Revised as per HEC New UEP 2023

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF STATISTICS

BS Statistics, BS Statistics (Data Science), BS Statistics (Biostatistics) Curriculum (2025 & onwards)

Revised as per HEC New UEP 2023

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF STATISTICS

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Department Curriculum Committee

1. Dr. Soofia Iftikhar (Assistant Professor)
2. Dr. Najma Salahuddin (Lecturer)
3. Ms. Ghazala Sahib (Lecturer)

Curriculum Revamp Committee

Dr.Farhat Amin. Associate Professor
Department of Bioinformatics, SBBWU
(Convener)

Ms.Sadia Nazeer (Member)
Assistant Professor
Department of English. SBBWU

Dr. Soofia Iftikhar (Member)
Assistant Professor
Department of Statistics, SBBWU

Dr. Samra Kiran (Member)
Assistant Professor
Department of Management Science, SBBWU

Dr. Rehana Masood (Member)
Assistant Professor
Department of Biochemistry, SBBWU

Ms.Mehwish Asmat Ullah (Member)
Deputy Director.
Quality Enhancement Cell, SBBWU

Ms.Tashfeen Zia (Member)
Deputy Director.
Affiliation and Monitoring, SBBWU

Dr.Rubi Bilal (Secretary)
Controller of Examinations, SBBWU

Dr.Safia Ahmed (T.I)
Dean Faculty of Sciences & Social Science,
SBBWU

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Sr.	Categories	Credit Hours Min – Max
1.	General Education (Gen Edu) Requirements: Mandatory Courses of General Education.	34– 34
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	**124 – 148**

***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 124-148
- 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)

Specialization Electives

1. In accordance with the NQF, the department may offer at least seven electives comprised of 21 credit hours (**minimum of 25 % of the main field i.e. Statistics that is comprised of 81 credit hours)** to meet the criteria of nomenclature with specialization. Where the range of major exceeds beyond eighty-one (81) credit hours, the number of specialization electives will accordingly be increased.

2. Where the electives are adopted from within a single specialization domain, the degree will be offered as Bachelor of Science in Statistics (with name of specialization) in accordance with the NQF (2015) such as **Bachelor of Science in Statistics (Data Science), Bachelor of Science in Statistics (Biostatistics) and Bachelor of Science in Statistics (Population Studies)** etc.

3. Subject to approval of the relevant statutory body, the department may develop additional specializations other than those prescribed in this policy.

4. It should however be noted that offering of the degree program with Specialization is an option only and not as a mandatory requirement or a binding on the department. The department may consider to offer the degree program with specialization or not, as per its available academic, human, and infrastructural resources.

➢ PROGRAM STRUCTURE

The Bachelor of Science in Statistics is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1 and comprises of **143** credit hours (including internship/field experience) spread over eight (08) regular semesters. The details are provided in the Table below:

Minimum Credit Hours (Including all program related requirements)	**143**
General Education Courses	34credit hours (14 courses)
Major/ Discipline Related Courses	81 credit hours (27 courses including 7 mandatory elective courses)

Interdisciplinary / Allied Courses (IDS)	12 credit hours (4 courses)
Internship	3 credit hours
Capstone Project	3 credit hours
Program Duration	Minimum: 4 Years Maximum: 6 Years (further extendable by another year subject to approval of the university's statutory body)
Semester Duration	6-18 weeks for regular semesters (1-2 weeks for examination) 8-9 weeks for summer semesters (1 week for examination)
Course Load (per semester)	15-18 credit hours for regular semesters Up-to 8 credit hours for summer semesters (for remedial/deficiency/failure/repetition courses only)
3 Credit Hours (Theory)	3 classes (1 hour each) OR 2 classes (1.5 hour each) OR 1 class (3 hours) per week throughout the semester
Number of Seats	50 Seats in BS Statistics and 50 seats in each specialization

- **STANDARD NOMENCLATURE**

The scheme of study prescribed for the four-year undergraduate degree in Statistics is based on a total of seven electives. Where the electives are adopted from within a single specialization domain, the degree will be offered as Bachelor of Science in Statistics (with name of specialization) in accordance with the NQF (2015), and where the elective courses are adopted from more than one specialization domains, the degree will be awarded as Bachelor of Science in Statistics in its generic form and without any specialization.

➢ LIST OF MAJOR COURSES

Below is the list of Major courses for the award of Bachelor of Science in Statistics degree.

Course Code	Course Title	Credit
STAT-306	Introduction to Statistics	3
STAT-307	Fundamentals of Probability and Probability Distributions	3
STAT-315	Introduction to Sampling Theory	3
STAT-412	Official Statistics	3
STAT-405	Exploratory Data Analysis & Visualization	3
STAT-406	Basic Statistical Inference	3
STAT-407	Introduction to Regression and Analysis of Variance	3
STAT-409	Data Wrangling	3
STAT-410	Non-Parametric Techniques	3
STAT-408	Statistical Packages	3
STAT-516	Probability Distributions	3
STAT-512	Sampling Techniques	3
STAT-515	Bio-Statistics and Epidemiology	3
STAT-514	Regression Analysis	3
STAT-525	Experimental Designs	3
STAT-526	Applied Multivariate Analysis	3
STAT-633	Statistical Programming Using R and Python	3
STAT-614	Survey and Research Methods	3
STAT-613	Statistical Quality Control	3
STAT-634	Statistical Inference	3

➢ LIST OF ELECTIVES COURSES:

Below is the recommended list of electives in case where the Bachelor of Science in Statistics is without specialization. The concerned department may offer any courses from the following list or the lists of specialization.

Course Code	Course Title	Credit
STAT-507	Population Studies	3
STAT-524	Econometrics	3
STAT-615	Robust Methods	3
STAT-616	Operations Research	3
STAT-617	Statistical Practicum	3
STAT-618	Applied Bio Statistical Analysis	3
STAT-623	Stochastic Processes	3
STAT-624	Time Series Analysis	3
STAT-625	Decision Theory	3
STAT-626	Reliability Analysis	3
STAT-627	Survival Analysis	3
STAT-629	Actuarial Statistics	3
STAT-630	Mathematical Modeling & Simulation	3
STAT-631	Bayesian Analysis	3
STAT-632	Applied Econometrics	3
STAT-635	Actuarial Statistics	3
STAT-636	Design and Analysis of Medical Studies	3
STAT-637	Analysis of Repeated Measurements	3
STAT-638	Bayesian Statistics	3
STAT-639	Population Studies and Demographic Techniques	3

*The department may also add other major electives to the list given below subject to availability of experts

- **LIST OF SPECIALIZATION 1: DATA SCIENCE**

Below is the recommended list of courses within the given specialization. The department may offer any (07) courses from the following list. Other specialized courses may be added to the list of specialization and offered subject to availability of experts.

Course Code	Course Title	Credit
CSC-524	Database Management Systems	4
CSC-543	Artificial Intelligence	3
CSC-536	Introduction to Data Science	3
CSC-528	Machine Learning	3
STAT-661	Statistics for Deep Learning	3
CSC-660	Big Data Analytics	3
CSC-634	Data Mining	3
CSC-	Digital Analytics	3
CSC-641	Data Warehousing and Business Intelligence	3
STAT-662	High Dimensional Data Analysis	3
CSC-637	Modeling & Simulation	3

- **LIST OF SPECIALIZATION 2: BIOSTATISTICS**

Below is the recommended list of courses within the given specialization. The department may offer any (07) courses from the following list. Other specialized courses may be added to the list of specialization and offered subject to availability of experts.

New Code	Course Title	Credit
STAT-571	Bio-statistical Literacy	3
STAT-572	Logistic Regression and Survival Analysis	3
STAT-620	Applied Categorical Data Analysis	3
STAT-671	Introduction to Epidemiology	3
STAT-672	Design and Conduct of Trials	3
STAT-673	Advanced Epidemiology	3
STAT-674	Predictive Modeling in the Health Sciences	3

STAT-675	Bio-Informatics	3
STAT-676	Statistical Genetics	3
STAT-677	Generalized Linear Models	3

LIST OF INTERDISCIPLINARY/ALLIED COURSES (IDS) FOR BS STATISTICS

Below is the recommended list of Interdisciplinary courses (IDS). The department may offer any four (04) courses from the following list either random or related/ supporting the specialization. Other courses may be added to the list of specialization and offered subject to availability of experts.

List of Interdisciplinary/Allied Courses for

1. BS Statistics
2. BS Statistics (Biostatistics)

No.	Course Code	Course Title	Credit
1	MTH-301	Calculus and Analytical Geometry	3
2	MTH-302	Advanced Calculus	3
3	MTH-405	Linear Algebra	3
4	CSC-302	Programming Fundamentals	4

- **List of Interdisciplinary/Allied Courses for BS STATISTICS (DATA SCIENCE)**

No.	Course Code	Course Title	Credit
1	CSC-302	Programming Fundamentals	4
2	MTH-301	Calculus and Analytical Geometry	3
2	CSC-423	Data Structures	4
3	CSC-312	Object Oriented Programming	4

- **CAPSTONE PROJECT AND INTERNESHIP**

No.	Course Title	CR
Final Year Capstone Project		
1	Final Year Capstone Project	3

No.	Course Title	CR
Field Experience/Internship		
1	Field Experience/Internship	3

- **STANDARD SCHEME OF STUDY FOR THE PROGRAM OF BACHELOR OF SCIENCE IN STATISTICS**

Semester	Category	Course Codes	Course Title	Lectures	Lab	Cr.Hrs
Semester 1	Art & Humanities	XXX	Art & Humanities	2	0	2
	Interdisciplinary/Allied Course*	MTH-301	Calculus & Analytical Geometry	3	0	3
	Functional English	ENG-303	Functional English	3	0	3
	Major I	STAT-306	Introduction to Statistics	3	0	3
	Application of Information and Communication Technologies.	CSC-308	Applications of Information and Communication Technologies(ICT)	2	1	3
	Ideology and Constitution of Pakistan	PST-313	Ideology and Constitution of Pakistan	2	0	2
			Total			**16**
Semester 2	Social Sciences	XXX	Social Science	2	0	2
	Expository Writing	ENG-304	Expository Writing	3	0	3
	Islamic Studies	ISL-301	Islamic Studies/Religious Studies	2	0	2
	Interdisciplinary/Allied Course*	MTH-302	Advanced Calculus	3	0	3
	Pakistan Studies	PST-323	Pakistan Studies	2	0	2
	Major II	STAT-307	Fundamentals of Probability and Probability Distributions	3	0	3
	Major III	STAT-315	Introduction to Sampling Theory	3	0	3
			Total			**18**
Semester 3	Fehm-e-Quran	ISL-325	Fehm-e-Quran I	0	1	1
	Quantitative Reasoning (QR I)	MTH-401	Quantitative Reasoning (QR-I)	3	0	3
	Natural Science	XXX	Natural Science	2	1	3
	Entrepreneurship	MS-309	Introduction to Entrepreneurship	2	0	2
	Major IV	STAT-412	Official Statistics	3	0	3
	Major V	STAT-405	Exploratory data analysis and visualization	3	0	3
	Major VI	STAT-406	Basic Statistical Inference	3	0	3
			Total			**18**
Semester 4	Fehm-e-Quran	ISL-325	Fehm-e-Quran II	0	1	1
	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-409	Data Wrangling	3	0	3
	Major IX	STAT-410	Non-parametric techniques	3	0	3
	Major X	STAT-408	Statistical Packages	3	0	3
			Total			**18**
Semester 5	Interdisciplinary/Allied Course*	MTH-405	Linear Algebra	3	0	3
	Major XI	STAT-516	Probability Distributions	3	0	3
	Major XII	STAT-512	Sampling Techniques	3	0	3
	Major XIII	STAT-515	Biostatistics and Epidemiology	3	0	3
	Major XIV	STAT-514	Regression Analysis	3	0	3
			Total			**15**
Semester 6	Interdisciplinary/Allied Course*	CSC-302	Programming Fundamentals	3	1	4
	Major XV	STAT-525	Experimental Designs	3	0	3
	Major XVI	STAT-526	Applied Multivariate Analysis	3	0	3
	Major XVII(Elective) **	STAT-XXX		3	0	3
	Major XVIII(Elective) **	STAT-XXX		3	0	3
			Total			**16**
Semester 7	Internship (Mandatory)	STAT-698	Internship (Mandatory)	3	0	3
	Major XX	STAT-633	Statistical Programming Using R and Python	3	0	3
	Major XXI	STAT-614	Survey and Research Methods	3	0	3
	Major XXII	STAT-613	Statistical Quality Control	3	0	3
	Major XXIII(Elective)**	STAT-XXX		3	0	3
	Major XXIVElective) **	STAT-XXX		3	0	3
			Total Cr.Hrs.			**18**
Semester 8	Major XXV	STAT-634	Statistical Inference	3	0	3
	Major XXVI(Elective) **	STAT-XXX		3	0	3
	Major XXVII (Elective) **	STAT-XXX		3	0	3
	Major XXVIII (Elective) **	STAT-XXX		3	0	3
	Capstone Project	STAT-697	Capstone Project	3	0	3
			Total Cr.Hrs.			**15**
			Total Cr.Hrs.	**134**		

* These interdisciplinary courses are proposed by the NCRC(HEC), however, the university/offering department may offer any four (04) interdisciplinary courses from the proposed list provided in this document, or any other such course to enhance the interdisciplinary understanding of the students, keeping in view its available academic, human and infrastructural resources. Credit combination may be arranged in accordance with the nature of the course.

** Read in conjunction with the guidance given on "Standard Nomenclature" in this policy, the department may offer any eight (07) courses from either the general list of electives or from within one of the specializations, keeping in view its available academic, human, and infrastructural resources. Credit combinations may be arranged in accordance with the nature of the course.

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/ Religious Studies	**Course Code: ISL-301**
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: After completing the course, the students will be able to	
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: Functional English	**Course Code: ENG-303**
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:

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.

Probability Concepts, Addition and Multiplication rules, bivariate frequency tables, joint and marginal probabilities, Conditional probability and independence, Bayes' rule. Discrete vs. continuous random variables .Common probability distributions (e.g., Binomial, Poisson). Misuse of statistics: Manipulation and misrepresentation, Ethical considerations in data collection and analysis, Understanding and avoiding bias, Responsible reporting of statistical findings. Index number.

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. Moore, D. S., McCabe, G. P., & Craig, B. A. (2023). *Introduction to the practice of statistics* (11th ed.). W. H. Freeman.
2. Sullivan, M. J. (2021). *Fundamentals of statistics* (6th ed.). Pearson.
3. Triola, M. F. (2021). *Elementary statistics* (14th ed.). Pearson.

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

Course Title: Applications of Information and Communication Technologies	**Course Code: CSC-308**
Course Structure: Lectures: 2 Lab:1	**Credit Hours: 3**
Prerequisites: None	
Course Objective:	
Course Outline: The Course contents will be taken from the booklet of mandatory and general courses.	
Course Outcomes:	
Recommended Books:	

Course Title: Ideology and Constitution of Pakistan	**Course Code: PST-313**
Course Structure: Lectures: 2	**Credit Hours: 2**

Prerequisites:
Course Objective:
Course Outline: The Course contents will be taken from the booklet of mandatory and general courses.
Course Outcomes: By the end of this course, students will be able to:
Recommended Books: Latest Edition of the Following Books.

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: None	
Course Objective:	

Course Outline: The Course contents will be taken from the booklet of mandatory and general courses.
Course Outcomes: By the end of the course, the students will be able to;
Recommended Books:

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 Distribution, 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 Name: Introduction to Sampling Theory	**Course Code: STAT-315**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: None

Course Objective:

- Understand the fundamental concepts of sampling theory, including population, sample, sampling frame, and types of sampling methods.
- Demonstrate how to draw samples using basic probability and non-probability techniques, and recognise issues of representativeness and bias.
- Understand and interpret sampling distributions of common statistics such as the sample mean, variance, and proportion, including the role of the central limit theorem.
- Apply sampling concepts to real-life examples and evaluate basic sample size considerations and potential sources of non-sampling error.

Course Outline:

Discussion on the distinction between populations and samples; the importance of sampling in statistical investigations; definition and construction of a sampling frame; parameter and statistic; introduction to probability and non-probability sampling methods; overview of simple random, stratified, systematic, and cluster sampling techniques; practical procedures for drawing such samples; representativeness and sampling bias; introduction to sampling distributions; sampling distribution of the sample mean, variance, and proportion; standard error and its interpretation; concept of precision and accuracy in sampling; basic sample size considerations; real-life examples of sampling applications.

Course Outcomes: After completion of the course students will be able to:

- Understand basic sampling theory related to sample, types of sampling, and sampling frame.
- Identify and comprehend different sampling plans.

- Compute sample size in various practical scenarios.
- Understand sampling distributions of popular statistics including sample mean variance, proportion etc.

Recommended Books: Latest Edition of the Following Books

1. Singh, S. (2003). Advanced Sampling Theory with Applications: How Michael Selected Amy (Vol. 2). Springer Science & Business Media.
2. Cochran, W.G. (1991). Sampling Techniques, 3rd Edition. Wiley.
3. Lohr, S.L. (2010). Sampling: Design and Analysis, 2nd Edition. Brooks/Cole.
4. Kish, L. (1965). Survey Sampling. Wiley.
5. Mukhopadhyay, P. (2008). Theory and Methods of Survey Sampling. PHI Learning.
6. Singh, D. & Chaudhary, F.S. (1986). Theory and Analysis of Sample Survey

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: Pakistan Studies	**Course Code: PST-323**
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: Nil	
Course Objective:	
Course Outline: **To be provided by Pakistan Studies Department**	
Course Outcomes:	
Recommended Books: Latest Edition of the Following Books.	

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: 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:	
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: 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 Outline: Exploratory Data Analysis: Explore, Visualize, Analyse, Repeat. Selective data collective and data exploration. Data sources, Data types, Data structures, Merging datasets, Samples and sampling bias, Data dictionaries and meta-data. Start Exploring: 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).
Course Outcomes: After completing the course, the students will be able to • describe exploratory data analysis and visualization concepts • describe data analysis and visualization models and algorithms • describe applicability of different data analysis and visualization models' techniques to solve real-world problems • pre-process data and apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
Recommended Books: Latest Edition of the Following Books. 1. Cook, D., Swayne, D. F. (2007). Interactive and Dynamic Graphics for Data Analysis: With R and GGobi. Germany: Springer 2. Peng R. (2015) Exploratory Data Analysis with R http://leanpub.com/exdata 3. Chang, W. (2013). R Graphics Cookbook. O'Reilly. http://www.cookbook-r.com/ 4. Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis (2nd edition Springer. http://ggplot2.org/book/; http://hadley.nz/

Course Title: Official Statistics	**Course Code: STAT-412**
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.

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. Singh, S. (2003). Advanced Sampling Theory with Applications: How Michael Selected Amy (Vol. 2). Springer Science & Business Media.
2. Cochran, W.G. (1991). Sampling Techniques, 3rd Edition. Wiley.
3. Lohr, S.L. (2010). Sampling: Design and Analysis, 2nd Edition. Brooks/Cole.
4. Mukhopadhyay, P. (2008). Theory and Methods of Survey Sampling. PHI Learning.
5. 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.
6. Kish, L. (1992). "Survey Sampling", John Wiley, New York.
7. Murthy, MN. (1979). "Quality of Data, Country Course on Sample Surveys", Karachi.
8. Statistics Division, "Activity Report" (1988-89). Government of Pakistan, Islamabad.
9. Statistical Institute for Asia & Pacific SIAP (1984). "Training of Trainers in Statistical Operations and Procedures" Part-I, II UNDP, Tokyo.

Suggested Reports:

10. 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.
11. NIPA (1962). Administrative uses of Statistics. NIPA Karachi.
12. Statistical Institute for Asia and Pacific SIAP (1984). Training of Trainers in Statistical Operations and Procedures. Part-I, II UNDP, Tokyo.

13. Statistics Division (1979). Retrospect, Perspective and Prospect. Islamabad.
14. Statistics Division Activity Report (1988-89). Government of Pakistan, Islamabad.
*Various Publications of PBS, State Bank of Pakistan, Ministry of Finance, etc.

Course Title: Basic Statistical Inference	**Course Code: STAT-406**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: STAT- 306	

Course Objective:

- To understanding of basic techniques of sampling and estimation, their properties and application
- To select a sample from a given population and use it to make inferences about the population and its parameter
- 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:

Distribution of sample mean and central limit theorem. Estimation: Point Estimation. Desirable Properties of a Good Estimator. Interval Estimation. lnterval Estimation of population mean. Large and small sample confidence intervals for Population Mean. Nature of Hypothesis Testing and Types 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 Mean of Two Normal Populations using Independent Samples (variances are assumed Equal/Not Equal). Inference for Two Populations Mean using Paired Samples. Inferences for Population Proportions. Confidence Intervals and hypothesis Testing for Population Proportion. Inferences for Two Populations Proportions using independent Samples, Estimation of sample size. Chi-Square Procedure. Chi-Square Goodness-of fit Test. Chi-Square Independence Tests, F-test.

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: Civics and Community Engagement.	**Course Code: PSC-418**
Course Structure: Lectures: 2	**Credit Hours: 2**
Prerequisites:	
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:

Course Title: Introduction to Regression and Analysis of Variance	**Course Code: STAT-407**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: STAT-306	
Course Objective: • To provide foundations of regression analysis and experimental designs and their uses in different disciplines. • To provide basic knowledge and art of statistical data analysis and planning and designing of experiments. • To enable the students to predict and draw inference about the parameters of the population.	
Course Outline: Concepts of Regression and Correlation, Simple linear regression model, Estimation of parameters by method of least squares and corresponding variance estimates, Testing and confidence intervals for least squares estimators, mean prediction and individual prediction. Multiple linear regression with two regressors, coefficient of multiple determination, Partial and multiple correlation up to three variables. Inference of simple, partial and multiple correlation coefficients, Analysis of variance for one-way classification and two-way classification. Decomposition of total sum of squares, Multiple comparison tests; least significant difference and Duncans multiple range test, Tukey test and Least significant difference test.	
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.	
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 Kitan 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.
7. Weiss, N.A, (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub.Company, Inc.

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.
9. Crc Press.
10. Manoukian, E. B. (2022). Mathematical nonparametric statistics. Taylor & Francis.

Course Title: Statistical Packages	**Course Code: STAT-408**
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: Data Wrangling	**Course Code: STAT-409**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:

- Introduce students to the concept and importance of data wrangling in the context of the data analysis pipeline.
- Equip students with the skills to collect and import raw data from a variety of sources and formats.
- Develop the ability to clean and preprocess data using appropriate programming tools (R and/or Python).
- Teach techniques for handling missing values, identifying and managing outliers, and transforming variables.
- Enable students to perform data integration, reshaping, and merging from multiple data sources.
- Emphasize reproducibility, documentation, and automation of data cleaning workflows.

Prepare students to build clean, structured, and analysis-ready datasets suitable for statistical modeling and decision-making.

Course Outline:

Introduction to Data Wrangling and the Data Analysis Pipeline, Common Challenges in Raw Data Handling, Data Collection from Multiple Sources (CSV, Excel, JSON, APIs, Web Scraping), Importing and Exporting Data in R and Python, Data Types and Type Conversion, Parsing and Standardizing Dates and Times, Handling and Cleaning Categorical Variables, Data Cleaning Techniques (Whitespace, Case, Formatting Errors), Missing Data Detection and Imputation Techniques, Outlier Detection and Treatment Methods, Data Filtering, Sorting, and Subsetting, Data Reshaping and Restructuring (Pivot, Melt, Spread, Gather), Merging and Joining Datasets, String Manipulation and Regular Expressions, Feature Engineering and Variable Transformation, Binning and Categorization, Normalization and Standardization, Creating Derived Variables, Introduction to Reproducible Workflows, Building Data Pipelines using dplyr (R) and pipelines (Python), Ensuring Data Quality and Consistency, Documenting

and Automating the Data Wrangling Process, Case Studies in Data Cleaning and Preparation, Final Project: Cleaning and Preparing a Real-World Dataset.
Course Outcomes: By the end of this course, the students will be able to: • Understand and explain the key concepts, challenges, and importance of data wrangling in the data analysis pipeline. • Collect, clean, and preprocess raw data from various sources using appropriate tools. • Apply data transformation techniques, including handling missing data, outlier detection, and feature engineering, to improve data quality. • Integrate data preprocessing techniques into a reproducible data analysis pipeline, ensuring clean and ready-to-analyze datasets for statistical modeling.
Recommended Books: Latest Edition of the Following Books. • Wickham, H., & Grolemund, G. (2017). *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media. • Zumel, N., & Mount, J. (2019). *Practical Data Science with R* (2nd Edition). Manning Publications. • McKinney, W. (2022). *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython* (3rd Edition). O'Reilly Media. • VanderPlas, J. (2016). *Python Data Science Handbook: Essential Tools for Working with Data*. O'Reilly Media. • Shirani-Mehr, H. (2023). *Hands-On Data Wrangling with Python*. Packt Publishing.

5th Semester Courses

Course Title: **Probability Distributions**	**Course Code: STAT-516**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3Cr.Hrs**
Prerequisites: Nil	
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: Introduction to Probability. Conditional probability and Bayes' theorem. Random variables, Probability mass function and probability density function. Mathematical expectation and its properties, generating functions, Probability distributions: Hypergeometric, Binomial, Multinomial, Negative Binomial, Geometric, Poisson, Normal and Lognormal distributions, Uniform, Exponential, Gamma, Beta, Laplace, Weibull, Rayleigh with moments, Distributions of functions of random	

variables; Chi-square, t and F distributions, their derivations, and properties. Order statistics. Distributions of rth and sth order statistics. Bivariate Normal 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. Stuart, A. and Ord, J .K. Kendall's' (2010), "Advanced Theory of Statistics", Vol. I, Charles Griffin, London.
2. Hogg, R.M. and Craig, A.T. (2019). "Introduction to Mathematical Statistics". Pearson, Englewood Cliffs, New Jersey 8th edition.
3. Freund, J.E. (2004). "Mathematical Statistics", 7th Edition, Prentice Hall, New Jersey.
4. Haq, M. (1984). Foundation of Probability and Statistics, Tahir sons, Urdu Bazar, Karachi
5. Hirai, A.S. (2002), A Course in Mathematical Statistics, Ilmi Katab Khana, Lahore.
6. Hogg, R.M., McKean, J. and Craig, A.T. (2013). Introduction to Mathematical Statistics. Prentice Hall, New Jersey, USA.
7. Khan, M. K., (1996). "Probability with Applications", Maktiba Ilmi, Lahore**.**
8. Mood, AM, Graybill, F.A. and Boss, D.C. (1997), "Introduction to the Theory of Statistics", McGraw Hill, New York.
9. Stirzaker, D. (2004). "Probability and Random Variables". Cambridge University Press, Cambridge

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

Course Objective:

- Understand and explain the key concepts, challenges, and importance of data wrangling in the data analysis pipeline.
- Collect, clean, and preprocess raw data from various sources using appropriate tools.
- Apply data transformation techniques, including handling missing data, outlier detection, and feature engineering, to improve data quality.
- Integrate data preprocessing techniques into a reproducible data analysis pipeline, ensuring clean and ready-to-analyze datasets for statistical modeling.

Course Outline:

Probability and non-probability sampling techniques; properties, implementation, and evaluation of random and non-random sampling methods; estimation of population parameters—total, mean, and

variance—under various sampling schemes; detailed treatment of simple random sampling (SRS), stratified sampling, systematic sampling, cluster and multistage sampling. construction and properties of ratio, regression, and product estimators; comparison of estimators based on bias and mean squared error; PPS-sampling; double sampling; Thomson-Hurwitz estimator.
Course Outcomes: After completing the course, the students will be able to • Use and implement random and non-random sampling with their properties. • Estimate population -total, -mean and -variance, etc. for different sampling plans. • Distinguish among ratio, regression, and product estimators for different sampling designs and its applications.
Recommended Books: Latest Edition of the Following Books. 1. Bethelem, J. (2009). Applied Survey Methods: A Statistical Perspective. Wiley. 2. Singh, S. (2003). Advanced Sampling Theory with Applications: How Michael 3. Cochran, W.G. (1977), "Sampling Techniques' 3rd ed, John Wiley and Sons, New York. 4. Ferguson, T.S. (1996), "A Course in large Sample theory, Chapman & Hall, London. 5. Kish, L. (1992). "Survey Sampling", John Wiley, New York. 6. Raj, D. (1971) "Design of Sample Survey". McGraw Hill, New York. 7. Raj, D. & Chandhok, P. (1998), "Sample Survey Theory". Narosa Publishing House, New Delhi. 8. Singh, R. and Singh N, (1996), "Elements of Survey Sampling", Kuiwar Academic Publisher, Dodrecht. 9. Sukhatme, P.V, Sukhatme, B., Sukhatme, S., and Asok, A. (1985), "Sampling Theory of Survey with Application". Iowa State University Press.

Course Title: Bio-Statistics and Epidemiology	**Course Code: STAT-515**
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: 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: 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.

Course Title: Linear Algebra	**Course Code: MTH-405**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: NIL

Course Objective:

- help students learn in rigorous manner, the tools and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences
- to develop mathematical skills needed to apply these to the problems arising within their field of study; and to various real-world problems.

Course Outline:

System of Linear Equations: Representation in matrix form. Matrices. Operations on matrices. Echelon and reduced echelon form. Inverse of a matrix (by elementary row operations). Solution of linear system. Gauss-Jordan method. Gaussian elimination.

Determinants: Permutations of order two and three and definitions of determinants of the same order. Computing of determinants. Definition of higher order determinants. Properties. Expansion of determinants.

Vector Spaces: Definition and examples, subspaces. Linear combination and spanning set. Linearly Independent sets. Finitely generated vector spaces. Bases and dimension of a vector space. Operations on subspaces, Intersections, sums and direct sums of subspaces. Quotient Spaces. **Linear mappings:** Definition and examples. Kernel and image of a linear mapping. Rank and nullity. Reflections, projections, and homotheties. Change of basis. Eigen-values and eigenvectors. Theorem of Hamilton-Cayley. **Inner product Spaces:** Definition and examples. Properties, Projection. Cauchy inequality. Orthogonal and orthonormal basis. Gram Schmidt Process. Diagonalization.
Course Outcomes: After completing this course, students will able to • Solve systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion. • Carry out matrix operations, including inverses and determinants. • Demonstrate understanding of the concepts of vector space and subspace. • Demonstrate understanding of linear independence, span, and basis. • Determine eigenvalues and eigenvectors and solve eigenvalue problems. • Apply principles of matrix algebra to linear transformations. Demonstrate understanding of inner products and associated norms.
Recommended Books: Latest Edition of the Following Books. 1) Messer, R. (2021). Linear Algebra: Gateway to Mathematics. United States: American Mathematical Society. 2) Anton, H., Kaul, A. (2019). Elementary Linear Algebra. United Kingdom: Wiley. 3) Matrices and Linear Algebra With GAP. (2020). (n.p.): Akhilesh Chandra Yadav. 4) Neri, F. (2019). Linear Algebra for Computational Sciences and Engineering. Germany: Springer International Publishing. 5) Johnston, N. (2021). Introduction to Linear and Matrix Algebra. India: Springer International Publishing. 6) O'Leary, M. L. (2021). Linear Algebra. United Kingdom: Wiley.

6th Semester Courses

Course Name: Programming Fundamentals	**Course Code: CSC-302**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours: 4**
Prerequisites: None	
Course Objective:	

- This course provides fundamental concepts of programming to freshmen. The courses is pre-requisite to many other courses, therefore, students are strongly advised to cover all contentsand try to achieve CLOs to the maximum possible level.
- The course may be taught as language independent. Further, it is up to the university to choose any language for the practical/Lab purpose but that must be latest and market oriented.

Course Outline:

Introduction to problem solving, a brief review of Von-Neumann architecture, Introduction to programming, role of compiler and linker, introduction to algorithms, basic data types andvariables, input/output constructs, arithmetic, comparison and logical operators, conditionalstatements and execution flow for conditional statements, repetitive statements and execution flow for repetitive statements, lists and their memory organization, multi- dimensional lists, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations.

Course Outcomes: After completion of the course students will be able to:

- Understand basic problem-solving steps and logicconstructs
- Apply basic programing concepts
- Design and implement algorithms to solve real worldproblems

Recommended Books: Latest Edition of the Following Books

1. Python Crash Course" by Eric Matthes
2. Automate the Boring Stuff with Python" by Al Sweigart
3. Learning Python" by Mark Lutz
4. Fluent Python" by Luciano Ramalho
5. Python Cookbook" by David Beazley and Brian K. Jones
6. Tony Gaddis,, Starting out with Programming Logic & Degins, 4th Edition, 2018,Peearson.
7. Brian W. Kernighan, Dennis M. Ritchie, The C Programming Language, 2nd Edition, 1988,Pearson
8. Robert Lafore, Object Oriented Programming in C++,2001,Sams.
9. Paul Deitel & Harvey Deitel , C How to Program, 7th Edition, 2015,Pearson
10. Jeri R. Hanly & Elliot B.Koffman, Problem Solving and Program Design in C++, 7th Edition,2006,Edison Wesley

Course Title: Experimental Designs	**Course Code:** STAT-525
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. 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). Introduction to factorial designs, 2^k factorial designs, Main effects and interaction effects, Estimation and interpretation of effects, Confounding and aliasing in factorial experiments, Fractional factorial designs (basic concepts). Introduction and need for split-plot design, Layout and analysis of split-plot experiments.

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.
5. Montgomery, D.C. (2000). “Design and Analysis of Experiments”, John Wiley, New York.
6. Montgomery, D.C. (2020). “Design and Analysis of Experiments”, 10th Edition, John Wiley, New York.
7. Oehlert, G.W. (2000). A first course in design and analysis of experiments, W.H. Freeman, New York, USA.
8. Mead, R., Gilmour, S.G., and Mead, A. (2012). “Statistical Principles for the Design of Experiments: Applications to Real Experiments”, Cambridge University Press, Cambridge.

Course Title: Applied Multivariate Analysis	**Course Code: STAT-526**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

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:

Review of Multivariate Normal Distribution and Matrix Algebra Results, Principal Component Analysis. Introduction. Definition and Properties of Principal Components. Sampling Properties of Principal Components. Inference about Principal components. Factor Analysis Introduction. The Factor Model. Principal Factor Analysis. Maximum Likelihood Factor Analysis. Goodness of Fit Test. Factors Scores. Discriminant Analysis. Introduction. Discrimination When the Populations are known. Discrimination under Estimation. Fisher's Linear Discriminant Function. Probabilities of Misclassification. Cluster Analysis. 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" (6^{th} ed.). NJ: Pearson
7. Lattin, J., Carroll, D., and Green, P. (2003). "Analyzing Multivariate Data". Thomson Learning.

7th Semester:

Course Title: Statistical Programming Using R and Python	**Course Code: STAT-633**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: NIL	
Course Objective: • To introduce students to fundamental programming concepts and practical statistical computing using R and Python. • To develop students' abilities to write code, manipulate data, perform basic statistical analyses, and generate visualizations. • Students will gain hands-on experience with R packages and Python libraries commonly used in data analysis, enabling them to solve statistical problems using real-world datasets.	
Course Outline: statistical programming through two leading languages: R and Python. install and configure RStudio and Jupyter Notebook, explore the syntax, data types, variables, operators, and control structures (conditionals and loops) in both languages. Functions, data structures such as vectors, lists, matrices, arrays, and data frames in R, and lists, tuples, dictionaries, arrays, and Pandas Data Frames in Python. import and export data from various formats (CSV, Excel, text files), perform data cleaning and transformation, and handle missing values. Exploratory data analysis (EDA) using summary statistics, cross-tabulations, and grouped summaries. Visualization techniques are taught using R's base graphics and ggplot2, as well as Python's Matplotlib and Seaborn libraries, enabling students to create and customize various plots such as histograms, boxplots, scatterplots, and time series graphs. Core statistical methods including hypothesis testing, correlation analysis, and linear regression are introduced, with implementation in both R and Python.	
Course Outcomes: By the end of this course, the students will be able to: • Understand basic programming concepts, including algorithms, data structures, flow control, etc., using R and Python. • Use different R packages and Python libraries for statistical computing. • Use R and Python programming for statistical problems.	
Recommended Books: Latest Edition of the Following Books. • Grolemund, G. (2014). *Hands-On Programming with R: Write Your Own Functions and Simulations*. O'Reilly Media. • Wickham, H. & Grolemund, G. (2017). *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media. • Matloff, N. (2011). *The Art of R Programming: A Tour of Statistical Software Design*. No Starch Press. • Offers in-depth coverage of R programming concepts with advanced topics for serious learners.	

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 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

8th Semester:

Course Title: Statistical Inference	**Course Code: STAT-634**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites:	

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.

Tests of Hypotheses: critical regions. Neyman-Pearson Lemma, uniformly most powerful tests. Randomized Tests. Unbiased tests, Likelihood ratio tests and their asymptotic properties. Sequential Tests: SPRT and its properties, Average Sample Number and Operating Characteristic functions.

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.

➢ STANDARD SCHEME OF STUDY FOR THE PROGRAM OF BACHELOR OF SCIENCE IN STATISTICS (DATA SCIENCE)

Semester	Category	Course Codes	Course Title	Lectures	Lab	Cr. Hrs
Semester 1	Art & Humanities	XXX	Art & Humanities	2	0	2
	Interdisciplinary/Allied Course*	CSC-302	Programming Fundamentals	3	1	4
	Functional English	ENG-303	Functional English	3	0	3
	Major I	STAT-306	Introduction to Statistics	3	0	3
	Application of Information and Communication Technologies.	CSC-308	Applications of Information and Communication Technologies(ICT)	2	1	3
	Ideology and Constitution of Pakistan	PST-313	Ideology and Constitution of Pakistan	2	0	2
			Total			**17**
Semester 2	Social Sciences	XXX	Social Science	2	0	2
	Expository Writing	ENG-304	Expository Writing	3	0	3
	Islamic Studies/Religious Studies/Ethics	ISL-301	Islamic Studies/Religious Studies	2	0	2
	Interdisciplinary/Allied Course*	MTH-301	Calculus & Analytical Geometry	3	0	3
	Pakistan Studies	PST-323	Pakistan Studies	2	0	2
	Major II	STAT-307	Fundamentals of Probability and Probability Distributions	3	0	3
	Major III	STAT-315	Introduction to Sampling Theory	3	0	3
			Total			**18**
Semester 3	Fehm-e-Quran	ISL-325	Fehm-e-Quran I	0	1	1
	Quantitative Reasoning (QR I)	MTH-401	Quantitative Reasoning (QR-I)	3	0	3
	Natural Science	XXX	Natural Science	2	1	3
	Entrepreneurship	MS-309	Introduction to Entrepreneurship	2	0	2
	Major IV	STAT-412	Official Statistics	3	0	3
	Major V	STAT-405	Exploratory data analysis and visualization	3	0	3
	Major VI	STAT-406	Basic Statistical Inference	3	0	3
			Total			**18**
Semester 4	Fehm-e-Quran	ISL-325	Fehm-e-Quran II	0	1	1
	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-409	Data Wrangling	3	0	3
	Major IX	STAT-410	Non-parametric techniques	3	0	3
	Major X	STAT-408	Statistical Packages	3	0	3
			Total			**18**
Semester 5	Interdisciplinary/Allied Course*	CSC-423	Data Structures	3	1	4
	Major XI	STAT-516	Probability Distributions	3	0	3
	Major XII	STAT-512	Sampling Techniques	3	0	3
	Major XIII	STAT-515	Biostatistics and Epidemiology	3	0	3
	Major XIV	STAT-514	Regression Analysis	3	0	3
			Total			**16**
Semester 6	Interdisciplinary/Allied Course*	CSC-312	Object Oriented Programming	3	1	4
	Major XV	STAT-525	Experimental Designs	3	0	3
	Major XVI	STAT-526	Applied Multivariate Analysis	3	0	3
	Major XVII(Elective) **	XXX		3	0	3
	Major XVIII(Elective) **	XXX		3	0	3
			Total			**16**
Semester 7	Internship (Mandatory)	STAT-698	Internship (Mandatory)	3	0	3
	Major XX	STAT-633	Statistical Programming Using R and Python	3	0	3
	Major XXI	STAT-614	Survey and Research Methods	3	0	3
	Major XXII	STAT-613	Statistical Quality Control	3	0	3
	Major XXIII(Elective)**	XXX		3	0	3
	Major XXIVElective) **	XXX		3	0	3
			Total Cr.Hrs.			**18**
Semester 8	Major XXV	STAT-634	Statistical Inference	3	0	3
	Major XXVI(Elective) **	XXX		3	0	3
	Major XXVII (Elective) **	XXX		3	0	3
	Major XXVIII (Elective) **	XXX		3	0	3
	Capstone Project	STAT-697	Capstone Project	3	0	3
			Total Cr.Hrs.			**15**
			Total Cr.Hrs.	**136**		

IMPORTANT NOTE: <u>THE CURRICULUM FOR BS STATISTICS (DATA SCIENCE) IS NOT EQUIVALENT TO BS DATA SCIENCE.</u>

<u>DUE TO THE NON-EQUIVALENT NATURE OF THE TWO PROGRAMS, REQUESTS FOR EQUIVALENCY BETWEEN BS STATISTICS (DATA SCIENCE) AND BS DATA SCIENCE</u>

WILL NOT BE ENTERTAINED.

* These interdisciplinary courses are proposed by the NCRC(HEC), however, the university/offering department may offer any four (04) interdisciplinary courses from the proposed list provided in this document, or any other such course to enhance the interdisciplinary understanding of the students, keeping in view its available academic, human and infrastructural resources. Credit combination may be arranged in accordance with the nature of the course.

** Read in conjunction with the guidance given on "Standard Nomenclature" in this policy, the department may offer any eight (07) courses from either the general list of electives or from within one of the specializations, keeping in view its available academic, human, and infrastructural resources. Credit combinations may be arranged in accordance with the nature of the course.

COURSE CONTENTS OF MAJOR ELECTIVES FOR BS STATISTICS (DATA SCIENCE)

Course Name: Database Management Systems	**Course Code: CSC-524**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:** 4
Prerequisites: None	
Course Objective: • The course aims to introduce basic database concepts, different data models, data storage and retrieval techniques and database design techniques. • The course primarily focuses on relational data model and DBMS concepts. **Course Outcomes:** • After completing the course, the students will be familiar with data modelling concepts used in DB development. • Undertake and successfully complete logical data base design tasks. • Be familiar with a broad range of data management issues, including data integrity, concurrency and security.	
Course Outline: Basic database concepts; Entity Relationship modeling, Relational data model and algebra,Structured Query language; RDBMS; Database design, functional dependencies and normal forms;query optimization concepts,Transaction processing and optimization concepts; concurrency control and recovery techniques; Database security and authorization. Small Group Project implementing a database. Physical database design: Storage and file structure; indexed files; b-trees; files with dense index; files with variable length records; Database efficiency and tuning.	

Lab Outline: Structured Query Language commands, creating and populating tables, design of simple databases, database normalization techniques, query optimization, indexing techniques, partial and full recovery techniques, developing GUI techniques, implementation of database security mechanisms.
Recommended Books: Latest Edition of the Following Books. 1. Jeffrey A. Hoffer, V. Ramesh, Heikki Topi. Modern Database Managment 11th Edition, 2012, Prentice Hall. 2. Connolly,R., Begg,P. Database Systems: A Practical Approach to Design, Implementation and Management, 5th Edition, 2009, Addison-Wesley Pub. Co. 3. Ramez Elmasri and Shamkant B. Navathe. Fundamentals of Database Systems. 6th Edition, 2010, Pearson. 4. C.J.Date,. An Introduction to Database System, 8th Edition, 2004, Addison-Wesley.

Course Name: Artificial Intelligence	**Course Code: CSC-543**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Object Oriented Programming	
Course Objective: • Artificial Intelligence has emerged as one of the most significant and promising areas of computing. • This course focuses on the foundations of AI and its basic techniques like Symbolic manipulations, Pattern Matching, Knowledge Representation, Decision Making and Appreciating the differences between Knowledge, Data and Code. • AI programming language Python has been proposed for the practical work of this course.	
Course Outlines: An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min- max algorithm, Alpha beta pruning, Game-playing); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learning from examples; ANN and Natural Language Processing;Recent trends in AI and applications of AI algorithms. Python programming language will be used to explore and illustrate various issues and techniques in Artificial Intelligence.	
Course Outcomes: After completion of the course students will be able to: • Understand the fundamental constructs of Pythonprogramming language. • Understand key concepts in the field of artificialintelligence • Implement artificial intelligence techniques and casestudies	
Recommended Books: Latest Edition of the Following Books 1. Russell, S. and Norvig, P. Artificial Intelligence. A Modern Approach, 3rd ed, 2015, PrenticeHall, Inc.. 2. Norvig, P., Paradigms of Artificial Intelligence Programming: Case studies in Common	

Lisp, 1992 Morgan Kaufman Publishers, Inc..
3. Luger, G.F. and Stubblefield, W.A., AI algorithms, data structures, and idioms in Prolog, Lisp, and Java, 2009, Pearson Addison-Wesley.
4. Severance, C.R., Python for everybody: Exploring data using Python 3.2016, CreateSpace Independent Publ Platform.
5. Miller, B.N., Ranum, D.L. and Anderson, J., Python programming in context. 2019, Jones & Bartlett Pub.
6. Joshi, P.,Artificial intelligence with python. 2017, Packt Publishing Ltd.

Course Name: Introduction to Data Science	**Course Code: CSC-536**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: Artificial Intelligence

Course Objective:

- Data Science is the study of the generalizable extraction of knowledge from data. Being a data scientist requires an integrated skill set spanning mathematics, statistics, machine learning, databases and other branches of computer science along with a good understandingof the craft of problem formulation to engineer effective solutions.
- The aim of this course isto: Introduce students to this rapidly growing field and equip them with some of its basic principles and tools as well as its general mindset. Explain the significance of exploratory data analysis in data science.
- Identify common approaches used for Feature Generation as well as Feature Selection, and finally discuss the Ethical and Privacy issues. Programming language Python has been proposed for the practical work of this course.

Course Outlines

Introduction: What is Data Science? Big Data and Data Science hype, Datafication, Currentlandscape of perspectives, Skill sets needed; Statistical Inference: Populations and samples,Statistical modeling, probability distributions, fitting a model, Intro to Python; Exploratory Data Analysis and the Data Science Process; Basic Machine Learning Algorithms: Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes; Feature Generation and Feature Selection; Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis; Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs; Data Visualization: Basic principles, ideas and tools fordata visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics,Next-generation data scientists.

Course Outcomes: After completion of the course students will be able to:

- Describe what Data Science is and the skill sets needed to be a data scientist.
- Apply EDA and the Data Science process in a case study. C3 (Apply)
- Comprehend the fundamental constructs of Python programming language.
- Apply basic machine learning algorithms to solve real world problems of moderate complexity.

Recommended Books: Latest Edition of the Following Books

1. Blum, A., Hopcroft, J., & Kannan, R., Foundations of data science, 2016.
2. Jeffrey S. Saltz, Jeffrey M. Stanton, An Introduction to Data Science, 2017, SAGE Publications.
3. Severance, C.R., Python for everybody: Exploring data using Python 3, 2016, CreateSpace Independent Pub Platform.
4. Cathy O'Neil and Rachel Schutt, Doing Data Science, Straight Talk from the Frontline, 2014, O'Reilly.
5. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing andPresenting Data, 2015, EMC Education Services, John Wiley & Sons.

Course Name: Machine Learning	**Course Code: CSC-528**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: Artificial Intelligence

Course Objective:

Machine learning is one of the fastest growing areas of computer science, with far-reachingapplications. The aim of this course is to:

- Present the basic machine learning concepts;
- Present a range of machine learning algorithms along with their strengths and weaknesses;
- Apply machine learning algorithms to solve problems of moderate complexity.

Course Outlines

Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Aglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi- supervised learning with EM using labeled and unlabled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses.Bagging, boosting.

Course Outcomes: After completion of the course students will be able to:

- Describe basic machine learning concepts, theories and applications.
- Apply supervised learning techniques to solve classification problems of moderate complexity.
- Apply unsupervised learning techniques to solve clustering problems of moderate complexity
- Apply reinforcement learning algorithms to environments with complex dynamics.
- Develop a reasonable size project using suitable machine learning technique

Recommended Books: Latest Edition of the Following Books

1. Tom, M, Machine Learning, 1997, McGraw Hill.
2. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, 2012, MIT Press.

Course Title: Statistics for Deep Learning	**Course Code: STAT-661**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:

- Provide a statistical foundation for understanding deep learning algorithms.
- Introduce probabilistic models relevant to neural networks and learning processes.
- Explore model evaluation techniques such as cross-validation, regularisation, and Bayesian interpretation.
- Bridge theoretical statistics with practical applications in deep learning frameworks.

Course Outline:

Probability theory, random variables, and distributions commonly encountered in deep learning contexts. Expectation, variance, covariance, and transformations of variables, with special focus on multivariate distributions. Maximum likelihood estimation and Bayesian inference as foundational tools for training and evaluating deep learning models. The role of regularisation techniques such as L1/L2 penalties from a statistical perspective. Probabilistic graphical models and their applications in structured deep learning, including variational autoencoders and Bayesian neural networks. Model evaluation strategies, such as k-fold cross-validation, bootstrapping, and statistical significance testing of results, are also covered. Real-world examples will demonstrate how statistical thinking enhances interpretability and robustness in deep learning applications.

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

- Interpret the role of statistical principles in designing and evaluating deep learning models.
- Apply probabilistic and statistical concepts to enhance neural network performance.
- Analyse uncertainty and variability in model predictions using statistical tools.
- Critically assess deep learning results using appropriate statistical validation techniques.

Recommended Books: Latest Edition of the Following Books.

- Bishop, C. M. (2006). *Pattern Recognition and Machine Learning*. Springer.
- Murphy, K. P. (2023). *Probabilistic Machine Learning: An Introduction.* MIT Press.
- Géron, A. (2022). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (3rd ed.). O'Reilly Media.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.
- McElreath, R. (2020). *Statistical Rethinking: A Bayesian Course with Examples in R and Stan* (2nd ed.). CRC Press.

Course Name: Big Data Analytics	**Course Code: CSC-660**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: Introduction to Data Science

Course Objective:

- The course is all about fundamental information to get insight into the Challenges with big data.

Course Outline

Introduction to Big Data Analytics, Big Data Platforms, Data Store & Processing using Hadoop, Big Data Storage and Analytics, Big Data Analytics ML Algorithms, Recommendation, Clustering, and Classification, Linked Big Data: Graph Computing and Graph Analytics, Graphical Models and Bayesian Networks, Big Data Visualization, Cognitive Mobile Analytics.

Course Outcomes: After completion of the course students will be able to:

- Provide fundamental information to get insight into the Challenges with big data.
- Understand techniques for storing and processing large amounts of structured and unstructured data
- Application of big data concepts to get valuable information on market trends
- Implement and deploy a sample project for extracting useful information from a mid-sized dataset.

Recommended Books: Latest Edition of the Following Books

1. Jure Leskovec, Anand Rajaraman, Jeff Ullman, Mining of Massive Datasets, 2nd edition, 2011,Cambridge Unv Press.
2. Tom White , Hadoop: The Definitive Guide, 4th edition. 2012,Yahoo Press.
3. Jimmy Lin and Chris ,Data-Intensive Text Processing with Map Reduce, 2010, Morgan and Claypool.

Course Name: Data Mining	**Course Code: CSC-634**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: Advance Statistics, Introduction to Data Science

Course Objective:

- Expand on the student's understanding and awareness of the concepts of data mining basics, techniques, and application.
- Introduce the concepts of Data Pre-processing and Summary Statistics.
- Introduce the concepts of Frequent Item Set Generation, Associations and Correlations measures.
- Introduce the concepts of Classification, Prediction, and Clustering algorithms.Build on the programming and problem-solving skills developed in previous subjects studied by the student, to achieve an understanding of the development of Classification, Prediction, and Clustering pplications.

Course Outlines

Introduction to data mining and basic concepts, Pre-Processing Techniques & Summary Statistics, Association Rule mining using Apriori Algorithm and Frequent Pattern Trees, Introduction to Classification Types, Supervised Classification (Decision trees, Naïve Bae Classification, K-Nearest Neighbors, Support Vector Machines etc.), Unsupervised Classification (K Means, K Median, Hieratical and Divisive Clustering, Kohonan Self Organizing maps), outlier & anomaly detection, Web and Social Network Mining, Data Mining Trends and Research Frontiers. Implementing concepts using Python

Course Outcomes: After completion of the course students will be able to:

- Apply preprocessing techniques on any given raw data.
- Select and apply proper data mining algorithm to discover interesting patterns
- Analyze and extract patterns to solve problems and point out how to deploy solution
- Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy

Recommended Books: Latest Edition of the Following Books

1. Jiawei Han & Micheline Kamber, Jian Pei, Data Mining: Concepts andTechniques, 3rd Edition, 2011, Moran-Kaufmann.
2. Pang-Ning Tan, Michael Steinbach, and Vipin Kumar, Introduction to DataMining, 2005,Pearson.
3. Charu C. Aggarwal, Data Mining: The Textbook, 2015, Springer.
4. D. Hand, H. Mannila, P. Smyth, Principles of Data Mining, 2001, MIT Press.

Course Title: Digital analytics	**Course Code: CSC-**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective: • Familiarise students with digital platforms and their data structures. • Introduce digital marketing metrics and behavioural analysis. • Develop skills to build dashboards and interpret KPIs. • Empower students to apply analytics in business and social research	
Course Outline: The landscape of digital analytics, including measurement, data collection, and analysis from websites, social media, and mobile platforms. Setting up tracking using Google Tag Manager, configuring Google Analytics, understanding of key metrics such as sessions, bounce rates, conversion rates, CTR, and CAC. A/B testing, funnel analysis, customer journey analytics, and digital dashboards. Tools such as Tableau, Power BI, and R Shiny are introduced for data presentation. Students will analyses campaign data and digital experiments, focusing on translating findings into actionable insights for policy and marketing.	
Course Outcomes: By the end of this course, the students will be able to: • Understand core concepts and tools used in digital analytics. • Analyse digital user behaviour using data from web and social media platforms. • Implement tracking and data collection strategies using Google Analytics and similar tools. Interpret digital metrics to inform marketing and policy decisions.	
Recommended Books: Latest Edition of the Following Books. • Clifton, B. (2020). *Advanced Web Metrics with Google Analytics* (4th ed.). Wiley. • Kaushik, A. (2015). *Web Analytics 2.0: The Art of Online Accountability & Science of Customer Centricity*. Wiley. • Cutroni, J. (2010). *Google Analytics*. O'Reilly Media. • Stokes, R. (2023). *eMarketing: The Essential Guide to Marketing in a Digital World* (7th ed.). Quirk Education. Chaffey, D., & Ellis-Chadwick, F. (2019). *Digital Marketing* (7th ed.). Pearson.	

Course Name: Data Warehousing and Business Intelligence	**Course Code: CSC-641**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Introduction to Data Science	
Course Objective:	
Course Outlines	

Introduction to Data Warehouse and Business Intelligence; Necessities and essentials of Business Intelligence; DW Life Cycle and Basic Architecture; DW Architecture in SQL Server; Logical Model; Indexes; Physical Model; Optimizations; OLAP Operations, Queries and Query Optimization; Building the DW; Data visualization and reporting based on Datawarehouse using SSAS and Tableau; Data visualization and reporting based on Cube; Reports and Dashboard management on PowerBI; Dashboard Enrichment; Business Intelligence Tools.
Course Outcomes: After completion of the course students will be able to: • Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process • Demonstrate an understanding of the fundamental concepts of the Star and the Snowflake Schema; learn how to design the schema of a DW based on these two models. • Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas • Use Analytic SQL to aggregate, analyze and report, and model data.
Recommended Books: Latest Edition of the Following Books 1. W. H. Inmon, "Building the Data Warehouse", Wiley-India Edition. 2. Ralph Kimball, "The Data Warehouse Toolkit – Practical Techniques for Building Dimensional Data Warehouse," John Wiley & Sons, Inc. 3. Matteo Golfarelli, Stefano Rizzi, "Data Warehouse Design - Modern Principles and Methodologies", McGraw Hill Publisher

Course Title: High Dimensional Data Analysis	**Course Code: STAT-662**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective: • Introduce statistical challenges of high-dimensional data. • Equip students with tools for variable selection and regularisation. • Explore modern dimension reduction techniques. Promote computational thinking for efficient model fitting and validation.	
Course Outline: Overview of the curse of dimensionality, Multicollinearity, and sparsity. Shrinkage methods such as ridge regression, lasso, and elastic net. Dimension reduction techniques including principal component analysis (PCA), factor analysis, and t-distributed stochastic neighbour embedding (t-SNE). Variable selection algorithms, model stability, and interpretability in high-dimensional settings. Real-world applications from genomics, text data, and image analysis. Students will use R and Python to analyse case studies and high-dimensional simulation datasets.	
Course Outcomes: By the end of this course, the students will be able to: • Identify and apply techniques suited for high-dimensional datasets. • Reduce dimensionality using statistical methods to retain relevant information. • Implement shrinkage and penalisation methods for model regularisation.	

• Evaluate models using appropriate statistical and computational metrics.
Recommended Books: Latest Edition of the Following Books. • Bühlmann, P., & Van De Geer, S. (2011). *Statistics for High-Dimensional Data: Methods, Theory and Applications*. Springer. • Hastie, T., Tibshirani, R., & Friedman, J. (2017). *The Elements of Statistical Learning* (2nd ed.). Springer. • Fan, J., & Lv, J. (2010). *A Selective Overview of Variable Selection in High-Dimensional Feature Space*. Statistica Sinica, 20(1), 101-148. • Witten, D. M., & Hastie, T. (2021). *Statistical Learning with Sparsity: The Lasso and Generalizations*. CRC Press. • Izenman, A. J. (2022). *Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning* (2nd ed.). Springer.

Course Name: Modeling & Simulation	**Course Code: CSC-637**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours:** 3
Prerequisites: None	
Course Objective • This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers.	
Course Outline Baics, Performance modeling and evaluation, bench marking, performance evaluation of high parallel systems architecture, application of performance evaluation, measurement techniques, hardware monitoring, software monitoring, hybrid monitoring, fundamentals of queuing models, structure and performance parameters, operational analysis of queuing models, general features of queuing models, birth and death processes, m/m/i and m/g/1 systems, dependability modeling, analysis of reliable, available and 30 high assurance systems, fault-tolerant techniques, software reliability modeling, adaptive modeling, agent based modeling.	
Lab Outline Introduction to modeling techniques using simulation tools like MATLAB. Bioinformatics toolbox for various performance modeling,evaluation, analysis and study various queuing techniques.	

Recommended Books:

1. I. Mitran, Simulation Techniques for Discrete Event Systems,Cambridge Computer Science text 14, Published by University Press, Cambridge,1982.

2. Banks,Jerry, Discrete Event system simulation, Pearson Prentice Hall, 2009
3. Law,A.M,Kelton and W.David Simulation modeling and analysis, Mcgraw Hill,2000.

COURSE CONTENTS OF INTERDISIPLINARY/ ALLIED COURSES FOR BS STATISTICS (DATA SCIENCE)

1. Programming Fundamentals
2. Calculus and Analytical Geometry
3. Data Structures
4. Object Oriented Programming

The Course Contents of "Programming Fundamentals" and "Calculus and Analytical Geometry" are already given in BS STATISTICS (Irrespective of the specialization).

The Course Contents of the courses titled "Data Structures" and "Object Oriented Programming" are as below

Course Name: Data Structures	**Course Code: CSC-423**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours: 4**
Prerequisites:	
Course Objective: • The course is designed to teach students structures and schemes, which allow them to write programmer to efficiently manipulate, store, and retrieve data. • Students are exposed to the concepts of time and space complexity of computer programs.	
Course Outline Abstract data types, complexity analysis, Big Oh notation, Stacks (linked lists and array implementations), Recursion and analyzing recursive algorithms, divide and conquer algorithms, Sorting algorithms (selection, insertion, merge, quick, bubble, heap, shell, radix,bucket), queue, dequeuer, priority queues (linked and array implementations of queues), linked list & its various types, sorted linked list, searching an unsorted array,	

binary search for sorted arrays, hashing and indexing, open addressing and chaining, trees and treetraversals, binary search trees, heaps, M-way tress, balanced trees, graphs, breadth-first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection.

Course Outcomes: After completion of the course students will be able to:

- Implement various data structures and their algorithmsand apply them in implementing simple applications.
  - Analyze simple algorithms and determine theircomplexities.
  - Apply the knowledge of data structure to other applicationdomains.
  - Design new data structures and algorithms to solveproblems.

Recommended Books: Latest Edition of the Following Books

1. Mark A. Weiss , Data Structures and Algorithm Analysis in Java,2011,Pearson.
2. Frank M. Carrano & Timothy M. Henry ,Data Structures and Abstractions with Java,2014,Pearson.
3. Adam Drozdek, Data Structures and Algorithms in C++ ,2012,Cengage Learning.
4. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++ ,2013,Pearson.
5 John Lewis & Joseph Chase Java Software Structures: Designing and Using Data Structures, 2013, Pearson.

Course Name: Object Oriented Programming	**Course Code: CSC-312**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:4**

Prerequisites: Programming Fundamentals

Course Objective:

- The course aims to focus on object-oriented concepts, analysis and software development.
- The basic concept of OOP is covered in this course.

Course Outline:

Introduction to object oriented design, history and advantages of object oriented design, introduction to object oriented programming concepts, classes, objects, data encapsulation, constructors, destructors, access modifiers, const vs non-const functions, static data members& functions, function overloading, operator overloading, identification of classes and their relationships, composition, aggregation, inheritance, multiple inheritance, polymorphism, abstract classes and interfaces, generic programming concepts, function & class templates, standard template library, object streams, data and object serialization using object streams,exception handling.

Course Outcomes: After completion of the course students will be able to:

- Understand principles of object-oriented paradigm.
- Identify the objects & their relationships to build objectoriented solution
- Model a solution for a given problem using objectoriented principles
- Examine an object oriented solution

Recommended Books: Latest Edition of the Following Books

2. Paul Deitel, Java: How to Program, 9th Edition, 2011,Pearson College Div.
3. Ivor Horton, Beginning Java 2, 7th Edition, 1999, Apress
4. C. ThomasWu , An Introduction to Object Oriented Programming with Java, 5th Edition,2009,McGeraw Hills
5. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, 2017,Pearson.
6. Deitel & Deitel, C++ How to Program, 10th Edition, 2005, Prentice Hall
7. Robert Lafore, Object Oriented Programming in C++, 3rd Edition,2008,Sams.

COURSE CONTENTS OF MAJOR ELECTIVES FOR BS STATISTICS (BIOSTATISITCS)

Course Title: BIO-STATISTICAL LITERACY	**Course Code: STAT-571**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:

- Become familiar with data structures commonly encountered in public health research
- Perform exploratory data analysis including descriptive statistics and graphical representations
- Formulate scientific questions into statistical hypotheses
- Determine appropriate statistical techniques by considering the scientific question and available data
- Perform statistical tests for associations between pairs of variables, assess statistical significance and interpret results
- Appreciate the need for biostatistics in public health research and be prepared to collaborate with biostatisticians in a research setting

Course Outline:

Fundamental concepts of study design, cross-sectional study, cohort study, case-control study, experimental study, descriptive statistics, hypothesis testing, confidence intervals, odds ratios, relative risks, models in multiple linear, logistic and Poisson regression, survival data, Kaplan-Meier methods, proportional hazards models. The focus will be when to use a given method and how to interpret the results.

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

- Perform exploratory data analysis
- Apply appropriate statistical test to assess associations between variables,
- Interpret parameter estimates and p-values from statistical tests and models,

- Understand the concept of confounding and how to use multivariate regression methods to control for potential confounding variables

Recommended Books: Latest Edition of the Following Books.

- Bland, M. (2015) "Introduction to Medical Statistics". (4th ed), Oxford University Press, Oxford.
- Dawson, B., & Trapp, R. G. (2019). "Basic and Clinical Biostatistics". (5th ed.). McGraw Hill.
- Glover, T., & Mitchell, K. (2015). "An introduction to biostatistics". (3rd ed.). Boston: McGraw Hill.
- Daniel, W.W. (2018). "Biostatistics: A foundation for Analysis in the Health Sciences". (11th ed), John Wiley and Sons, Inc. New York.
- Le, C. T. (2009). "Health and numbers: a problems-based introduction to biostatistics". (3rd ed), New York: Wiley-Liss.
- Zar J. H. (2020). "Bio-statistical Analysis". (6th ed.), Pearson Education Indian Branch.
- Shoukri, M. M & Pause, C. A. (1998). "Statistical Methods for Health Sciences". (2nd ed), CRC Press, Florida.
- Daniel, W.W. (1996). "Biostatistics: A Foundation for the Health Sciences", (6th ed), John Wiley, New York.
- Diggle, J. P., Liang, Kung-Yee and Zeger, S. L. (1996). "Analysis of Longitudinal Data", Clarendon Press, Oxford.

Course Title: Logistic Regression and Survival Analysis	**Course Code: STAT-572**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	

Course Objective:

- Students will be able to identify situations when it is best to utilize logistic regression and survival analysis
- Students will be able to perform logistic regression analysis and interpret the results.
- Students will be able to perform survival analysis and interpret the results.
  Students will learn how to run these types of analysis by using Stata and R software

Course Outline:

Basic knowledge of logistic regression: Regression modeling of categorical or time-to-event outcomes with continuous and categorical predictors, model assumptions, goodness of fit, use of maximum likelihood to determine estimates and test hypotheses, use of descriptive and diagnostic plots. Analysis of survival data: Patient time and study time, Survival function and hazard function, Time dependent and censored survival data, Estimation of Survival function hazard function, median and percentiles of Survival times, Confidence interval and comparison of group; stratified and log-rank tests for trend.

Modeling of Survival data, Cox proportional hazards regression, Diagnostics for proportional hazards, Sample size requirement for survival study. Computer software for Survival analysis; Stata and R.
Course Outcomes: By the end of this course, the students will be able to: • Describe how binary logistic regression and Cox regression are commonly used • Distinguish the nature of the outcome variable for logistic regression and Cox regression compared to linear regression • Interpret an estimated survival curve • Evaluate a Kaplan-Meier plot comparing the survival curves of two different groups
Recommended Books: Latest Edition of the Following Books. • Kleinbaum, D. G., & Klein, M. (2022). *Logistic regression: A self-learning text* (4th ed.). Springer. • Harrell, F. E. (2015). Regression modeling strategies: With applications to linear models, logistic and ordinal regression, and survival analysis (2nd ed.). Springer. • Cleves, M., Gould, W., Marchenko, Y.V. (2016). "An Introduction to Survival Analysis Using Stata". (3rd ed), Stata Press. • Collett, D. (2015). *Modelling survival data in medical research* (3rd ed.). CRC Press. • Christensen, R. (2018). *Log-linear models and logistic regression* (2nd ed.). Springer. • Kleinbaum, D. G., & Klein, M. (2010). Logistic regression: A self-learning text (3rd ed.). Springer. • Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). Applied logistic regression (3rd ed.). Wiley. • Allison, P. D. (2010). Survival analysis using SAS: A practical guide (2nd ed.). SAS Institute. • Lee, E.T. (1997). "Applied Survival Analysis", John Wiley and Sons, New York. Muller, R.G. and Xian Zhou (1996). "Survival Analysis with long-term Survivors' John Wiley. New York.

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: Introduction to Epidemiology	**Course Code: STAT-671**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Nil	
Course Objective: • Students will be able to identify situations when it is best to utilize logistic regression and survival analysis • Students will be able to perform logistic regression analysis and interpret the results. • Students will be able to perform survival analysis and interpret the results. • Students will learn how to run these types of analysis by using Stata and R software	
Course Outline: Introduction to basic epidemiology, Indices of health and disease, Descriptive study designs case report, case series, cross sectional study, Analytical observational study designs case control study, Experimental study designs RCT, Quassi study, Sampling techniques, Measure of association (Odds ratio, Relative Risk), Measure of association (Population attributable Risk), Screening Validity, Reliability, Sensitivity, Specificity, PPV, NPV	

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

- Demonstrate the role of basic epidemiology and biostatistics in health and medicine.
- Demonstrate the patterns of health and disease in the population in terms of persons, time and place.
- Apply epidemiological research methods for preventive strategies.

Recommended Books: Latest Edition of the Following Books.

- Gordis, L. (2014). *Epidemiology* (5th ed.). Philadelphia, PA: Elsevier Saunders. **ISBN**: 9781455737338
- Aschengrau, A., & Seage, G. R. III. (2020). *Essentials of Epidemiology in Public Health* (4th ed.). Burlington, MA: Jones & Bartlett Learning.
- Szklo, M., & Nieto, F. J. (2019). *Epidemiology: Beyond the Basics* (4th ed.). Burlington, MA: Jones & Bartlett Learning. **ISBN**: 9781284116595
- Rothman, K. J., Greenland, S., & Lash, T. L. (2020). *Modern Epidemiology* (4th ed.). Philadelphia, PA: Wolters Kluwer.
- Friis, R. H., & Sellers, T. A. (2020). *Epidemiology for Public Health Practice* (6th ed.). Burlington, MA: Jones & Bartlett Learning.

Course Title: Design and Conduct of Clinical Trials	**Course Code: STAT-672**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:

- Upon completion of the course, the student will be able to have a working knowledge of how to collect and manage clinical trial data
- Students will be able to analyze continuous, dichotomous, and time-to-event clinical trial data Students will be able to contribute to the statistical portions of a clinical trial study design

Course Outline:

Introduction to clinical trials, types and aspects of clinical trials; definition, phases and protocol: Design of Clinical Studies; Randomized controlled design, crossover design, cluster randomization, equivalence trial, large sample trial: Randomization; fixed randomization, adaptive randomization: Review of Methods of analysis; Randomization tests, stratified analysis, survival analysis: Surrogate endpoints; surrogate versus clinical endpoints, validation of surrogate end points: Statistical planning; sample size determination: Equivalency testing; Testing for the similarity of treatments: Multiple Testing; Multiple comparisons, subgroup analysis, multiple endpoints, covariate adjustment: Statistical Monitoring; methods of repeated testing of hypotheses over time: Noncompliance / Departure from intended treatment; Intent to treat principle, Efficacy analysis.

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

- Fundamental understanding of how clinical trials are conducted
- The student will gain the overall knowledge required to interpret clinical trial statistical results

Recommended Books: Latest Edition of the Following Books.

- Lawrence, M. C., & Garret, E. S. (2023). *Principles and practice of clinical trial design*. Cambridge University Press.
- Brody, T., & Solomon, S. (2022). *Clinical trials: Study design, endpoints, and biomarkers, drug*

safety, and FDA and ICH guidelines (2nd ed.). Academic Press.
- Chow, S.-C., & Liu, J. P. (2022). *Design and analysis of clinical trials: Concepts and methodologies* (4th ed.). Wiley.
- Friedman L.M., Furberg C. and DeMets D.L. (2010). Fundamentals of Clinical Trials. Springer Verlag, New York.
- Rosenberg, W.F., Lachin, J.M. (2002) Randomization in Clinical Trials: Theory and Practice. Wiley, New York.
- C. Jennison and B. W. Turnbull (1999). Group Sequential Methods with Applications to Clinical Trails, CRC Press.
- Chow S.C. and Liu J.P. (2003): Design and Analysis of Clinical Trials: Concepts and Methodologies, 2nd Edition, Wiley.
  E. Marubeni and M. G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

Course Title: Advanced Epidemiology	**Course Code: STAT-673**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:

- To provide skills in understanding data
- To develop ability of analyzing data which may be useful in understanding disease prevalence
- To understand using the statistical software as a form of help in analysis

Course Outline:

Measures of disease frequency and exposure effects, Rates and Risk measurements, Odds ratios as an estimate of Relative Risk, Confidence intervals for rates and rate ratio, Test for heterogeneity of Rate Ratios, Person-year Analysis : Cohort studies, Comparison of several exposure groups using different statistical techniques, Exposed cohort compared to an external standard, Analysis of unmatched case-control studies, Selection Bias, Analysis of matched Case-control studies, Estimating Risk ratios and Rate Ratios in case-Control studies, Clustering of cases of disease, Analysis of data with multiple episodes as outcome, Laws of probability and Binomial Distribution, Conditional probability, Comparison of survivorship curves, Multiple comparisons and sequential trials, Time series.

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

- At the end of the course, the student should be able to apply statistical measures in the analysis of Cohort and Case control studies.
- Analyze Disease Frequency in a wider perspective keeping the population dynamics in view.
- Effectively apply statistical modeling techniques in different study Designs.
- Apply comparisons in several exposure groups.
  Apply the analysis for interaction when studying confounding etc.

Recommended Books: Latest Edition of the Following Books.

- Ahrens, W., & Pigeot, I. (Eds.). (2014). Handbook of Epidemiology. Springer New York, NY.
- Celentano, D. D., & Szklo, M. (2018). Gordis Epidemiology (6th ed.). Elsevier.
- Webb, P., Bain, C., & Page, A. (2020). *Essential epidemiology: An introduction for students and health professionals* (4th ed.). Cambridge University Press.
- Friis, R. H., & Sellers, T. A. (2020). *Epidemiology for public health practice* (6th ed.). Jones & Bartlett Learning.
- Quick, J. D. (2018). The End of Epidemics: The Looming Threat to Humanity and How to Stop It. St. Martin's Press.
- Shah, S. (2010). The Fever: How Malaria Has Ruled Humankind for 500,000 Years. Farrar, Straus and Giroux.
- Turnock, B. J. (2015). Essentials of Public Health (3rd ed.). Jones & Bartlett Learning.
- Abramson JH, Abramson ZH. Survey methods in community medicine, 5th ed. Edinburgh: Churchill Livingstone; 1999.
- Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991.
- Bowling A. Research methods in health: investigating health and health services, 2nd ed. Buckingham: Open University Press; 1997.

Course Title: Predictive Modeling in the Health Sciences	**Course Code: STAT-674**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:

- Students will be able to identify situations when it is best to utilize logistic regression and survival analysis
- Students will be able to perform logistic regression analysis and interpret the results.
- Students will be able to perform survival analysis and interpret the results.
  Students will learn how to run these types of analysis by using Stata and R software

Course Contents

Basics of data analysis for the healthcare system Define the concept of clinical intelligence as compared with business intelligence and the role of analytics in supporting a data-driven learning healthcare system. Key topics include tactical BI vs strategic BI, operational BI, definitions of Big Data, Overview-Overwhelm framework, sample size selection, existing quality/performance measurement frameworks (HEDIS), existing Analytics maturity model (DELTA), comparing healthcare delivery, and attributes of high performing healthcare systems. Learn to navigate complex data structures and efficiently retrieve the data needed to answer a question or solve a problem. This module explores the types and sources of healthcare data, along with methods for selecting, preparing, querying and transforming healthcare data. Common health data formats like CCD, CCR and terminologies used in the healthcare system and the basics of R language and XML. Examine

epidemiological concepts in healthcare analytics and their application to patient and population outcomes research. Topics include a basic health statistics primer (as refresher); mortality, morbidity, and risk adjustment; cost effectiveness analysis; and methods for evaluating population variation. Plotting and implementing data visualization in R. The proliferation of data in the post-EHR era creates opportunities for large scale data analysis to discover meaningful patterns and trends. In this module, students explore the application of data mining techniques for purposes of big data analytics using administrative and clinical systems data. Topics include an overview of the data mining process, data mining standards and output protocols, and common techniques used in mining healthcare data. You will learn textual analysis and sentiment analysis of post-EHR era data. Stemming from systems biology, systems medicine incorporates diverse experimental data with interactions between all components of health and disease, including gene and gene product expression and behavioral and environmental factors. You will learn about integrating genotypic and phenotypic data into predictive models using classification and clustering techniques.

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

- Describe the changing context of healthcare services including the trend value-based healthcare systems and the role of data in promoting improved outcomes.
- Import data from electronic health record (EHR) systems into data warehousing system and use analytical tools.
- Design data models that integrate patient data from multiple sources to create comprehensive patient-centered views of data.
- Design an analytic strategy to frame a potential issue and solution relevant to the health improvement of patient populations.

Recommended Books: Latest Edition of the Following Books.

- Dinov, I.D. (2018). Data Science and Predictive Analytics: Biomedical and Health Applications using R. Springer (ISBN 978-3-319-72346-4).
- Strickland, J. (2014). Predictive modeling and analytics. Lulu. com.
- Madsen, L. (2012). Healthcare business intelligence: a guide to empowering successful data reporting and analytics. John Wiley & Sons.
- Ng, S. K., Xiang, L., & Yau, K. K. W. (2019). Mixture modelling for medical and health sciences. Chapman and Hall/CRC.
- Polgar, S., & Thomas, S. A. (2011). Introduction to Research in the Health Sciences E-Book. Elsevier Health Sciences.
- Schreier, G., Ammenwerth, E., & Hörbst, A. (2016). Health Informatics Meets EHealth: Predictive Modeling in Healthcare–From Prediction to Prevention. Proceedings of the 10th EHealth2016 Conference (Vol. 223). IOS Press.
- Siegel, E. (2013). Predictive analytics: The power to predict who will click, buy, lie, or die (Vol. 10). Hoboken: Wiley.
- Van Belle, G., & Kerr, K. F. (2012). Design and Analysis of Experiments in the Health Sciences. Wiley.

Course Title: Bio-Informatics	**Course Code: STAT-675**

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

Prerequisites: Nil

Course Objective:

- Students will be able to identify situations when it is best to utilize logistic regression and survival analysis
- Students will be able to perform logistic regression analysis and interpret the results.
- Students will be able to perform survival analysis and interpret the results.
- Students will learn how to run these types of analysis by using Stata and R software

Course Contents

Cell, Molecule, Gene, Chromosom, DNA, RNA, Protein, Connection DNA-RNA-Protein, Protein structures, Protein functions. Bio-chemical properties of Amino Acids, Motif, Domain, Protein Families, Evolution, Similarity, Homology. Means-Ends Analysis, Problem Reduction, Goal Tree, DepthFSearch, BreadthFSearch, BestFSearch, Optimal Search, Branch and Bound, Dynamic Programming Principle, (Minimax procedure, Alpha-Beta pruning). PAM-Matrices (Dayhoff), BLOSUM (Henikoff and Henikoff), Scoring Systems based on Amino Acid Classifications. Cost (measure) of Multiple Alignment, Dynamic Programming, Progressive Alignment (CLUSTAL), Use of Local Multiple Alignment. Methods for finding Relative Positions of DNA Sequences on a Chromosome. (Small and Large scale). Construction using Character States, Construction using Distance Matrices. Statistical significance, Dot matrix methods, Dynamic programming (MPSearch), FASTA, BLAST, Search with profiles. The PROSITE-database, Sequence Driven Methods, Pattern Driven Methods. Introduction to the RNA Secondary Structure Prediction and Protein Folding problems.

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

- Understand the basic principles and concepts in exploring sequence storage, retrieval and analysis.
- Develop understanding of gene and protein at structural level using computational tools.
- Demonstrate the ability to apply skills in a professional environment via an industrial or academic internship.

Recommended Books: Latest Edition of the Following Books.

- Lesk, A. (2019). Introduction to bioinformatics. Oxford university press.
- Bult, C. J. (1998). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Science, 282(5389), 635-636.
- Gibas, C., Jambeck, P., & Fenton, J. (2001). Developing bioinformatics computer skills. " O'Reilly Media, Inc.".
- Gu, J., & Bourne, P. E. (Eds.). (2009). Structural bioinformatics (Vol. 44). John Wiley & 117 Sons.
- Krane, D. E. (2002). Fundamental concepts of bioinformatics. Pearson Education India.
  Su, C. (2006). Bioinformatics: A Practical Guide to the Analysis of Genes & Proteins, (third editon). Edited by Andreas D. Baxevanis and BF Francis Ouellette New York: John Wiley & Sons.

Course Title: Statistical Genetics	**Course Code: STAT-676**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:

- Students will be able to identify situations when it is best to utilize logistic regression and survival analysis
- Students will be able to perform logistic regression analysis and interpret the results.
- Students will be able to perform survival analysis and interpret the results.
  Students will learn how to run these types of analysis by using Stata and R software

Course Contents

Mendelian genetic traits. Population genetics; Hardy-Weinberg, allelic variation, subdivision. Likelihood inference, information, and power; latent variables and EM algorithm. Pedigree relationships and gene identity. Meiosis and recombination. Linkage detection. Multipoint linkage analysis. Statistical basis for describing variation in quantitative traits. Decomposition of trait variation into components representing genes, environment, and gene-environment interaction. Methods of mapping and characterizing quantitative trait loci.

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

- Introduce statistical methods for genetic studies.
- Understand basic principles of inheritance and students will gain experience in variety of molecular techniques used in gene analysis.
- Learn basic quantitative genetics concepts and basic and advanced statistical methods for genetic data analysis.
  Understand the fundamentals of mice genetics, and other special topics.

Recommended Books: Latest Edition of the Following Books.

- Lange, K. (2003). Mathematical and statistical methods for genetic analysis. Springer Science & Business Media.
- Durrett, R. (2008). Probability models for DNA sequence evolution. Springer Science & Business Media.
- Laird, N. M., & Lange, C. (2010). The fundamentals of modern statistical genetics. Springer Science & Business Media.
- Neale, B., Ferreira, M., Medland, S., & Posthuma, D. (Eds.). (2007). Statistical genetics: gene mapping through linkage and association. Garland Science.
- Neale, B., Ferreira, M., Medland, S., & Posthuma, D. (Eds.). (2007). Statistical genetics: gene mapping through linkage and association. Garland Science.
  Stein, C. M., Morris, N. J., & Nock, N. L. (2012). Statistical Human Genetics: Methods and Protocols. Methods in Molecular Biology, 850.

Course Title: Generalized Linear Models	**Course Code: STAT-677**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Nil

Course Objective:

- Students will be able to identify situations when it is best to utilize logistic regression and survival analysis
- Students will be able to perform logistic regression analysis and interpret the results.
- Students will be able to perform survival analysis and interpret the results.
- Students will learn how to run these types of analysis by using Stata and R software

Course Contents

Definition of a model, MLE, Parameter estimation, Likelihood ratio test, Model simplification and criticism, Modeling binary response data, ML for Bernoulli and Binomial distribution. Normal distribution and Box-Cox transformation family, Factorial design, Cross-classifications, Missing data. Contingency table, Profile and conditional likelihood in 2 x 2 tables, Multidimensional contingency tables with binary response. Poisson distribution, Multicategory responses, Multinomial logit model, Ordered response categories. Survival data, Exponential distribution, Censoring, Kaplan-Meier estimator, Gamma distribution, Weibull, distribution, Extreme value distributions, Cox proportional hazard model, Logistic and log-logistic distribution

Mendelian genetic traits. Population genetics; Hardy-Weinberg, allelic variation, subdivision. Likelihood inference, information, and power; latent variables and EM algorithm. Pedigree relationships and gene identity. Meiosis and recombination. Linkage detection. Multipoint linkage analysis. Statistical basis for describing variation in quantitative traits. Decomposition of trait variation into components representing genes, environment, and gene-environment interaction. Methods of mapping and characterizing quantitative trait loci.

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

- Learn different types of generalized linear models and their applications in biostatistics.
- Understand the various types of techniques to analyze binary and multicategory responses.
- Have sound knowledge of survival data and its related distributions

Recommended Books: Latest Edition of the Following Books.

- Agresti, A. (2012). Categorical Data Analysis (3rd ed). John Wiley and Sons.
  Suggested Readings:
- Aitkin, M., Francis, B., & Hinde, J. (2005). Statistical Modeling in GLIM 4 (2nd ed.). Oxford: Oxford Science Publications.
- Lloyd, C. J. (2016). Statistical Analysis of Categorical Data. John Wiley and Sons.
  McCullagh, P., & Nelder, J. A. (1989). Generalized linear models (2nd ed.). London: Chapman and Hall.

COURSE CONTENTS OF MAJOR ELECTIVES

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.
1. 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.
13. Poston, Jr., D. L., Bouvier, L. F. (2010). Population and Society: An Introduction to Demography. United States: Cambridge University Press.

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: 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-617**
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: 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: 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.

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.

ITEM No. II: Approval of Two General Courses (Social Science Category) to be offered for other Departments (2025 & Onwards)

Decision: The above agenda item is approved by the members of the board of Faculty.
it is now presented to Academic Council for their kind consideration and approval.

The following new courses enlisted will be offered as General Courses under Social Science Category for other departments.

1. Basics of Ecological Statistics
2. Applications of Basic Statistics in Environment

S.No	Course Code	Course Title	Credit Hours
1	STAT-312	Basics of Ecological Statistics	2
2	STAT-313	Applications of Basic Statistics in Environment	2

Details of the Courses

Course Title: Basics of Ecological Statistics	**Course Code: STAT-312**
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: NIL	
Course Objective: • To equip students with a fundamental understanding of statistical methods and their application in ecological research.	
Course Outline: Definition and importance of Ecological statistics; Types of ecological data (e.g., presence/absence, abundance, environmental variables); Random, stratified, systematic sampling; sample size determination; Sampling of Ecological attributes; Principles of experimental design (replication, randomization, controls); Types of ecological experiments (field vs. lab experiments); One-way ANOVA, Regression and Correlation; Temporal patterns in ecological data; Analyzing long-term ecological data.	
Course Outcomes: After completing the course students will be able	

- To articulate the role of statistics in ecological studies.
- To gain skills in calculating sample sizes for various study designs, designing and conducting field and lab experiments, and performing and interpreting ANOVA and regression analyses.
- To apply autoregressive models to ecological time series data and handle and analyze long-term datasets.

Recommended Books: Latest Edition of the Following Books.

1. DelSole, T., Tippett, M. (2022). Statistical Methods for Climate Scientists. India: Cambridge University Press
2. Burnette, G. A. (2022). Managing Environmental Data: Principles, Techniques, and Best Practices. United Kingdom: CRC Press.
3. Gordon A. Fox, Simoneta Negrete-Yankelevich, Vinicio J. Sosa (2015). Ecological Statistics: Contemporary Theory and Application. United Kingdom: Oxford University Press.
4. Gotelli, N. J., Ellison, A. M. (2013). A Primer of Ecological Statistics. United States: Oxford University Press, Incorporated.
5. Gurevitch, J., Scheiner, S. M., Fox, G. A. (2006). The ecology of plants. United Kingdom: Oxford University Press, Incorporated
6. Krebs, C. J. (1999). Ecological Methodology. Netherlands: Benjamin/Cummings.
7. Schneider, D. C. (2009). Quantitative Ecology: Measurement, Models and Scaling. Netherlands: Elsevier Science.
8. Shumway, R. H., Stoffer, D. S. (2017). Time Series Analysis and Its Applications: With R Examples. Germany: Springer International Publishing.
9. Whitlock, M., Schluter, D. (2020). The Analysis of Biological Data. United States: Macmillan Learning.
10. Zar, J. H. (2010). Biostatistical Analysis. United Kingdom: Prentice Hall.

Course Title: Applications of Basic Statistics in Environment	**Course Code: STAT-313**
Course Structure: Lectures: 2, Labs: 0	**Credit Hours: 2**
Prerequisites: NIL	

Course Objective:

- To learn about principle of statistics and the application for further research in environmental studies.

Course Outline: Overview of Environmental Statistics; Importance and Applications in Environmental Science; Types of Data: Qualitative and Quantitative; Levels of Measurement: Nominal, Ordinal, Interval, and Ratio; Descriptive Statistics: Mean, Median, Variance, Standard

Deviation; Data Collection and Sampling Techniques; Designing Environmental Surveys; Hypothesis testing; Chi-Square Tests; Mann-Whitney U Test; Basics of Time Series data.
Course Outcomes: After completing the course, the students will be able to • Have a solid foundation in environmental statistics, enabling them to pursue more advanced studies • Apply their knowledge in practical environmental science contexts.
Recommended Books: Latest Edition of the Following Books. 1. DelSole, T., Tippett, M. (2022). Statistical Methods for Climate Scientists. India: Cambridge University Press. 2. Burnette, G. A. (2022). Managing Environmental Data: Principles, Techniques, and Best Practices. United Kingdom: CRC Press. 3. Cochran, W. G. (1977). Sampling Techniques. Wiley. 4. Conover, W. J. (1998). Practical Nonparametric Statistics. Wiley. 5. Fortin, M.-J., & Dale, M. R. T. (2005). Spatial Analysis: A Guide for Ecologists. Cambridge University Press. 6. Manly, B. F. J. (2008). *Statistics for Environmental Science and Management*. CRC Press. 7. Moore, D. S., McCabe, G. P., & Craig, B. A. (2016). Introduction to the Practice of Statistics. W.H. Freeman. 8. Newman, M. C. (2018). Fundamentals of Ecotoxicology: The Science of Pollution. CRC Press. 9. Shumway, R. H., & Stoffer, D. S. (2017). Time Series Analysis and Its Applications: With R Examples. Springer. 10. Zar, J. H. (2010). *Biostatistical Analysis*. Pearson.

AGENDA ITEM No. III: Approval of a Short Course

Decision: The above agenda item is approved by the members of the board of Faculty with the following recommendation

1. The short course is a non-credit offering, so credit hours shouldn't be applicable.

After incorporating the changes suggested it is now presented to Academic Council for their kind consideration and approval.

The following new course enlisted will be offered as General Courses for all the departments in SBBWU and General Public.

S.No	Course Title

1	Practical Statistics for Researchers: A Computer-Based Approach

Course duration: 02 months

Course Overview

This course is designed to introduce fundamental statistical concepts and techniques with a strong emphasis on practical, computer-based application using statistical software (SPSS primarily, with mentions of R/Python where appropriate). It is ideal for students, researchers, and professionals engaged in quantitative research.

Module 1: Introduction to Quantitative Research

- Difference between qualitative and quantitative research
- Role of statistics in research
- Examples of quantitative research in various fields
- Overview of the statistical analysis process

Module 2: Research Question Development

- Identifying research problems
- Converting research objectives into statistical questions
- Formulating hypotheses (null and alternative)
- Variables: independent, dependent

Module 3: Study Design and Sampling

- Types of study design: experimental vs observational
- Cross-sectional, longitudinal, and case-control studies
- Sampling methods: random, stratified, cluster, convenience
- Sample size and power calculation basics

Module 4: Types of Data

- Data levels: nominal, ordinal, interval, ratio
- Numerical and categorical variables
- Impact of Scales of measurement on analysis

Module 5: Graphical Display of Data and Results

- Bar charts, histograms, pie charts, boxplots, scatterplots
- Choosing the right graph for the data

- Graph customization and interpretation in SPSS

Module 6: Summarizing Numeric and Categorical Data

- Frequency tables and cross-tabulations
- Descriptive statistics: mean, median, mode, range, standard deviation
- Using SPSS to summarize and describe data

Module 7: Hypothesis Testing

- Concepts of null and alternative hypotheses
- Type I and Type II errors
- Significance level (alpha) and power

Module 8: Confidence Intervals and p-values

- Understanding and interpreting confidence intervals
- p-values: meaning and uses
- Reporting significance in research

Module 9: Parametric Statistical Tests

- Assumptions of parametric tests
- Independent and paired t-tests
- One-way and two-way ANOVA
- Post-hoc tests and interpretation

Module 10: Non-Parametric Tests

- When to use non-parametric tests
- Mann-Whitney U, Wilcoxon signed-rank, Kruskal-Wallis tests
- Chi-square test
- Rank-based tests in SPSS

Module 11: Correlation and Regression Analysis

- Pearson and Spearman correlation
- Simple linear regression: interpretation and assumptions
- Multiple regression models

Module 12: Practical Statistical Analysis Using SPSS

- Understanding the interface of SPSS, Data entry, and coding

- Running and interpreting SPSS output
- Exporting results and creating reports
- Mini-project using real data

Module 13: Introduction to Other Statistical Tools

- Overview of R and Python for statistics
- Differences and similarities with SPSS
- When to choose SPSS vs R vs Python

Module 14: Interpreting and Reporting Statistical Results

- How to write up statistical findings in research papers
- Referencing style

Recommended Books:

1. Hilton, T. P., Fawson, P. R., Sullivan, T. J., DeJong, C. R. (2024). Applied Social Research: A Tool for Social Work and the Human Services. United States: Springer Publishing Company.
2. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Wilcox, R. R. (2009). Basic statistics: understanding conventional methods and modern insights. Oxford University Press.
4. Mendenhall, W.,Beaver,R. J.,& Beaver, B. M. (2012) Introduction to probability and Statistics. Cengage Learning.
5. Heumann, C., & Shalabh, M. S. (2016). Introduction to statistics and data analysis. Springer International Publishing Switzerland.
6. Manoukian, E. B. (2022). Mathematical nonparametric statistics. Taylor & Francis.
7. Zumel, N., & Mount, J. (2014). Practical data science with R. Manning Publications Co.
8. Norusis. Marija (2006) SPSS 14.0 Guide to Data Analysis, Prentice Hall, New Jersey.
9. Eric Matthes (1972) Python Crash Course