel, N.D. (1974). "Methods for Statistical Analysis of Reliability", John Wiley & Sons.

Course Title: Survival Analysis	Course Code: STAT-627
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: NIL

Course Objective:
- To introduce the basic concepts of survival analysis
- To describe and explain how survival analysis can be applied in different fields
- To learn the usage of appropriate statistical software for survival data analysis

Course Outline:
Describing the probability distributions of the survival and hazard functions. Basic layout of the survival problem both manually and computer-based presentation of survival data. Computation of the descriptive measures for survival data both graphically and empirically.

Estimation of the survival function, survival probabilities. Estimation of the survival functions from possibly censored samples by means of the Kaplan-Meier estimator, the Nelson-Aalen estimator and the kernel density estimator or the Ramlau-Hansen estimator and comparisons of k independent survival functions by means of the generalized log-rank test and related alternative approaches. The Proportional Hazards Model, the likelihood function, the Partial Likelihood Function, identification of Significant Covariates, estimation of the Survivorship Function with Covariates. Cox's semi-parametric models. Evaluation of the assumptions of Cox proportional hazard model. Introduction to estimation of Stratified Cox's procedures for single and multiple variable adequacy Assessment of the Proportional Hazards Model.

Course Outcomes: After completing the course, the students will be able to
- Understand the basic concepts and ideas of survival analysis
- Derive properties and methods for standard survival time distributions

- Perform and interpret simple non-parametric survival analyses using software
- Apply and interpret semi-parametric regression models for survival data using software

Recommended Books: Latest Edition of the Following Books.

1. Collet, D. (2014). *Modelling Survival Data in Medical Research*. 3rd edition, CRC Press, Taylor and Francis Group. Fl, USA.
2. Gjessing, H., Aalen, O. O. and Borgan, O. (2012). *Survival and Event history analysis*. Springer Series, New York, NY, USA.
3. Kleinbaum, D.G. and Klein, M. (2012). *Survival Analysis: A self-learning text*. 3rd edition. Springer, New York, NY, USA.
4. Klein, J. P., and Moeschberger, M. L. (2003). *Survival Analysis: Techniques for Censored and Truncated data*. 2nd edition, Springer series, New York, NY, USA.
5. Lee, E. T., and Wang, J. W (2013). *Statistical Methods for Survival Data Analysis*, 4th edition, John Wiley & Sons, New Jersey, USA.
6. Machin, D., Cheung, Y. B. and Parmar, M. K. (2006). *Survival Analysis: A practical approach*. 2nd edition, John Wiley & Sons, Ltd. England, U.K.

Course Title: Data Mining	Course Code: STAT-628
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
The course is designed to enable the students to

- Interpret the contribution of data warehousing and data mining to the decision-support level of organizations
- Understanding of pattern mining, association, correlation, classification, prediction, and cluster and outlier analysis
- Have knowledge different classification methods

Course Outline:
Introduction to databases including simple and relational databases, data warehouses, Review of classification methods from multivariate analysis; classification, decision trees: classification and regression trees. Clustering methods from both statistical and data mining viewpoints; vector quantization. Unsupervised learning from univariate and multivariate data; dimension reduction and feature selection. Supervised learning from moderate to high dimensional input spaces; introduction to artificial neural networks and extensions of regression models.

Course Outcomes: After completing the course, the students will be able to
- design and implement systems for data mining
- evaluate the performance of different data-mining algorithms
- decision through classification and regression trees

Recommended Books: Latest Edition of the Following Books.
1. Tan, P., Steinbach, M. & Kumar, V. (2006). *Introduction to Data Mining*, Addison Wesley, New York, USA.
2. Benson and Smith, S.J. (1997). "*Data Warehousing, Data Mining'*, and OLAP. McGraw-Hill.
3. Bramer M (2007): *Principles of Data Mining*. Springer-Verlag London Limited UK.
4. Breiman, L. Friedman, J.H. Olshen, R.A. and Stone, C.J. (1984). "*Classification and Regression Trees*" Wadsworth and Brooks/Cole.
5. Han, J., Kamber, J. Pei, J., and Burlington, M. A. (2012) Data mining: concepts and techniques. Haryana, India.
6. Han, J. and Camber, M. (2000). Data Mining; "*Concepts and Techniques*". Morgan Gaufmann.
7. Mitchell, T.M. (1997). *"Machine Learning*". McGraw-Hill.
8. Rao C. R., Wegman E. J. & Solka J. L (2005): *Handbook of Statistics, Vol. 24: Data mining and data visualization*. Elsevier B.V., North Holland.

Course Title: Actuarial Statistics	Course Code: STAT-629
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
- To develop understanding of the mathematical concepts and techniques that are used by actuaries to model stochastic processes of both assets and liabilities.
- To learn about various types of insurance and pension schemes.

Course Outline:

Utility theory. Insurance and unity theory, models for individual claims and their sums survival function curate future lifetime, force of mortality. Life table and its relation with survival function. Examples. Assumption for tractional ages. Some analytical laws of mortality, select and ultimate tables multiple life functions. mint life and last survivor status, insurance and annuity benefits through multiple life function evaluation for special mortality laws Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrements. Net single premiums and their numerical evaluations Distribution of aggregate claims compound Poisson distribution and its applications.

Life Tables: 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. 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. Mortality: Theories of Mortality, analytical laws of mortality, techniques of projections of population mortality. Pension Theory: Structure and design of pension funds, Basic actuarial aspects of pension plans, Actuarial assumptions and actuarial cost methods, periodic gain and loss analyses, Relative merits of cost methods, sensitivity analysis.

Course Outcomes: After completing the course, the students will be able to
- Basic Mathematics involved in Actuarial Computations.
- Insurance, Types and Applications in Pakistan.
- Understanding the Life Contingencies and Actuarial Notations.
- Understanding the Life Tables, Types and Computations.

Recommended Books: Latest Edition of the Following Books.
1. Booth, P.M. et al. (1999). Modern Actuarial Theory and Practice, Chapman & Hall.
2. Bowers, N.L. Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Society of Actuaries, 2nd Edition.
3. Broverman, S.A. (2015). Mathematics of Investment and Credit, 6th Edition, ACTEX Publications.
4. Daniel, J.W. and Vaaler, L.J.F. (2007). Mathematical Interest Theory, Pearson, Prentice Hall.
5. Dickson, D.C.M. Hardy, M.R. and Waters, H.R. (2013). Actuarial Mathematics for Life Contingent Risks, 2nd Edition.
6. Gerber, H.U. (1997), Life Insurance Mathematics, Springer-Verlag, 3rd Edition
7. Johnson, A. (2016). Actuary Career (Special Edition): The Insider's Guide to Finding a Job at an Amazing Firm, Acing the Interview & Getting Promoted.
8. Miller, T. (2015). Achieving Your Pinnacle: A Career Guide for Actuaries.

Course Title: Mathematical Modeling and Simulation	Course Code: STAT-630
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- To understand the mathematical models using simulation
- Knowledge of simulation approaches to problem solving, on a diverse variety of disciplines.
- To check the validity of models.

Course Outline:
Monte Carlo methods: Different methods of generating random variables, generation of random numbers, acceptance and rejection techniques from various distributions. Comparison of algorithms to generate random variables. Generating random variables from failure rates. Generation from multinomial distribution / Monte Carlo integration. Gibbs sampling and other techniques. Variance

reduction techniques: importance sampling for integration, control varieties and antithetic variables.

Course Outcomes: After completing the course, the students will be able to
• Recognize the connections between simulated and real data. • Familiar with a variety of simulated examples where mathematical models helps accurately explain physical phenomena. • Able to independently expand their mathematical or statistical expertise when needed, or for interest's sake.

Recommended Books: Latest Edition of the Following Books.
1. Daniel P. M, Maynard T. (2006). Mathematical Modeling and Computer Simulation, Thomson Brooks/Cole 2. Fishman, G.S. (1996). Monte Carlo: Concepts, Algorithms, and Applications. Springer. 3. Ross, S.M. (2002). Simulation, 3rd Edition. Academic Press. 4. Ripley, B.D. (1987) "Stochastic Simulations" (Wiley) 5. Velten, K. (2009). Mathematical modelling and simulation. Wiley VCH, Germany.

Course Title: Bayesian Analysis	**Course Code: STAT-631**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
• The aim of this course is to introduce the modern approach to Bayesian statistics, • This course is emphasizing the computational aspects and the differences between the classical and Bayesian approaches. • This course will help in formulating appropriate Bayesian models, including data and prior distributions.

Course Outline:
Introduction to Bayesian Inference, goals of Bayesian Inference, Conditional Probability, Conditional independence, Prior distribution and its different types, Posterior distribution, its mean, median (Bayes estimators under loss functions) and variances. Posterior Inference based on one parameter e.g. binomial, Poisson etc. Posterior inference based on normal distribution: Posterior predictive distributions, Bayesian Hypotheses Testing: Bayes factor; The highest density region; Introduction to Monte Carlo method, Discrete approximations.

Course Outcomes: After completing the course the students will be able to
• Understanding basic techniques of Bayesian statistics for decision making • Using different simulation techniques to handle complex posterior distribution • Knowing the application of Bayesian statistics in different models

Recommended Books: Latest Edition of the Following Books.
1. Albert, J. (2007). Bayesian Computation with R, 1st ed. Springer, New York, USA.
2. Carlin, B. P. and Louis, T. A. (2008). *Bayesian Methods for Data Analysis*. Chapman & Hall/CRC Press, New York, USA.
3. Congdon, P. (2006). *Bayesian Statistical Modelling*, John Wiley & Sons , New York, USA.
4. Gelman, A., Carlin, J. B., Stern, H. S. and Rubin, D. B. (2014). *Bayesian Data Analysis*. Chapman & Hall/CRC Press, New York, USA.
5. Hoff, P.D. (2009). *A First Course in Bayesian Statistical Methods*, Springer, New York, USA.

COURSE FOR NON-STATISTICS MAJOR

BS/ Masters Programs

2023-onwards

List of courses

For BS and Masters Programs

Course Code	Course Title	Credit Hours	Pre-requisite
The Courses of to be Offered in BS 1st and 2nd Semester			
STAT-301	Fundamentals of Statistics	3	
STAT-302	Descriptive Statistics	3	
STAT-303	Business Statistics	3	
STAT-311	Inferential Statistics	3	
The Courses of to be Offered in BS 3rd and 4th Semester			
STAT-401	Biostatistics	3	
STAT-402	Probability and Statistics	3	
STAT-403	Probability Theory	3	
STAT-404	Applied Statistical Methods	3	
Masters Programs			
The First two Course to be Offered in M.A/M. Sc 1st, 2nd and the Second in 3rd , 4th Semester			
STAT-501	Elements of Statistics and	3	

	Biometry		
STAT-502	Elements of Statistics	3	
STAT-602	Basics of Statistics	3	

Details of Courses

Course Title: Fundamentals of Statistics	**Course Code: STAT-301**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
To give the basic knowledge of Statistics to the students not majoring in Statistics

Course Outline:
 Introduction to Statistics: Definition, scope, Descriptive and inferential Statistics scope. Types of variables. Presentation of data: classification of data, tabulation, Graphs and Charts: Bar charts, Pie charts, histogram frequency polygon and curve and their interpretation. Measures of Central Tendency; mean, median and mode; properties, usage, limitations and comparison through examples. Measure of dispersion; Variance and standard deviation; properties. Co-efficient of variation. Simple linear regression, Measures of correlation. Introduction to Sampling and sampling Distributions. Importance of sampling, Statistics vs. parameters b. sampling errors c. The probability and non-probability sampling. Hypothesis Testing; The logic of hypothesis tests; translating a research question into null and alternative hypotheses ii. P-values; Type I and Type II errors. Testing of hypothesis about mean and difference of mean.

Course Outcomes: After completing the course, the students will be able to
- Understand the use of the essential tools of basic Statistics;
- Organize and display the data through tables and graphs.
- Understand and differentiate between the types of data and variables.
- Evaluate and interpret basic descriptive statistics.
- Apply the concepts and the techniques in their respective disciplines.

Recommended Books: Latest Edition of the Following Books.
1. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
2. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Clark, G.M and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.

4. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th ed.Prentice Hall, New Jersey.
5. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
6. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

Course Title: Descriptive Statistics	Course Code: STAT-302
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
The objective is to provide a basic understanding of data analysis using statistics and to use computational tools on problems of applied nature.

Course Outline:
Introduction to descriptive statistics, types of variables, measurement scales. Data collection principles. Examining and visualizing numerical and categorical data; Tabulation of data. Graphical methods, histograms, frequency polygon, frequency curve, ogive, bar plots, box plot. Measure of central tendency; average, median, mode. Measure of Dispersion, the variance, standard deviation, co-efficient of variation, moments, properties of variance and standard deviation. Introduction to Sampling and sampling Distributions. Importance of sampling, Statistics vs. parameters, sampling and non-sampling errors, the probability and non-probability sampling. Correlation and regression; simple linear regression, properties and model fitting. Co-efficient of Determination, Correlation.

Course Outcomes: After completing the course, the students will be able to
- Demonstrate their understanding of descriptive statistics.
- Effectively visualize the data. Carry out practical application of data visualization. Carry out data analysis.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Chaudhry. S.M. (2006), "Introduction to Statistical Theory" Parts I & II, Ilmi Kitab Khana, Lahore, Pakistan.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th ed.Prentice Hall, New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
5. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

Course Title: Business Statistics	Course Code: STAT-303

Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: NIL

Course Objective:
The main objectives of the course are to enhance student's competency in application of statistics to solve business management problems and to improve their level of quantitative sophistication for further advanced business analysis.

Course Outline:
Definition, Descriptive Statistics & Inferential Statistics, Statistics Applications in Business. data condensation and presentation**:** The Data Array and Frequency Distribution**,** Relative Frequency Distribution**,** Cumulative frequency distribution. data condensation and presentation. Measures of central tendency for grouped and ungrouped data, measures of dispersion for grouped and ungrouped data, index numbers, probability and laws of probability, probability distribution.

Course Outcomes: After completing the course, the students will be able to
- Data description and data presentation in a business environment;
- Measures of Central Tendency
- Measure of Relative Dispersion
- Use of index numbers
- Basic probability concepts and probability distributions as an aid to business decision making.

Recommended Books: Latest Edition of the Following Books.
1. David, S Moore et.al, Introduction to the Practice of Statistics, 6th Edition WH.Freeman.
2. Levin I. Richard., Statistics for Management, 4th ed; McGraw Hill.
3. Engle wood Cliffs, New Jersey, Prentice Hall International, 1987.
4. Michael J. Evans & Jeffrey S. Rosenthal, Probability and Statistics , WHFreeman
5. Starr K. Martian &Sobal Gross Marion, Statistics for Business and Economics,1st Ed; New York, McGraw Hill, International, 1983.
6. Walpole, R, Introduction to Statistics, Edition 3.
7. Shaum and Seigel, Statistics for Business (Latest Edition).

Course Title: Inferential Statistics	Course Code: STAT-311
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: NIL

Course Objective:
To provide understanding of basic techniques of estimation, their properties and applications.

To test, deduce and infer the validity of different types of hypotheses and models built on the basis

of the raw data collected in diverse problem-situations.

Course Outline:
Inferential Statistics; Sampling distribution; Estimation: Point Estimation. Properties of a Good Estimator. Interval Estimation; interval Estimation of population mean. Large and small sample confidence intervals for Population Mean. Hypothesis Testing; Formulation of null and alternative hypothesis, level of significance, Types of errors. Hypothesis Testing for Population Mean and difference of means using Z and T-statistics. Analysis of Variance; One way analysis of variance, two-way analysis of variance. Testing of hypothesis; testing the significance of correlation co-efficient and regression co-efficient.

Course Outcomes: After completing the course, the students will be able to
- Have the knowledge of the sampling distributions and their properties.
- Derive the appropriate estimators for parameters.
  Use appropriate hypotheses testing procedures

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998). A Basic Course in Statistics. 4th ed, Arnold, London.
2. Casella, G. and Berger, R.L. (2008). Statistical Inference, Cengage Learning, New York, USA.
3. Ross, S. (2017). A first course in Probability. 9th edition. Pearson Education Limited.
4. Srivastava, M.K., Khan, A.H. and Srivastava, N. (2014). Statistical Inference: Theory of Estimation. Prentice-Hall of India Pvt. Ltd
5. Walpole, RE., Myers, R.H. and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

Course Title: Biostatistics	**Course Code: STAT-401**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
To provide knowledge of importance of and its application in Biological Sciences. Understanding of use of statistical techniques to summarize and analyze biological data

Course Outline:
Introduction to Biostatistics, scope. Types of data, variables; Categorical, numerical and censored data. Descriptive Statistics; Measure of central tendency; mean, median, mode. Measure of dispersion; Variance and standard deviation. Simple linear regression; model fitting. Correlation; correlation co-efficient, co-efficient of determination. Logistic regression. Logit transformations and their analysis, p values and its importance and role. Hypothesis testing.

Course Outcomes: After completing the course, the students will be able to
- Understand the applications of statistical tools in biological science.

- Demonstrate an understanding of the central concepts of statistical theory in Biological Sciences.
- Apply appropriate statistical techniques to biological data and analyze and communicate the results of statistical analysis effectively.

Recommended Books: Latest Edition of the Following Books.
1. Antonisamy, B. Premkumar, P. and Christopher, S. (2017). *Principles and Practice of Biostatistics*. 1st edition. Elsevier, India.
2. Daniel, W.W. (2010). *Biostatistics: A Foundation for the Health Sciences*. 6th edition. John Wiley, New York. NY, USA.
3. Sullivan, M.L. (2018). *Essentials of Biostatistics in Public Health*. 3rd edition. Jones and Bartlett Learning, Burlington, MA, USA.
4. Zar, J. (2000). *Biostatistical Analysis.* 5th Edition. John Wiley & Sons, New York, NY, USA.
5. Pagano, M., Gauvreau, K., & Mattie, H. (2022). *Principles of biostatistics*. CRC Press.
6. Gerstman, B. B. (2014). *Basic biostatistics*. Jones & Bartlett Learning, LLC.
7. Kaps, M., & Lamberson, W. R. (Eds.). (2017). *Biostatistics for animal science*. Cabi.

Course Title: Probability and Statistics	Course Code: STAT-402
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
The course is designed to enable the students to understand basic concepts of Statistics, descriptive statistics and probability; conditional probability, random variables and probability distributions.

Course Outline:
 Introduction to Statistics: Descriptive Statistics, Graphical presentation of data, Histogram, Bar charts, Pie charts, box-plot, stem and leaf plot. Measures of Central Tendency; mean, median and mode. Measure of dispersion; Variance and standard deviation; properties. Co-efficient of variation. Correlation and regression. Hypothesis testing. Introduction to counting techniques; Permutation, combination. Basic concept of probability, random experiment, event, sample space. Laws of probability, conditional probability, Bayes theorem with application to discrete and continuous random variable. Random variables and Probability Distributions; Discrete Random Variables, Bernoulli trials, Binomial and Poisson distributions. Continuous Random Variable, probability density function and its properties. Normal Distribution and its properties.

Course Outcomes: After completing the course, the students will be able to
- Demonstrate basic descriptive statistics and analyse and interpret data.
- Demonstrate the basic knowledge of probability and probability distributions.

• Use basic counting techniques (multiplication rule, combinations, and permutations) to compute probability and odds.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Chaudhry. S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9t ed, Prentice Hall, New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
5. Walpole, RE., Myers, R.H and Myers, S.L. (1998), 'Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.
6. Weiss, N.A. (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub. Company, Inc.

Course Title: Probability Theory	**Course Code: STAT-403**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
The course is designed to introduce the fundamentals of probability theory and its applications. To provide knowledge of basic laws of probability, random variables, random processes and probability distributions

Course Outline:
Introduction to Probability theory; counting techniques; Permutation, Combination. Random experiment, event, sample space (continuous and discrete). Laws of probability, conditional probability, independent events. Bayes theorem. Random variables; Mean and variance of a discrete random variable. Probability Distributions; Discrete Probability Distribution and its properties. Bernoulli trials, Binomial and Poisson distributions. Continuous Random Variable, probability density function and its properties. Uniform distribution, Normal Distribution and its properties. Expectation; Moments, Expectation of a function of a random variable, characteristic function.

Course Outcomes: After completing the course, the students will be able to
- Demonstrate the knowledge of probability and probability distributions.
- Apply basic counting techniques (multiplication rule, combinations, and permutations) to compute probability and odds.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Chaudhry. S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

3. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9t ed, Prentice Hall, New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
5. Walpole, RE., Myers, R.H and Myers, S.L. (1998), 'Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.
6. Weiss, N.A. (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub. Company, Inc.

Course Title: Applied Statistical Methods	Course Code: STAT-404
Course Structure: Lectures: 3, Labs: 0	Credit Hours: 3

Prerequisites: NIL

Course Objective:
To provide knowledge of statistics and applications of statistical techniques to real world problems.

Course Outline:
Fundamentals of statistics for data analysis in research. Data collection, exploratory data analysis, random variables, types of variables. Sampling: Need of sampling, Sample versus population, Random and nonrandom sampling, concepts of statistic and population parameter. Sampling techniques: Simple Random, Stratified and Systematic random sampling. Survey problem framing of questionnaire. Sampling and Non-Sampling Errors. Review of estimation, confidence intervals, hypothesis testing. Linear regression and correlation, analysis of variance; one-way ANOVA, and data analysis. Data analysis using statistical software.

Course Outcomes: After completing the course, the students will be able to
- Demonstrate the application of statistical methods.
- to use statistical software to analyze data and report and interpret the results of a statistical analysis;
- Highlight the limitations and possible sources of errors in the analysis.

Recommended Books: Latest Edition of the Following Books.
1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Mclave, J.T. Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th Prentice Hall New Jersey.
3. Silverman, B. W. (2018). Density estimation for statistics and data analysis. Routledge.
4. Walpole, P.E. Myers, RH., Myers S.L. (1998), "Probability and Statistics for Engineers and Scientists", Prentice Hall.
5. Chaudhry, S.M. and S. Kamal, (1996), "introduction to Statistical Theory" Part I, II, 6th Ed, llmi Kitab Khana, Lahore, Pakistan.
6. Cochran, W.G. "Sampling Techniques".3rd Ed.
7. Pollard, A.H.. Yousuf, F. and Pollard G.M. (1982), "Demographic Techniques", Pergamon

Press, Sydney.

Course Title: Elements of Statistics and Biometry	Course Code: STAT-501
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:
- To provide students with background knowledge in research design and statistical techniques employed in social and biological sciences;
- To identify a suitable statistical method for analyzing any type of data and correctly interpret results.

Course Outline:
Introduction to Biostatistics its scope and importance. Data types, variables; Categorical, numerical and censored data. Descriptive Statistics; Measure of central tendency; mean, median, mode. Measure of dispersion; Variance and standard deviation. Simple linear regression; model fitting. Correlation; correlation co-efficient, co-efficient of determination. Chi-square and T-test. Logistic regression. Logit transformations and their analysis, p values and its importance and role. Hypothesis testing.

Course Outcomes: After completing the course, the students will be able to
- Apply appropriate research designs and statistical analysis to social and biological research and /or future research work
- Identify a suitable statistical method for analyzing any type of data and correctly interpret results.

Recommended Books: Latest Edition of the Following Books.
1. Clarke, G.M and Cooke, D. 2004. A Basic Course in Statistics. Oxford University Press. New York.
2. Johnson, R.A. and Bhattacharyya, G.K. 2006. Statistics. Principles and Methods. 5th ed. John Wiley & Sons USA.
3. Mead, R.Curnow, R.N and Hasted, A.M. 1993. Statistical methods in Agricultural and Experimental biology 2nd, Chapman and Hall.
4. Nardi, P.M. (2002). Doing survey research: A guide to quantitative research methods. Allyn and Bacon publishers.
5. Walpole, R.E. and Myers, R.H. (1989). Probability and statistics for engineers and scientists. Macmillan Inc.
6. Fruend, J.E. (1992). Mathematical Statistics. Prentice Hall

Course Title: Elements of Statistics	Course Code: STAT-502
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	

Course Objective:
To give the basic knowledge of Statistics to the students not majoring in Statistics

Course Outline:
Introduction to Statistics: Measures of Central Tendency; mean, median and mode; properties, usage, limitations and comparison through examples. Measure of dispersion. Index Numbers. Sampling and sampling Distributions. Importance and scope of sampling. The probability and non-probability sampling. Hypothesis Testing; hypothesis testing procedure; Formation of research question into null and alternative hypotheses, P-values; Type I and Type II errors. Hypothesis testing about mean and difference of mean, t-test, z-test and Chi-square test.

Course Outcomes: After completing the course, the students will be able to
- Have the knowledge of basic Statistics;
- Understand and differentiate between the types of data and variables.
- Interpret basic descriptive statistics.
  Apply the concepts and the techniques in their respective disciplines

Recommended Books: Latest Edition of the Following Books.
1. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
2. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Clark, G.M and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
4. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th ed.Prentice Hall, New Jersey.
5. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
6. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

Course Title: Basics of Statistics	Course Code: STAT-601
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	
Course Objective:	

To give the sound knowledge of Statistics to the students not majoring in Statistics

Course Outline:
Introduction to Statistics, Types of variables. Presentation of data: tabulation, Graphs and Charts and their interpretation. Descriptive Statistics, Measure of Central Tendency. Measure of dispersion. Regression and Correlation. Introduction to Sampling and its Importance, Sampling Distributions of sampling, Statistics and parameters, sampling errors c. The probability and non-probability sampling. Hypothesis Testing; The logic of hypothesis tests; translating a research question into null and alternative hypotheses ii. P-values; Type I and Type II errors. Testing of hypothesis about mean and difference of mean. Chi- square and T-test.

Course Outcomes: After completing the course, the students will be able to
- Understand the essential tools of Statistics;
- Summarize and display the data through tables and graphs;
- Understand and differentiate between the types of data and variables;
- Apply the statistical techniques in their respective disciplines.

Recommended Books: Latest Edition of the Following Books.
1. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
2. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Clark, G.M and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
4. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9th ed.Prentice Hall, New Jersey.
5. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
6. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.