MNS UNIVERSITY OF AGRICULTURE MULTAN

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APPROVED SCHEME OF STUDIES

BS Data Science

DEPARTMENT OF COMPUTER SCIENCE

Approved vide	Meeting	Date
Academic Council	7th	09.08.2021
Syndicate	31st	10.10.2021

Curriculum of Bachelor of Data Science - BS (DS)

Program's Aims & Objectives:

The aim of BS (Data Science) is to integrate scientific methods from statistics, computer science and data-based business management to extract knowledge from data and drive decision making. Graduates are prepared to meet the challenges at the intersection between big data, business analytics, and other emerging fields. Department of Computer Science at MNS University of Agriculture felt the need to impart knowledge in this innovative area of study. A BS Program is being proposed in this area which will impart the skills of large data handling and analysis to the students. By the time of graduation, the students develop an ability to:

1. Knowledge of how to apply analytic techniques and algorithms (including statistical and data mining approaches) to large data sets to extract meaningful insights.
2. Acquisition of hands-on experience with relevant software tools, languages, data models, and environments for data processing and visualization.
3. Ability to communicate results of analysis effectively (visually and verbally) to a broad audience.
4. Ability to extract useful knowledge from data in various forms that help drive evidence-based decisions.
5. To prepare students to stand out in one of the world's fastest growing careers

Structure of BS Data Science:

The structure of BS (Data Science) program is dynamic and provides basis for various options including Breadth-Based and Integrated Breadth & Depth-Based specializations. Students may choose a particular option, which is the most appropriate to their planned future career. Followings are the distribution of total credit hours:

Sr.#	Category	Credit Hours
1	**Computing Courses**	
	Core	39
2	**Data Science Courses**	
	Core	18
	Elective	12

3	**Computer Science Core**	18
	University Elective Courses	12
	Mathematics and Science Foundation	12
	General Education Courses	19
	Total Credit Hours:	**130**

Course Category	**Credit Hrs**
Comp. Core	39
General Education	19
Data Science Core	18
CS Core	18
Data Science Elective	12
University Elective	12
Mathematics and Science Foundation	12

BS (Data Science)

Program Structure:

BS (Data Science) has a dual emphasis on basic principles of statistics and computer science, with foundational training in statistical and mathematical aspects of data analysis. This program develops foundation on broad computer science principles, including algorithms, data structures, data management and machine learning. This program will prepare graduates for a career in data analysis, combining foundational statistical concepts with computational principles from computer science.

PROPOSED CURRICULUM FOR BS (DATA SCIENCE)

Following are the proposed areas which are required to cover to complete the degree. Covered

areas consist of core courses (compulsory), foundation courses, general courses and electives.

Areas Covered in BS (DS)

Course Group	Credit Hour	Min No of Courses
General Education	19	7
University Electives	12	4
Mathematics & Science Foundation	12	4
Computing Core	39	10
Computer Science Core	18	5
DS Core (Domain Core)	18	6
DS Electives (Domain Electives)	12	4
TOTAL	**130**	**40**

General Education Courses 19 Credit Hours

Course Title	Credit Hour
Introduction to Information & Communication Technology (ICT)	3 (2-1)
English Composition & Comprehension	3 (3-0)
Communication & Presentation Skills	3 (3-0)
Islamic Studies	2 (2-0)
Technical & Business English Writing	3 (3-0)
Pakistan Studies	2 (2-0)
Professional Practices	3 (3-0)
Total Credits:	**19 (18-1)**

University Elective Courses 12 Credit Hours (Select any 4 courses)

Course Title	Credit Hour
Principles of Accounting	3 (3-0)
Principles of Economics	3 (3-0)
Principles of Psychology	3 (3-0)
Organizational Behaviour	3 (3-0)

Remote Sensing and GIS Applications in Animal Sciences	3 (2-1)
Entrepreneurship	3 (3-0)
IoT in Digital Agriculture	3 (3-0)
Introduction and Role of ICT in Agriculture	3 (2-1)
Total Credits:	**24 (24-0)**

Math and Science Foundation courses 12 Credit Hours

Course Title	**Credit Hour**
Calculus & Analytical Geometry	3 (3-0)
Linear Algebra	3 (3-0)
Probability & Statistics	3 (3-0)
Differential Equations	3 (3-0)
Total Credits:	**12 (12-0)**

Computing Core Courses (Compulsory) Courses

Course Title	**Credit Hour**
Programming Fundamentals	4 (3-1)
Object Oriented Programming	4 (3-1)
Discrete Structures	3 (3-0)
Data Structures & Algorithms	4 (3-1)
Software Engineering	3 (3-0)
Operating System	4 (3-1)
Computer Networks	4 (3-1)
Database Systems	4 (3-1)
Information Security	3 (3-0)
Final Year Project	6 (0-6)
Total	**39 (27-12)**

Computer Science Core Courses 18 Credit Hours

Course Title	Credit Hour
Artificial Intelligence	4 (3-1)
Digital Logic Design	4 (3-1)
Design & Analysis of Algorithms	3 (3-0)
Computer Organization & Assembly Language	4 (3-1)
Parallel & Distributed Computing	3 (2-1)
Total Credits:	**18 (14-4)**

DS Core Courses 18 Credit Hours

Course Title	Credit Hours
Advance Statistics	3 (3-0)
Introduction to Data Science	3 (2-1)
Data Mining	3 (2-1)
Data Visualization	3 (2-1)
Data Warehousing & Business Intelligence	3 (2-1)
Big Data Analytics	3 (2-1)
TOTAL	**18 (13-5)**

DS Electives 12 Credit Hours

Course Title	Credit Hours
Machine Learning	3 (2-1)
Deep Learning	3 (3-0)
Theory of Automata & Formal Languages	3 (3-0)
Cloud Computing	3 (3-0)
TOTAL	**12 (11-1)**

Scheme of Study Bachelor of Science in Data Science BS (DS)
4 years Degree Program (Bachelor of Sciences in Data Science)
40 courses covering 130 credit hours spread over 8 semesters
Eligibility Criteria: The minimum requirements for admission in BSDS are: 1. F.Sc. (Pre-Engineering/Pre-Medical)/ ICS/ A-level students (with Mathematics/Biology). 2. Minimum 50% marks in intermediate. 3. DAE (specialized in electrical, mechanical, electronics and Telecommunication) (two (02) reserved seats only). **Note:** Students of F.Sc. (Pre -Medical)/ A-level students (with Biology) must have to take deficiency courses of Mathematics of 6 credit hours within one year of their regular studies.

Semester – I

Sr. #	Course Code	Course Title	Pre-Requisite	Cr. Division	Category	Credit Hours
1.	CS-301	Introduction to Information & Communication Technologies (ICT)		3 (2-1)	Gen Edu	3
2.	CS-303	Programming Fundamentals		4 (3-1)	Comp. Core	4
3.	*305	Uni. Elective-I		3(3-0)	Uni. Elective	3
4	SSH-307	Pakistan Studies		2(2-0)	Gen Edu	2
5.	ENG-309	English Composition & Comprehension		3(3-0)	Gen Edu	3
					Total Credit Hours:	**15**
	UAM-301	Social & Religious Tolerance		2(2-0)		2

Semester – II						
Sr. #	**Course Code**	**Course Title**	**Pre-Requisite**	**Cr. Division**	**Category**	**Credit Hours**
6.	CS-302	Discrete Structures		3(3-0)	Comp. Core	3
7.	CS-304	Object Oriented Programming	CS-303	4(3-1)	Comp. Core	4
8.	MATH - 306	Calculus & Analytical Geometry		3(3-0)	Math & Sci. Foundation	3
9.	ENG-308	Communication & Presentation Skills		3(3-0)	Gen Edu	3
10.	IS 310 / SSH-310	Islamic Studies / Ethics (For foreigner / Non-Muslims)		2(2-0)	Gen Edu	2
11.	CS-312	Digital Logic Design		4(3-1)	CS Core	4
					Total Credit Hours:	**19**
	UAM-301	Citizenship Education & Community Engagement		3(2-1)		3
	QS-302	Quranic Studies		1(1-0)		1
Semester – III						
Sr. #	**Course Code**	**Course Title**	**Pre-Requisite**	**Cr. Division**	**Category**	**Credit Hours**
12.	CS-401	Data Structures & Algorithms		4(3-1)	Comp. Core	4
13.	CS- 403	Computer Organization & Assembly Language		4(3-1)	CS Core	4
14.	MATH-405	Linear Algebra		3(3-0)	Math & Sci. Foundation	3
15.	ENG-407	Technical & Business English Writing		3(3-0)	Gen Edu	3

16.	*409	Uni. Elective-II		3(3-0)	Uni. Elective	3
					Total Credit Hours:	**17**
Semester – IV						
Sr. #	**Course Code**	**Course Title**	**Pre-Requisite**	**Cr. Division**	**Category**	**Credit Hours**
17.	CS-402	Software Engineering		3(3-0)	Comp. Core	3
18.	CS-404	Operating Systems		4(3-1)	Comp. Core	4
19.	CS-406	Database Systems		4(3-1)	Comp. Core	4
20.	CS-408	Design & Analysis of Algorithms	CS-401	3(3-0)	CS Core	3
21.	DS-410	Introduction to Data Science		3(2-1)	DS Core	3
22.	STAT-412	Probability & Statistics		3(3-0)	Math & Sci. Foundation	3
					Total Credit Hours:	**20**
	QS-302	Quranic Studies		1(1-0)		1
Semester – V						
Sr. #	**Course Code**	**Course Title**	**Pre-Requisite**	**Cr. Division**	**Category**	**Credit Hours**
23.	CS-501	Computer Networks		4(3-1)	Comp. Core	4
24.	DS-503	Theory of Automata & Formal Languages		3(3-0)	DS Elective	3
25.	*505	Uni. Elective-III		3(3-0)	Uni. Elective	3
26.	CS-507	Information Security		3(3-0)	Comp. Core	3
27.	DS-509	Advance Statistics	STAT-412	3(3-0)	DS Core	3
28.	MATH-511	Differential Equations		3(3-0)	Math & Sci. Foundation	3
					Total Credit Hours:	**19**
Semester – VI						
Sr.	**Course**	**Course Title**	**Pre-**	**Cr.**	**Category**	**Credit**

#	Code		Requisite	Division		Hours
28.	CS-502	Artificial Intelligence		4(3-1)	CS Core	4
29.	DS-504	Big Data Analytics		3(2-1)	DS Core	3
30.	DS-506	Data Warehousing & Business Intelligence		3(2-1)	DS Core	3
31.	*508	Uni. Elective-IV		3(3-0)	Uni. Elective	3
32.	CS-510	Parallel & Distributed Computing	CS-404	3(2-1)	CS Core	3
					Total Credit Hours:	**16**
	QS-302	Quranic Studies		1(1-0)		1
Semester – VII						
33.	DS-601	Machine Learning		3(2-1)	DS Elective	3
34.	DS-603	Cloud Computing		3(3-0)	DS Elective	3
35.	DS-605	Data Visualization		3(2-1)	DS Core	3
36.	SSH-607	Professional Practices		3(3-0)	Gen Edu	3
37.	DS-609	Data Mining		3(2-1)	DS Core	3
					Total Credit Hours:	**15**
Semester – VIII						
39.	DS-602	Deep Learning		3(3-0)	DS Elective	3
40.	CS-604	Final Year Project		6(0-6)	Comp. Core	6
					Total Credit Hours:	**9**
	QS-302	Quranic Studies		1(1-0)		1
					Total Credit Hours of the Program	**130**

BS (Data Science)

Program Learning Outcomes (PLOs)

Computing programs prepare students to attain educational objectives by ensuring that students demonstrate achievement of the following outcomes (derived from Graduate Attributes define by Seoul Accord www.seoulaccord.org).

No.	Program Learning Outcomes (PLOs)	Computing Professional Graduate
1.	Academic Education	To prepare graduates as computing professionals.
2.	Knowledge for Solving Computing Problems	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements.
3.	Problem Analysis	Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.
4.	Design/Development of Solutions	Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
5.	Modern Tool Usage	Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.
6.	Individual and Team Work	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.
7.	Communication	Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write

		effective reports, design documentation, make effective presentations, and give and understand clear instructions.
8.	Computing Professionalism and Society	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.
9.	Ethics	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.
10.	Life-long Learning	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional

Computing Core Courses

CS-303	**PROGRAMMING FUNDAMENTALS**		**4(3-1)**
Learning Objectives			
• To familiarize students with the basic structured programming skills • To emphasizes upon problem analysis, algorithm designing, and program development and testing			
Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** basic problem-solving steps and logic constructs	C	2	2
• **Apply** basic programing concepts	C	3	2
• Design and implement algorithms to **solve** real world problems.	C	3	4
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain			
SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)		

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system
Course Contents
Theory
Overview of computer programming; Principles of structured and modular programming; Overview of structured programming languages; Algorithms and problem solving; Program development, analyzing problem, designing algorithm/solution; Testing designed solution; Translating algorithms into programs; Fundamental programming constructs; Data types; Basics of input and output; Selection and decision (If, If-Else, Nested If-Else, switch statement and condition operator); Repetition (while and for loop, Do-While Loops); Break statement, continue statement; Control structures; Functions; Arrays; Pointers; Records; Files (Input-Output); Testing & debugging.
Practical
Practical exercises of building algorithms in different writing forms and converting them to programs in C language.
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book:
1. Deitel, P. and H. Deitel. 2013. C++ How to Program. 9th Ed. Prentice Hall, Upper Saddle River, NJ, USA.
Suggested Readings:
1. Hanly and Koffman. 2009. Problem Solving and Program Design in C, 6th edition. Addison-Wesley. Boston, MA, USA. 2. Kochan, S. G. 2014, Programming in C. 4th Ed. Pearson Education, Addison-Wesley, Boston, MA, USA. 3. Mustafa T., T. Mehmood, I. Saeed and A. R. Sattar. 2008. Object Oriented Programming using C++. IT-Series publications, Faisalabad, Pakistan.

CS-304	OBJECT ORIENTED PROGRAMMING	4(3-1)

Learning Objectives

- The course aims to develop students' Object-Oriented Programming skills.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Understand** principles of object-oriented paradigm.	C	2	2
• **Identify** the objects & their relationships to build object-oriented solution	C	3	3
• **Model** a solution for a given problem using object-oriented principles	C	3	4
• **Examine** an object-oriented solution.	C	4	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

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.

Practical

Practical exercises of building algorithms in different writing forms and converting them to programs in C++ language.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Deitel, P. and H. Deitel. 2015. Java: How to Program 10th Ed. Prentice Hall, Upper Saddle River, NJ, USA.

Suggested Readings:

1. Horton, I. 2011. Beginning Java, 7th Ed. John Willey & Sons, Hoboken, NJ, USA.
2. Robert, L. and S. Simonson. 2010. Object Oriented Programming in C++. 4th Ed. McGraw-Hill Higher Education, New York, NY, USA.
3. Schildt, H. 2009. Java the Complete Reference, 7th Ed. Pearson and Education, London, UK.
4. Wu, C. T. 2010. An Introduction to Object-Oriented Programming with Java, 5th Ed. McGraw-Hill, Columbus, OH, USA.

CS-401	**DATA STRUCTURES & ALGORITHMS**	**4(3-1)**

Learning Objectives

- This course provides an introduction to the theory, practice and methods of data structures and algorithm design.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Implement various data structures and their algorithms and **apply** them in implementing simple applications.	C	2, 3	2
• **Analyze** simple algorithms and determine their complexities.	C	4, 5	3

• **Apply** the knowledge of data structures to other application domains.	C	3	2
• **Design** new data structures and algorithms to solve problems.	C	6	4, 5

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

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 tree traversals; 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.

Practical

Practical exercises of searching, sorting and merging algorithms. Develop understanding of link lists, queues and stacks. Students implement projects requiring the implementation of the above data structures.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Mark, A. W. 2014. **Data Structures and Algorithm Analysis in C++**. 3rd Ed. Pearson, Harlow, UK.

Suggested Readings:
1. Adam, D. 2012. Data Structures and Algorithms in C++. 3rd Ed. Sydney, Australia. 2. Brijendra, K. J. 2010. Data structures and algorithms in C. Tata McGraw Hill Education, New Dehli, India. 3. Elliot, B. K. and A. T. Paul. 2016. Data Structures: Abstraction and Design using Java. 3rd Ed. John Wiley Sons, New York, NY, USA.

CS-302	**DISCRETE STRUCTURES**	**3(3-0)**
Learning Objectives		
• This course provides an introduction to the theory, practice and methods of data structures and algorithm design.		
Learning Outcomes		

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs, and Trees etc.	C	2	2
• **Apply** formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	C	3	2
• **Apply** discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C	3	2
• **Differentiate** various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular.	C	4	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Mathematical reasoning; propositional and predicate logic; rules of inference; proof by induction; proof by contraposition; proof by contradiction; proof by implication; set theory; relations; equivalence relations and partitions; partial orderings; recurrence relations; functions; mappings; function composition; inverse functions; recursive functions; Number Theory; sequences; series; counting; inclusion and exclusion principle; pigeonhole principle; permutations and combinations; elements of graph theory; planar graphs; graph coloring; Euler graph; Hamiltonian path; rooted trees; traversals.

Teaching Methodology:

Lectures, Written Assignments, Report Writing

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Final Exam

Text Book:

1. Richard, J. B. 2018. Discrete Mathematics. 7th Ed. Prentice Hall, New York, NY, USA.

Suggested Readings:

1. Kenneth H. R. and K. Krithivasan. 2013. Discrete Mathematics and its Applications. 7th Ed. McGraw-Hill, Singapore.
2. Ralph P. G. 1994. Discrete and Combinatorial Mathematics: An Applied Introduction. 5th Ed. Addison-Wesley, Boston, MA, USA.
3. Winifred. and J. P. Remblay. 1998 Logic and Discrete Mathematics: A Computer Science Perspective. Prentice Hall, Upper saddle River, NJ, USA.

CS-404	**OPEARTING SYSTEMS**	**4(3-1)**

Learning Objectives

- To help students gain a general understanding of the principles and concepts governing the functions of operating systems.

- To extend students understating of layered approach that makes design, implementation and operation of the complex OS possible.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems.	C	2	2
• **Analyze** and **evaluate** the algorithms of the core functions of the Operating Systems and explain the major performance issues with regard to the core functions.	C	4, 5	3
• **Demonstrate** the knowledge in applying system software and tools available in modern operating systems.	C	3	5, 7

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Operating systems basics; system calls; process concept and scheduling; inter-process communication; multithreaded programming; multithreading models; threading issues; process scheduling algorithms; thread scheduling; multiple-processor scheduling; synchronization; critical section; synchronization hardware; synchronization problems; deadlocks; detecting and recovering from deadlocks; memory management; swapping; contiguous memory allocation; segmentation & paging; virtual memory management; demand paging; thrashing; memory-mapped files; file systems; file concept; directory and disk structure; directory implementation; free space management; disk structure and scheduling; swap space management; system protection; virtual machines; operating system security .

Practical:

Process control system calls: The demonstration of fork, exec and wait system calls along with zombie and orphan states. Thread management using POSIX thread (pthread) library. Inter process communication in Linux. Implementing a CPU scheduling policy.

Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book:
1. Abraham, S. and G. Gagne. 2018. Operating System Concepts. 9th Ed. John Wiley & Sons. Hoboken, NJ, USA.
Suggested Readings:
1. Mehmood, T. and I. Saeed. 2005. A Comprehensive study of Operating systems & Networks, IT Series, Publication, Pakistan. 2. Raggo, M. T. and C. Hosmer. 2013. Data Hiding Exposing Concealed Data in Multimedia, Operating Systems, Mobile Devices and Network Protocols. Syngress, Waltham, MA, USA. 3. Ulrich, W. 2012. Quantum Dissipative Systems. 4th Ed. World Scientific Publisher, Singapore. 4. Wang, K. C. 2017. Embedded and Real-Time Operating Systems. Springer, Olympia, WA, USA.

CS-406	**DATABASE SYSTEMS**	**4(3-1)**
Learning Objectives		
• The held students learn the salient features of various types of databases, transaction management, data warehousing and data mining		
Learning Outcomes		

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Explain** fundamental database concepts.	C	2	2
• **Design** conceptual, logical and physical database schemas using different data models.	C	5	4
• **Identify** functional dependencies and resolve database anomalies by normalizing database tables.	C	2	3

• **Use** Structured Query Language (SQL) for database definition and manipulation in any DBMS	C	4	5

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Basic database concepts; Database approach vs file based system; database architecture; three level schema architecture; data independence; relational data model; attributes; schemas; tuples; domains; relation instances; keys of relations; integrity constraints; relational algebra; selection; projection; Cartesian product; types of joins; normalization; functional dependencies; normal forms; entity relationship model; entity sets; attributes; relationship; entity-relationship diagrams; Structured Query Language (SQL); Joins and sub-queries in SQL; Grouping and aggregation in SQL; concurrency control; database backup and recovery; indexes, NoSQL systems.

Practical

Practical work on SQL server and Oracle server with practice of all major SQL statements.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Elmasri, R. and S. Navathe. 2017. Fundamentals of Database Systems, 7th Ed. Addison-Wesley, Boston, MA, USA.

Suggested Readings:

1. Connolly, R. and P. Begg. 2015. Database Systems: A Practical Approach to Design, Implementation and Management. 6th Ed. Addison-Wesley, Boston, MA, USA.
2. Mustafa, T. and A. R. Sattar. 2010. Database Management System, IT Series Publications, Pakistan.

3. Ramakrishnan, R. and J. Gehrke. 2003. Database Management Systems, 3rd Ed. Pearson Education, Boston, MA, USA.
4. Silberschatz, A., H. F. Korth and S. Sudarshan. 2010. Database System Concepts. 6th Ed. McGraw Hill, New York, NY, USA.

CS-402	SOFTWARE ENGINEERING	3(3-0)

Learning Objectives

- To familiarise students with various software development models and software development life cycles.
- To emphasize upon understanding of concepts of project management, change control, process management, software development and testing through hands-on team Projects.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Describe** various software engineering processes and activities	C	1	2
• **Apply** the system modeling techniques to model a medium size software system	C	3	2
• **Apply** software quality assurance and testing principles to medium size software system.	C	4	2
• **Discuss** key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis	C	2	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Nature of Software; Overview of Software Engineering; Professional software development; Software engineering practice; Software process structure; Software process models; Agile

software Development; Agile process models; Agile development techniques; Requirements engineering process; Functional and non-functional requirements; Context models; Interaction models; Structural models; behavioral models; model driven engineering; Architectural design; Design and implementation; UML diagrams; Design patterns; Software testing and quality assurance; Software evolution; Project management and project planning; configuration management; Software Process improvement.
Teaching Methodology:
Lectures, Written Assignments, Project, Report Writing
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book:
1. Ian, S. 2016. Software Engineering. 10th Ed. Addison Wesley, Boston, MA, USA
Suggested Readings:
1. Craig, L. 2001. Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and the Unified Process. 2nd Ed. Prentice Hall, Upper Saddle River, NJ, USA. 2. Dines, B. 2011. Software Engineering Domains Requirements, and Software Design, Springer, Berlin, Germany. 3. Gary, B. S., T. J, Cashman and H. J. Rosenblatt. 2017. Systems Analysis and Design. 9th Ed. Cengage Learning, Boston, MA, USA. 4. Roger, S.P. 2016. Software Engineering: A Practitioner's Approach. 8th Ed. McGraw-Hill. Beijing, China.

CS-501	**COMPUTER NETWORKS**	**4(3-1)**

Learning Objectives

- To familiarize students with concepts related to network layers, network models, and protocol standards.
- To emphasizes upon understanding of modern network concepts.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Describe** the key terminologies and technologies of computer networks	C	2	2
• **Explain** the services and functions provided by each layer in the Internet protocol stack.	C	2	2

• **Identify** various internetworking devices and protocols, and their functions in a network.	C	4	3
• **Analyze** working and performance of key technologies, algorithms and protocols.	C	4	3
• **Build** Computer Network on various Topologies	P	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction and protocols architecture; basic concepts of networking; network topologies; layered architecture; physical layer functionality; data link layer functionality; multiple access techniques; circuit switching and packet switching; LAN technologies; wireless networks; MAC addressing; networking devices; network layer protocols; IPv4 and IPv6; IP addressing; sub netting; CIDR; routing protocols; transport layer protocols, ports and sockets; connection establishment; flow and congestion control; application layer protocols; latest trends in computer networks.

Practical

Basics of Networking: Familiarization of Internetworking, Network Cables, Colour coding, Crimping. Internetworking Operating Systems Configurations;

IP Routing: Implementing static routing, implementing dynamic routing using RIP, implementing dynamic routing using OSPF, implementing dynamic routing using EIGRP;

Switching Services - Virtual LANS: Layer 2 Switching configuration, VLAN configuration, VTP Configuration, VTP pruning, Implement inter-VLAN routing;
Security: Access Control List, Standard Access Lists, Extended Access Lists;
Managing Internetwork: Backup and restoring IOS, Familiarization of network simulators.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Behrouz A. F. 2013, Data Communications and Networking, 5th Ed. McGraw-Hill, New York, NY, USA.

Suggested Readings:

1. James F.K. and K. W. Ross. 2017. Computer Networking a Top-Down Approach Featuring the Internet. 7th Ed. Pearson Education, Harlow, UK.
2. Stallings, W. 2004. Data and Computer Communications. 6th Ed. McGraw Hill, New York, NY, USA.
3. Terry S., B. Burton and W. Burton. 2000. Advanced IP Routing in Cisco Networks. Prentice Hall, Upper Saddle River, NJ, USA.
4. William Stallings. 2014. Data and Computer Communications. 6th Ed. Pearson Education, Harlow, UK.

CS-507	**INFORMATION SECURITY**	**3(3-0)**

Learning Objectives

- To enhance students understanding about the essentials of information security and the algorithms for implementing security

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Explain** key concepts of information security such as design principles, cryptography, risk management, and ethics.	C	2	2
• **Discuss** legal, ethical, and professional issues in information security.	A	2	2
• **Apply** various security and risk management tools for achieving information security and privacy.	C	3	2
• **Identify** appropriate techniques to tackle and solve problems in the discipline of information security.	C	4	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure) 16 (Peace, Justice and Strong Institutions)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Information security foundations; security design principles; security mechanisms; symmetric and asymmetric cryptography; encryption; hash functions; digital signatures; key management; authentication and access control; software security; vulnerabilities and protections; malware; database security; network security, firewalls; intrusion detection; security policies; policy formation and enforcement; risk assessment; cybercrime, law and ethics in information security; privacy and anonymity of data.

Teaching Methodology:

Lectures, Written Assignments, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Bishop, M. 2015. Computer Security Art and Science. Wesley Professional, Addison, London, UK.

Suggested Readings:

1. Bidgoli, H. 2006. Handbook of Information Security. John Wiley, Hoboken, NJ, USA.
2. John, D. S. 2000. Principles of Global Security. Brookings Institution Press, WA. USA.
3. Michael, E. W. and H. J. Mattord. 2014. Principles of Information Security 4th Ed. Cengage Learning, Boston, MA, USA.
4. Stalling, W. 2012. Cryptography and Network Security, 6th Ed, Pearson Education, UK.

Computer Science Core (Compulsory) Courses

CS-312	DIGITAL LOGIC DESIGN	4(3-1)

Learning Objectives

- The course introduces students with digital circuit of large complexity and how such circuits could be built in a methodological way, starting from Boolean logic and applying a set of rigorous techniques.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits.	C	1	2
• Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques.	C	1, 2	2, 4
• Apply the acquired knowledge to simulate and implement small-scale digital circuits.	P	3	5
• Understand the relationship between abstract logic characterizations and practical electrical implementations.	C	2	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Number Systems; Logic Gates; Boolean Algebra; Combination logic circuits and designs; Simplification Methods (K-Map, Quinn Mc-Cluskey method); Flip Flops and Latches; Asynchronous and Synchronous circuits; Counters; Shift Registers; Counters; Triggered devices & its types; Binary Arithmetic and Arithmetic Circuits; Memory Elements; State Machines; Introduction to HDL based Digital Design Methodology, Introduction Programmable Logic Devices (CPLD, FPGA); Lab Assignments using tools such as Verilog HDL/VHDL; MultiSim.

Practical

Hardware labs: verify the behaviour of Logic Gates using Truth Table and Familiarization with Digital Integrated Circuits, Implementation of Boolean Function using Logic Gates and Introduction to Hierarchical Design of Digital Logic Circuits, Familiarization with the Different Portions of the Datasheet for a Digital IC and Using the Datasheet to Gather Relevant Information to Utilize the IC as a Component in another Digital Logic Circuit, Implementation of 8 bit Binary Comparator using 4 bit Binary Comparators, Implementation of 4bit into 3bit Binary Multiplier using 4bit Binary Adders, Implementation of BCD Adder using 4bit Binary Adders, 4 to 7 Segment Decoder and 2Digit 7 Segment Display, Implementing a Full Adder using (a) Decoder (b) Multiplexer, Flip Flops, construct various types of counters;

Hardware description language (Verilog) labs: Introduction to Basic Syntax of Verilog and Gate level Modelling through implementation of half adder at gate level and its simulation using Xilinx ISE tools, Introduction to the concepts of Instantiation and Hierarchical Design in Verilog through the implementation of full adder using the previously designed half adder modules, Introduction to the Concept of Vectors and Introduction to Dataflow modelling through implementation of half adder and full adder at dataflow level, Consolidation of the concepts of Dataflow level modelling and Introduction to the concept of Synthesis by the CAD tool, Introduction to Behavioural modelling through implementation of half adder and full adder at behavioural level, Introduction to if else statement and case statement in Behavioural modelling through implementation of Multiplexer, Introduction to the Concepts of Sequential Circuit and a TestBench module (Stimulus Block), Behavioural Level Coding of Basic Sequential Circuits and Consolidation of the concepts of TestBench module (Stimulus Block), Introduction to Field Programmable Gate Array(FPGA) and Steps involved in its Programming.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Thomas L. F. 2015. Digital Fundamentals, 11th Ed. Pearson Education, Boston, NJ, USA.

Suggested Readings:

1. Nikrouz, F. 2015. Digital Logic Design and Computer Organization with Computer Architecture for Security**.** 1st Ed. McGraw-Hill Education, New York, NY, USA.
2. Stephen, B. and Z. Vranesic. 2014 Fundamental of Digital Logic with Verilog Design, 3rd Ed. McGraw-Hill, New York, NY, USA.

3. Vaibbhav, T. 2016. Digital Logic Design using Verilog: Coding and RTL Synthesis. 2nd Ed. Springer, New Dehli, India.

CS-403	COMPUTER ORGANIZATION & ASSEMBLY LANGUAGE	4(3-1)

Learning Objectives

- This course covers the basics of computer organization with emphasis on the lower level abstraction of a computer system including digital logic, instruction set and assembly language programming.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Acquire** the basic knowledge of computer organization, computer architecture and assembly language.	C	1	2
• **Understand** the concepts of basic computer organization, architecture, and assembly language techniques.	C	1, 2	2
• **Solve** the problems related to computer organization and assembly language.	P	3	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to computer systems: Information is bits and context; programs are translated by other programs into different forms; it pays to understand how compilation systems work; processors read and interpret instructions stored in memory; caches matter; storage devices form a hierarchy; the operating system manages the hardware; systems communicate with other systems using networks; Representing and manipulating information: information storage; integer representations; integer arithmetic; floating point; Machine-level representation of programs: a historical perspective; program encodings; data formats; accessing information; arithmetic and logical operations; control; procedures; array allocation and access; heterogeneous data structures; putting it together: understanding pointers; life in the real world: using the GDB debugger; out- of-bounds memory references and buffer overflow; x86-64: extending ia32 to 64

bits; machine-level representations of floating-point programs; Processor architecture: the Y86 instruction set architecture; logic design and the Hardware Control Language (HCL); sequential Y86 implementations; general principles of pipelining; pipelined Y86 implementations.

Practical

To learn the basics of the MIPS Assembly Language and Practice its programming.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. David, A. P. and J. L. Hennessy. 2018. Computer Organization and Design the hardware/software interface. MA Morgan Kaufman Publishers, Cambridge, MA, USA.

Suggested Readings:

1. Erl, T. 2008. Soa: principles of service design. Prentice Hall, Upper Saddle River, NJ, USA.
2. Godse, A. P. and D. A. Godse. 2013. Computer Architecture Organiztion, Technical Publication, Pune, India.
3. Hamacher, V. C., Vranesic, Z. G., Zaky, S. G., Vransic, Z., and Zakay, S. 1996. Computer organization. McGraw-Hill, New York City, NY, USA.
4. Stallings, W. 2018. Computer Organization and architecture designing for performance. Pearson Education, Hoboken, UK.

CS-502	**ARTIFICIAL INTELLIGENCE**	**4(3-1)**

Learning Objectives

- This course will introduce the basic principles in artificial intelligence.
- To cover simple representation schemes, problem solving paradigms.
- The Prolog programming language will also be introduced

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Understand different types of AI agents.	C	**2**	2
• Know how to build simple knowledge-based systems.	C	3	2

• Apply knowledge representation, reasoning, and machine learning techniques to real-world problems.	C	4	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	8 (Decent work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Artificial Intelligence: Introduction; AI paradigms and hypothesis; Intelligent agents; Difference between cybernetic Intelligence and artificial Intelligence; Objectives; Scope of weak and strong AI; Problem solving; Solving Problems by searching; Informed search and exploration; Constraint satisfaction problems; Adversarial search; Knowledge and reasoning; Logical agents, First-order logic, Inference in first-order logic; Knowledge representation; Planning and acting in the real world; Uncertain knowledge and reasoning; Uncertainty; Probabilistic reasoning; Probabilistic reasoning over time; Making simple decisions; Making complex decisions; Learning, learning from observations; Knowledge in learning; Learning methods; Reinforcement learning; Communicating; Perceiving and acting; Probabilistic language processing; Perception and robotics; LISP/PROLOG; Expert systems (ES) and applications; Artificial general Intelligence; Issues in safe AI; Introduction to cognitive and conscious systems

Practical

Differences between propositional logic: first-order logic, fuzzy logic and default logic; Focus on artificial neural network and machine learning; Study of the Turing machine and a discussion of the questionable claims.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Bratko, I. 2001. Prolog Programming for Artificial Intelligence. 4th Ed. Addison Wesley, Boston, MA, USA

Suggested Readings:

1. George, F. 2008. Structures and Strategies for Complex Problem Solving 6th Ed. Pearson Education, London, UK.
2. Margulies, P. 2004. Artificial Intelligence. Blackbirch Press, Farmington Hills, MI, USA.

3. Noah, B. and T. Gale. 2011. Artificial Intelligence. Greenhaven Press, Farmington Hills, MI, USA
4. Stuart, J., N. Peter and F. Canny. Artificial Intelligence: A Modern Approach. 3rd Ed. Prentice Hall, Upper Saddle River, NJ, USA

CS-408	**DESIGN & ANALYSIS OF ALGORITHMS**	**3(3-0)**

Learning Objectives

- The course introduces students with the basic notions of the design of algorithms and the underlying data structures. Students will learn about several measures regarding the structure, complexity, and efficiency of algorithms.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm.	C	1	1, 2
• Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.	C	2	2, 3
• Determine informally the time and space complexity of simple algorithms.	C	2	2
• List and contrast standard complexity classes	C	4	3
• Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms.	C	4	3
• Use of the strategies (brute-force, greedy, divide-and- conquer, and dynamic programming) to solve an appropriate problem.	C	3	3
• Solve problems using graph algorithms, including single- source and all-pairs shortest paths, and at least one minimum spanning tree algorithm.	C	3	3

• Trace and/or implement a string-matching algorithm.	C	3	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction: role of algorithms in computing; Analysis on nature of input and size of input Asymptotic notations; Big-O, Big Ω, Big Θ; little-o, little-ω; Sorting Algorithm analysis; loop invariants; Recursion and recurrence relations; Algorithm Design Techniques: Brute Force Approach, Divide-and-conquer approach; Merge, Quick Sort; Greedy approach; Dynamic programming; Elements of Dynamic Programming; Search trees; Heaps; Hashing; Graph algorithms; shortest paths; sparse graphs; String matching; Introduction to complexity classes.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Text Book:

1. Cormen, T.H., C. E. Leiserson, E. L. Rivest, and C. Stein. 2009. Introduction to algorithms. 3rd edition, MIT press. Cambridge, USA

Suggested Readings:

1. Alfred, V., S. Ravi and D. Ullman. 2006. Compilers Principles Techniques and Tools. 2nd Ed. Wesley Pub, Lancing, MI, USA.
2. Amet, H. 1990. The Design and Analysis of Spatial Data. Wesley Series in Computer Science. Boston, MA, USA
3. Dick, G., E. Henri and J. H. Jacobs. 2010. Modern Compiler Design, 2nd Ed. John Wiley, New York City, NY, USA.
4. Kumar, V., A. Grama, A. Gupta and G. Karypis. 1994. Introduction to Parallel Computing Design and Analysis of Algorithms. Redwood City, Benjamin.
5. Lee, R., S. S. Tseng and R. C. Chang. 2005. Introduction to The Design and Analysis of Algorithms. McGraw Hill Higher Education, London, UK.

CS-510	PARALLEL & DISTRIBUTED COMPUTING	3(2-1)

Learning Objectives

This course will address issues in the design of parallel and distributed systems focusing on architectural models, software system models, models of synchrony processes and threads and synchronization

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Learn about parallel and distributed computers.	C	1	2
• Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library	C	2	2
• Analytical modelling and performance of parallel programs	C	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Asynchronous/synchronous computation/communication; Concurrency control, fault tolerance; GPU architecture and programming, heterogeneity: Interconnection topologies; Load balancing; Memory consistency model; Memory hierarchies; Message passing interface (MPI); MIMD/SIMD; Multithreaded programming; Parallel algorithms & architectures, parallel I/O; Performance analysis and tuning; Programming models (data parallel, task parallel, process-centric, shared/distributed memory); Scalability and performance studies; Scheduling; Storage systems; Synchronisation.

Practical:
Comparison of parallel and distributed program performance on selected processor, develop a simple CUDA renderer, develop a simple parallel and distributed webserver.
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Textbook 1. A. S. Tanenbaum and M. V. Steen. 2007. Distributed Systems: Principles and Paradigms, Prentice Hall, NJ, USA.
Suggested Readings:
1. David, A. P. and J. L. Hennessy. 2018. Computer Organization and Design the hardware/software interface. MA Morgan Kaufman Publishers, Cambridge, MA, USA. 2. Erl, T. 2008. Soa: principles of service design. Prentice Hall, Upper Saddle River, NJ, USA. 3. Godse, A. P. and D. A. Godse. 2013. Computer Architecture Organization, Technical Publication, Pune, India. 4. Hamacher, V. C., Vranesic, Z. G., Zaky, S. G., Vransic, Z. and Zakay, S. 1996. Computer organization. McGraw-Hill, New York City, NY, USA.

Data Science Core (Compulsory) Courses

DS-410	**INTRODUCTION TO DATA SCIENCE**	**3(2-1)**
Learning Objectives		
• To introduce students to the rapidly growing field and equip them with some of its basic principles and tools as well as its general mindset. • to explain the significance of exploratory data analysis in data science. • To identify common approaches used for Feature Generation as well as Feature Selection.		

- To discuss the Ethical and Privacy issues.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Describe what Data Science is and the skill sets needed to be a data scientist.	C	2	2
• Apply EDA and the Data Science process in a case study.	C	3	3
• Comprehend the fundamental constructs of Python programming language.	C	2	4
• Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction: What is Data Science? Big Data and Data Science hype; Datafication; Current landscape of perspectives; Skill sets needed; Statistical Inference: Populations and samples, Statistical modeling, probability distributions, fitting a model; Introduction 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, Neighbourhood properties in graphs; Data Visualization: Basic principles, ideas and tools for data visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists.

Practical

Programming language Python has been proposed for the practical work of this course; perform programing exercises to apply machine learning algorithms to solve real world problems.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Igual, L. S. Segui. 2017. Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications. 1st edition, Springer. Cham. ISBN 978-3-319-50016-4.

Suggested Readings:

1. Grus, J. 2015. Data Science from Scratch, O'Relly Media, 1st Edition, 2015; ISBN 978-1-491-90142-7
2. Saltz, J. S., J. M. 2017. Stanton, An Introduction to Data Science, SAGE Publications.
3. Subramanian, G. 2015. Python Data Science Cookbook. Packt Publishing, 1st Edition. ISBN 978-1-78439-640-4
4. Zaki. M. J., W. Meira. 2014. Data Mining and Analysis: Fundamental Concepts and Algorithms. 1st edition. Cambridge University Press. ISBN 978-0-521-76633-3

DS-509	**ADVANCE STATISTICS**	**3(3-0)**

Learning Objectives

- To familiarize students with statistical methods used for analysis of different datasets for forecasting the values, predicting the unknowns, relating the variables for getting deeper insights and relating data differences with real world complexities.
- To emphasize on extracting knowledge from data on the basis of hidden patterns which can be made explicit by incorporating the statistical algorithms in it.
- To prepare students on statistical techniques with a purview of artificial intelligence and data science.

Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Describe what part of statistics is meant for data scientist and what the applications of statistics in data science are.	C	1	2
• Apply Statistical techniques in real life problems.	C	3	3
• Analyze, Correlate, forecast data by using different statistical techniques.	C	2	4
• Apply basic data science statistical techniques by using SPSS on real world datasets.	C	3	5
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain			

SDGS addressed in the course:	4 (Quality Education) & 8 (Decent work & Economic Growth)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to Statistics; Use of Statistics in Data Science; Experimental Design; Statistical Techniques for Forecasting; Interpolation/ Extrapolation; Introduction to Probability; Conditional Probability; Prior and Posterior Probability; Random number generation (RNG); Techniques for RNG; Correlation analysis; Chi Square Dependency tests; Diversity Index; Data Distributions Multivariate Distributions; Error estimation; Confidence Intervals; Linear transformations; Gradient Descent and Coordinate Descent; Likelihood inference; Revision of linear regression and likelihood inference; Fitting algorithms for nonlinear models and related diagnostics; Generalized linear model; exponential families; variance and link functions; Proportion and binary responses; logistic regression; Count data and Poisson responses; log-linear models; Over-dispersion and quasi-likelihood; estimating functions; Mixed models; random effects; generalized additive models and penalized regression; Introduction to SPSS; Probability/ Correlation analysis/ Dependency tests/ Regression in SPSS.

Teaching Methodology:
Lectures, Written Assignments, Project.
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Text Book:
1. Miller, J.D. 2017. Statistics for Data Science: Leverage the power of statistics for Data Analysis, Classification, Regression, Machine Learning, and Neural Networks. Packt Publishing Ltd. Birmingham, UK.
Suggested Readings:
1. Hardin, J., R. Hoerl, N.J. Horton, D. Nolan, B. Baumer, O. Hall-Holt, P. Murrell. R. Peng, P. Roback. L. D. Temple, and M. D. Ward. 2015. Data science in statistics curricula: Preparing students to "think with data". The American Statistician, 69(4), pp. 343-353. 2. Mendenhall, W., R.J.Beaver and B.M. Beaver. 2012. Introduction to Probability and Statistics. Cengage Learning, Boston, MA, USA. 3. Ronald, W. and Y. Myer.2008. Probability & Statistics for Engineers & Scientists. 8th Ed. Prentice Hall, Upper Saddle River, NJ, USA. 4. Sandra, K. M. 2010. Statistics, McGraw-Hill, New York, NY, USA. 5. Serdobolskii, V. 2008. Multiparametric Statistics. Elsevier, Amsterdam, Netherlands.

DS-504	**BIG DATA ANALYTICS**	**3(2-1)**
Learning Objectives		
This course provides a platform for the dissemination of research, current practices, and future trends in the emerging discipline of **big data analytics**.		
Learning Outcomes		

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Understand the fundamental concepts of Big Data and its programming paradigm.	C	2	2
• Hadoop/MapReduce Programming, Framework, and Ecosystem	C	3	2
• Apache Spark Programming	C	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain	
SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)
Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system	
Course Contents	
Theory	
Introduction and Overview of Big Data Systems; Platforms for Big Data, Hadoop as a Platform, Hadoop Distributed File Systems (HDFS), MapReduce Framework, Resource Management in the cluster (YARN), Apache Scala Basic, Apache Scala Advances, Resilient Distributed Datasets (RDD), Apache Spark, Apache Spark SQL, Data analytics on Hadoop / Spark, Machine learning on Hadoop / Spark, Spark Streaming, Other Components of Hadoop Ecosystem.	
Practical:	
Download and install Hadoop, acquire dataset, import required libraries to MapReduce dataset, perform Hadoop streaming and multi-node clustering.	
Teaching Methodology:	
Lectures, Written Assignments, Practical labs, Semester Project, Presentations	
Course Assessment:	
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam	
Textbook 1. Leskovec, J., A. Rajaraman and U. Jeff, 2011. Mining of Massive Datasets, 2nd Ed. Cambridge University Press, UK.	
Suggested Readings:	
1. Jimmy, L. and Chris, 2010. Data-Intensive Text Processing with Map Reduce, 3rd Ed. Morgan & Claypool, UK 2. Ramakrishnan, R. and J. Gehrke. 2003. Database Management Systems, 3rd Ed. Pearson Education, Boston, MA, USA. 3. Tom W. 2003. Hadoop: The Definitive Guide, 4th Ed. O Reilly Media, Sebastopol, CA, USA 4. Silberschatz, A., H.F. Korth and S. Sudarshan. 2010. Database System Concepts. 6th Ed. McGraw Hill, NY, USA.	

DS-506	DATA WAREHOUSING & BUSINESS INTELLIGENCE	3(2-1)

Learning Objectives

- The course will enhance students understanding regarding the evolution, need and benefits of business intelligence.
- Students will also learn about various technical aspects of BI and understand the processes involving in planning, designing, building and maintaining BI environment.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process	C	3	2
• 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.	C	3	2
• Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas	C	2	4
• Use Analytic SQL to aggregate, analyze and report, and model data.	C	2	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

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 Data warehouse using SSAS and Tableau; Data visualization and reporting based on Cube; Reports and Dashboard management on PowerBI; Dashboard Enrichment; Business Intelligence Tools.

Practical:

Implement complete process of data warehousing: determine business objectives, collect information, identify core business processes, design conceptual and logic models, locate data sources, set tracking duration, and implement the plan using tools such as SSAS, Tableau, PowerBI, Oracle, Microsoft, Amazon Redshift, Teradata.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Textbook

1. Brian, L.2016. Delivering Business Intelligence with Microsoft SQL Server 2016. 4th Ed. McGraw- Hill Education, London, UK.

Suggested Readings:

1. Jeremy, K.M. 2012. Business Intelligence in Plain Language: A Practical Guide to Data Mining and Business Analytics. Applied Data Labs Inc., USA.
2. Müller, R. M. and H. J. Lenz. 2013. Business Intelligence. 2nd Ed. Springer, Berlin, Germany.
3. Robert, L. 2012. The Data Warehouse Mentor: Practical Data Warehouse and Business Intelligence Insights. 1st Ed. McGraw-Hill Companies, NY, USA.
4. Turban, E., R. Sharda and D. Delen. 2011. Decision Support and Business Intelligence Systems. 9th Ed. Pearson Education, India.

DS-605	DATA VISUALIZATION	3(2-1)

Learning Objectives

Students will be able

- to prepare data for visualization
- to design visualizations
- to use web technology to create visualizations

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Provides knowledge about importance, necessity, and justification of performing exploratory data analysis and visualization	C	2	2
• Introduce various type of charts along with their alternatives solution to show same data from versatile aspects.	C	2	2
• Improving the competency of the students to analyze different problems and select the most appropriate solution.	C	3	4
• Use of R, various recent tools, and technologies to develop hands-on skills for exploratory data analysis and visualization.	C	3	5

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction of Exploratory Data Analysis and Visualization, Building Blocks and Basic Operations; Types of Exploratory Graphs, single and multi-dimensional summaries, five number summary, box plots, histogram, bar plot and others; Distributions, their representation using histograms, outliers, variance; Probability Mass Functions and their visualization; Cumulative distribution functions, percentile-based statistics, random numbers; Modelling distributions, exponential, normal, lognormal, pareto; Probability density functions, kernel density estimation; Relationship between variables, scatter plots, correlation, covariance; Estimation and Hypothesis

Testing; Clustering using K-means and Hierarchical; Time series and survival analysis; Implementing concepts with R (or similar language)

Practical:

Graphical representation to see and understand trends, relationship, outliers, and patterns in data; Use indicators, line, bar, pie, area, pivot, scatter charts using tools such as MATLAB, R, PowerBI, Tableau, Sisense, Domo, D3JS.

Teaching Methodology:

Lectures, Written Assignments, Practical Labs Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Textbook

1. D. Peng Roger. Exploratory Data Analysis with R.

Suggested Readings:

1. Gorunescu, F. 2011. Data Mining Concepts, Models and Techniques. Springer Science & Business Media, Berlin, Germany.
2. Han, J., J. Pei and M. Kamber. 2011. Data mining Concepts and Techniques. 3rd Ed. Elsevier, Amsterdam, Netherlands.
3. Miller, H. J. and J. Han. 2001. Geographic Data Mining and Knowledge Discovery. Taylor & Francis, London, UK.
4. Ponniah, P. 2004. Data Warehousing Fundamentals. John Wiley & Sons, Hoboken, NJ, USA.

DS-609	**DATA MINING**	**3(2-1)**

Learning Objectives

- To expand on the student's understanding and awareness of the concepts of data mining basics, techniques, and application.
- To introduce the concepts of Data Pre-processing and Summary Statistics.
- To introduce the concepts of Frequent Item Set Generation, Associations and Correlations measures.
- To introduce the concepts of Classification, Prediction, and Clustering algorithms

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Describe what Data Science is and the skill sets needed to be a data scientist.	C	2	2
• Apply EDA and the Data Science process in a case study.	C	3	2
• Comprehend the fundamental constructs of Python programming language.	C	2	3
• Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C	3	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	8 (Decent Work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

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.

Practical

Programming language Python has been proposed for the practical work of this course; build on the programming and problem-solving skills developed in previous subjects studied by the student, practical part of this course aims to achieve an understanding of the development of Classification, Prediction, and Clustering applications by practical exercises.

Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations.
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book:
1. Igual, L. S. Segui. 2017. Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications. 1st edition, Springer. Cham. ISBN 978-3-319-50016-4.
Suggested Readings:
1. Grus, J. 2015. Data Science from Scratch, O'Relly Media, 1st Edition, 2015; ISBN 978-1-491-90142-7 2. Saltz, J.S., J. M. 2017. Stanton, An Introduction to Data Science, SAGE Publications. 3. Subramanian, G. 2015. Python Data Science Cookbook. Packt Publishing, 1st Edition. ISBN 978-1-78439-640-4 4. Zaki. M. J., W. Meira. 2014. Data Mining and Analysis: Fundamental Concepts and Algorithms. 1st edition. Cambridge University Press. ISBN 978-0-521-76633-3

General Education Courses

CS-301	**INTRODUCTION TO INFORMATION & COMMUNICATION TECHNOLOGIES**	**3(2-1)**

Learning Objective

- The course introduces students to information and communication technologies and their application in the workplace.
- Students will get basic understanding of computer software, hardware, and associated technologies.
- They will also learn how computers are used in the workplace, how communications systems can help boost productivity, and how the Internet technologies can influence the workplace.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Understand basics of computing technology	C	1	2

• Perform number systems conversions and arithmetic	C	2	3
• Know about different types of software & hardware	C	2	2
• Apply basic computing related technologies	P	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	8 (Decent Work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Brief history of Computer; Four Stages of History: Computer Elements; Processor: Memory: Hardware: Software; Application Software its uses and Limitations: System Software its Importance and its Types: Types of Computer (Super, Mainframe, Mini and Micro Computer); Introduction to CBIS (Computer Based Information System); Methods of Input and Processing; Class2. Organizing Computer Facility; Centralized Computing Facility: Distributed Computing Facility: Decentralized Computing Facility: Input Devices; Keyboard and its Types: Terminal (Dump, Smart, Intelligent): Dedicated Data Entry: SDA (Source Data Automation): Pointing Devices: Voice Input: Output Devices: Soft- Hard Copies: Monitors and its Types: Printers and its Types: Plotters: Computer Virus and its Forms; Storage Units; Primary and Secondary Memories: RAM and its Types; Cache: Hard Disks: Working of Hard Disk: Diskettes: RAID: Optical Disk Storages (DVD, CD ROM): Magnetic Types: Backup System; Data Communications; Data Communication Model: Data Transmission; Digital and Analog Transmission: Modems; Asynchronous and Synchronous Transmission: Simplex: Half Duplex: Full Duplex Transmission: Communications; Medias (Cables, Wireless): Protocols; Network Topologies (Star, Bus, Ring); LAN: LAN: Internet; A Brief History: Birthplace of ARPA Net: Web Link: Browser; Internet Services provider and Online Services Providers: Function and Features of Browser: Search Engines; Some Common Services available on Internet.

Practical

Practical work on Microsoft Office: creates documents in word, Stand-alone application for creating professional multimedia presentations using MS PowerPoint, creates simple to complex data/numerical spreadsheets using MS excel, database management applications using MS

Access, Introductory application for creating and publishing marketing materials using MS publisher, organise notes using MS OneNote; Basic web page designing using HTML.
Teaching Methodology
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book
1. Baldauf, K. 2011. Succeeding with Technology: Computer System Concepts for your Life. 2nd Ed. Cengage Learning. Boston, MA, USA.
Suggested Readings
1. Capron, H. L. and J.A, Johnson 1990. Computers: Tools for an Information Age. 8th Ed. Benjamin/Cummings Publishing Company, San Francisco, CA, USA. 2. Long, L. E and Long, N. 2001. Computers: Information Technology in Perspective. 11th Ed. Pearson Education, Trenton, NJ, USA. 3. Meyer, M. and R. Baber. 1998. Computers in your Future. Cisco press, Trenton, NJ, USA. 4. Snyder, L. 2008. Fluency with Information Technology, John Wiley & Sons, New York, NY, USA.

SSH-307	**PAKISTAN STUDIES**	**2(2-0)**
Learning Objective		
• Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan. • Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan		
Learning Outcomes		

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Learn about the History and Ideology of Pakistan.	C	1	1
• Get knowledge about the political and administrative structure of Pakistan.	C	2	1

• Get familiarity about the political transitions in Pakistan.	C	2	1

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Historical background of Pakistan; Muslim society in Indo-Pakistan: the movement led by the societies: the downfall of Islamic society: the establishment of British Raj- Causes and consequences: Political evolution of Muslims in the twentieth century; Sir Syed Ahmed Khan: Muslim League: Nehru: Allama Iqbal: Independence Movement; Lahore Resolution; Pakistan culture and society: Constitutional and Administrative issues: Pakistan and its geopolitical dimension; Pakistan and International Affairs; Pakistan and the challenges ahead.

Teaching Methodology

Lectures, Written Assignments

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Final Exam

Textbook

1. Malik, H. 1968. The Emergence of Pakistan. By Chaudhri Muhammad Ali. New York: Columbia University Press, 1967. ix, 418 pp. Index. *The Journal of Asian Studies*, *27*(4), 893-894.

Suggested Readings

1. Aziz, K. K. 2005. The making of Pakistan. Sang-e-Meel publ.
2. Basham, A. L. 1968. A Short History of Pakistan: Book One: Pre-Muslim Period.
3. Burke, S. M. and L. Ziring. 1993. Pakistan's Foreign Policy: An Historical Analysis. 2nd Ed. Oxford University Press, Oxford, U.K.
4. Mehmood, S. 1994. Pakistan Political Roots and Development. 2nd Ed. Five Star Publishing, Lahore, Pakistan.

ENG-309	ENGLISH COMPOSITION & COMPREHENSION	3(3-0)

Learning Objective

- Interact with academic content: reading, writing, listening and speaking.
- Demonstrate ability to think critically.
- Utilize information and digital literacy skills.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Interact with academic content: reading, writing, listening and speaking.	C	1	1
• Demonstrate ability to think critically	C	1	1
• Utilize information and digital literacy skills.	C	3	7

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Paragraph and Essay Writing; Descriptive Essays; Sentence Errors: Persuasive Writing; How to give presentations: Sentence Errors; Oral Presentations: Comparison and Contrast Essays: Dialogue Writing: Short Story Writing: Review Writing; Narrative Essays: Letter Writing.

Teaching Methodology

Lectures, Written Assignments, Semester Project, Presentations

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book

1. Langan, J. 2013. College Writing Skills with Readings, McGraw-Hill, 5th Edition

Suggested Readings

1. Khattak, A. 2000. A Textbook of English Prose and Structure. GIKI Institute
2. Rivers, W. M. and M. S. Temperley. 1978. A Practical Guide to the Teaching of English as a Second or Foreign Language. Oxford University Press, Oxford, UK.
3. Smalley, R. L., M. K. Ruetten and D. Kozyrev. 2001. Refining Composition Skills. 4th Ed. Heinle & Heinle Inc., Boston, MA, USA.
4. Vawdrey C. 1993. Practical Business English. 2nd Ed. Richard d Irwin Publishing, New York City, NY, USA.

ENG-308	COMMUNICATION & PRESENTATION SKILLS	3(3-0)

Learning Objective

- Evaluate information and its sources critically.
- Incorporate selected information into one's knowledge base.
- Use information effectively to accomplish a specific purpose.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Enrich the thought and culture and provides us with the most important international vehicle of expression.	C	1	1
• Enhance English language skills of the students and develop their critical thinking.	C	1, 3	1
• Demonstrate ability to think critically	C	3	7

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Principles of writing good English; understanding the composition process: writing clearly; words: sentence and paragraphs; Comprehension and expression; Use of grammar and punctuation; Process of writing; observing: audience collecting: composing: drafting and revising: persuasive writing: reading skills: listening skills and comprehension: skills for taking notes in class: skills for exams; Business communications; planning messages: writing concise but with impact: Letter formats; mechanics of business: letter writing: letters: memo and applications; summaries: proposals: writing resumes: styles and formats: oral communications: verbal and non-verbal communication: conducting meetings; small group communication: taking minutes: Presentation skills; presentation strategies: defining the objective: scope and audience

of the presentation: material gathering material organization strategies: time management; opening and concluding: use of audio-visual aids: delivery and presentation.
Teaching Methodology
Lectures, Written Assignments, Semester Project, Presentations
Course Assessment
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book
1. Ellis, M., and C. Johnson. 1994. Teaching Business English. pp. 25-38. Oxford.
Suggested Readings
1. Henri, E. B., C. J. Jacobs, K. G. Langendoen and D. Grune. 2012. Modern Compiler Design. 2nd Ed, John Wiley & Sons. New York City, NY, USA. 2. Masami, I. 2004. Algebraic Theory of Automata and Languages. World Scientific, River Edge, NJ, USA. 3. Nielsen, J. 2008. Effective Communication Skills: The Foundations for Change. Xlibris Corporation. 4. Schriver, K. A. 1997. Dynamics in Document Design. 3rd Ed. Wiley Inc. New York City, NY, USA. 5. Smalley, R. L., M. K Ruetten and D. Kozyrev. 2001. Refining Composition Skills. 4th Ed. Heinle & Heinle Inc., Boston, MA, USA.

IS-310/SS-310	**ISLAMIC STUDIES**	**2(2-0)**
Learning Objective		
• To enhance understanding of the students regarding Islamic Civilization • To improve Students skill to perform prayers and other worships • To enhance the skill of the students for understanding of issues related to faith and religious life.		
Learning Outcomes		

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Get the knowledge of basic teachings of Islam.	C	1	1

• Learn how to adopt Islamic life style.	C	2	1
• Know the rights of individuals given by the Islam.	C	2	1

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Basic Themes of Quran; Introduction to Sciences of Hadith; Introduction to Islamic Jurisprudence; Primary & Secondary Sources of Islamic Law; Makken & Madnian life of the Prophet; Islamic Economic System; Political theories: Social System of Islam.

Teaching Methodology

Lectures, Written Assignments

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Final Exam

Text Book

1. Hamidullah, M. 1980. Introduction to Islam. Series. Popular Library Publishers Lahore

Suggested Readings

1. Kamali, M. H. 1991. Principles of Islamic jurisprudence. pp. 283-296. Cambridge: Islamic Texts Society.
2. Waliullah, M. 2006. Muslim Jurisprudence and the Qur'anic Law of Crimes. Adam Pub.

ENG-407	**TECHNICAL & BUSINESS ENGLISH WRITING**	**3(3-0)**

Learning Objective

- To effectively plan and structure technical reports and to recognize the various stages in writing a technical report.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Enhance the Skills regarding primary and library research to discover and employ information.	C	1	1
• Enhance correspondence Skills (learning the generic conventions of each).	C	1	1
• Polish the excellent writing skills with no spelling mistakes.	C	3	7

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Overview of technical reporting; use of library and information gathering: administering questionnaires: reviewing the gathered information; Technical exposition; topical arrangement: exemplification: definition: classification and division: casual analysis: effective exposition: technical narration: description and argumentation: persuasive strategy: Organizing information and generation solution; brainstorming: organizing material: construction of the formal outline: outlining conventions: electronic communication: generation solutions: Polishing style; paragraphs: listening sentence structure: clarity: length and order: pomposity: empty words: pompous vocabulary: document design; document structure: preamble: summaries: abstracts: table of contents: footnotes: glossaries: cross referencing: plagiarism: citation and bibliography: glossaries: index: appendices: typesetting systems: creating the professional report; elements: mechanical elements and graphical elements: Reports; Proposals: progress reports: Leaflets: brochures: handbooks: magazines articles: research papers: feasibility reports: project reports: technical research reports: manuals and documentation: thesis; Electronic documents: Linear verses hierarchical structure documents.

Teaching Methodology

Lectures, Written Assignments, Presentations

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam

Text Book

1. Balzotti, J. 2021. Technical Communication: A Design-centric Approach. Routledge.

Suggested Readings

1. MacLemale, L. A. 2002. Technical and business communication for working professionals. (Book Reviews). Technical Communication, 49(2), 226-228.
2. Riordan, D. 2013. Technical report writing today. Cengage Learning.
3. Vengadasalam, S. S. 2021. Teaching Business, Technical and Academic Writing Online and Onsite: A Writing Pedagogy Sourcebook. Cambridge Scholars Publishing.

SSH-607	**PROFESSIONAL PRACTICES**	**3(3-0)**

Learning Objective

- To develop student understanding of historical, social, economic, ethical, and professional issues related to the discipline of Computing.
- To identify key sources for information and opinion about professionalism and ethics.
- To enable students to analyze, evaluate, and assess ethical and professional computing case studies.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Know the scope of computing field after graduating in it and what are the common things in every organization	C	1	1
• Distinguish between various fields of computing	C	2	1
• Describe the core of any profession.	C	1	1
• Know that how business and professional environment of computing field work	A	2	1
• Adhere the responsibilities according to profession, organization, and himself/herself	A	3	9

• Know the standards, tools, and rules about IPs and information security	C	1	9
• Write and analyse software contracts as an employer or to an employer	C	3	7
• Know the business and professional environment of software house	A	2	9

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education) 12 (Responsible Consumption and Production)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Computing Profession; Computing Ethics; Philosophy of Ethics; The Structure of Organizations; Finance and Accounting; Anatomy of a Software House; Computer Contracts: Intellectual Property Rights: The Framework of Employee Relations Law and Changing Management Practices; Human Resource Management and IT; Health and Safety at Work: Software Liability: Liability and Practice: Computer Misuse and the Criminal Law: Regulation and Control of Personal Information; Overview of the British Computer Society Code of Conduct; IEEE Code of Ethics; ACM Code of Ethics and Professional Conduct: ACM/IEEE Software Engineering Code of Ethics and Professional Practice: Accountability and Auditing; Social Application of Ethics.

Teaching Methodology

Lectures, Written Assignments, Semester Project, Presentations

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book

1. Bott, F., Coleman, A., and Rowland, D. 2000. Professional issues in software engineering. CRC Press.

Suggested Readings

1. Baase, S. 2008. A gift of fire: Social, legal, and ethical issues for computing and the Internet.

2. Beabout, G. R., and Wennemann, D. J. 1993. Applied professional ethics: A developmental approach for use with case studies. University Press of America.
3. Bynum, T. W., and Rogerson, S. 2003. Computer ethics and professional responsibility: introductory text and readings. Blackwell Publishers, Inc.

Data Science Elective Courses

DS-503	THEORY OF AUTOMATA & FORMAL LANGUAGES	3(3-0)

Learning Objectives

- The course introduces students with fundamental concepts of automata theory
- The course introduces students with formal languages to form basic models of computation which provide foundation of many branches of computer science, e.g. compilers, software engineering, concurrent systems, etc.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Prove properties of languages, grammars and automata with rigorously formal mathematical methods.	C	2	2, 3
• Design automata, regular expressions and context-free grammars accepting or generating a certain language.	C	3	4
• Transform between equivalent deterministic and non-deterministic finite automata and regular expressions.	C	3	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to Automata: The Methods and the Madness, Introduction to Formal Proof,

Inductive Proofs, The Central Concepts of Automata Theory. Finite Automata: Introduction of Finite Automata, Deterministic Finite Automata, Nondeterministic Finite Automata, Finite Automata With Epsilon Transitions. Regular Expressions and Languages, Regular Expressions, Finite Automata and Regular Expressions, Applications of Regular Expressions, Algebraic Laws for Regular Expressions. Properties of Regular Languages, Proving Languages Not to Be Regular, Closure Properties of Regular Languages, Decision Properties of Regular Languages, Equivalence and Minimization of Automata. Context-Free Grammars and Languages: Context-Free Grammars, Parse Trees, Applications of Context-Free Grammars, Ambiguity in Grammars and Languages, Pushdown Automata: Definition of the Pushdown Automaton, The Languages of a PDA, Equivalence of PDAs and CFGs, Deterministic Pushdown Automata. Properties of Context-Free Languages: Normal Forms for Context-Free Grammars, The Pumping Lemma for Context-Free Languages, Closure Properties of Context-Free Languages, Decision Properties of CFLs. Introduction to Turing Machines: Problems That Computers Cannot Solve, The Turing Machine, Programming Techniques for Turing Machines, Extensions to the Basic Turing Machine, Restricted Turing Machines, Turing Machines and Computers. Un-decidability: A Language That Is Not Recursively Enumerable, Un-decidable Problem That Is RE, Un-decidable Problems About Turing Machines, Posts Correspondence Problem, Other Un-Decidable Problems. Intractable Problems: The Classes P and NP, An NP-Complete Problem, A Restricted Satisfiability Problem.

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam

Text Book:

1. Linz, P. 2006. An Introduction to Formal Language and Automata. 4th Ed.

Suggested Readings:

1. Alfred, V., S. Ravi and D. Ullman. 2006. Compilers Principles Techniques and Tools. 2nd Ed. Wesley Pub, Lancing, MI, USA.
2. Andrew, W. and A. Appel. 2004. Modern Compiler Implementation in C. Cambridge University Press, Cambridge, UK.
3. Dick, G., E. Henri and J. H. Jacobs. 2010. Modern Compiler Design. 2nd Ed. John Wiley, New York City, NY, USA.
4. Henri, E. B., C. J. Jacobs, K. G. Langendoen and D. Grune. 2012. Modern Compiler Design. 2nd Ed, John Wiley & Sons. New York City, NY, USA.
5. Kelley, D. 1995. Automata and Formal Languages: an introduction. Prentice-Hall, Inc.
6. Masami, I. 2004. Algebraic Theory of Automata and Languages. World Scientific, River Edge, NJ, USA.

DS-601	MACHINE LEARNING	3(2-1)

Learning Objectives

This course will enable the students 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.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
Describe basic machine learning concepts, theories and applications.	C	1	2
Apply supervised learning techniques to solve classification problems of moderate complexity.	C	3	2
Apply unsupervised learning techniques to solve clustering problems of moderate complexity	C	3	2
Apply reinforcement learning algorithms to environments with complex dynamics.	C	3	2
Develop a reasonable size project using suitable machine learning technique	C	6	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

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 labelled and unlabelled 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.

Practical:

Anaconda and Jupyter Installation, Practical exercises on Linear & logistic regression, LDA, resampling, SVM, unsupervised learning, time-series analysis and natural language processing using libraries such as: NumPy, TensorFlow, Pandas, SciPy, Keras, Neural Designer, Scikit-learn.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Alpaydin, E. 2016. Machine Learning: The New AI/Ethem Alpaydin. MIT Press, USA.

Suggested Readings:

1. Bishop, C. 2006. Pattern Recognition and Machine Learning, Springer-Verlag, NY, USA.
2. Luger, G. F., P. Johnson, C. Stern, C. Newman and R. Yeo. 1994. Cognitive Science: The Science of Intelligent Systems. Academic Press, Boston, MA, USA.
3. Marsland, S. 2015. Machine learning: An Algorithmic Perspective, CRC Press, Boca Raton, London, UK.
4. Murty, M. N and V. S. Devi. 2015, Introduction to pattern recognition and machine learning, World Scientific. IISc Press, Singapore.

DS-602	**DEEP LEARNING**	**3(3-0)**

Learning Objectives

This course will enable the students to:

- gain a comprehensive review of the theories, practical implementations for problem-solving, and a focused introduction of at least one application area.
- Visual perception, speech or natural languages processing using the machine learning technology that has resulted in what is arguably responsible for the eternal spring of artificial spring.

Learning Outcomes			

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Apply deep learning algorithms to real-world problems	C	3	2
• Analyze results from deep learning to select appropriate solutions	C	4	3
• Code the novel neural network architectures from scratch and evaluating the performance on application specific standard benchmarks	C	5	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Theory of Generalization; Multi-layer perceptrons, error back-propagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc.

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Final Exam

Textbook:

1. Goodfellow, I., Y. Bengio, A. Courville and Y. Bengio. 2016. Deep learning (Vol. 1, No. 2). Cambridge: MIT press

Suggested Readings:

1. Beysolow, T. 2017. Introduction to Deep Learning using R. CA Apress, CA, USA.
2. Chollet, F. 2017. Deep Learning with Python. Manning Publications, NY, USA.
3. Josh P. and A. Gibson. 2017. Deep Learning: A Practitioner's Approach. 1st Ed. O'Reilly Media, Inc, Sebastopol, CA, USA.
4. Julius, P. 2016. Deep Learning: Fundamentals, Methods and Applications. Nova Science Publishers, NY, USA.
5. Sugomori, Y., B. Kaluza, F. M. Soares and A. M. F. Souza. 2017. Deep Learning, Packt Publishing, Birmingham, UK.

DS-603	**CLOUD COMPUTING**	**3(3-0)**

Learning Objectives

This course will enable the students to:

- Understand the definition and essential characteristics of cloud computing, its history, the business case for cloud computing, and emerging technology use cases enabled by cloud.
- Learn about the various cloud service models (IaaS, PaaS, SaaS) and deployment models (Public, Private, Hybrid) and the key components of a cloud infrastructure (VMs, Networking, Storage - File, Block, Object, CDN).
- Understand basics of cloud security, monitoring, and different job roles in the cloud industry.

Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Define cloud computing and explain its essential characteristics, history, the business case for cloud, and emerging technologies enabled by cloud.	C	3	2
• Explain emerging Cloud related trends including Hybrid Multicloud, Microservices, Serverless, Cloud Native, DevOps and Application Modernization	C	4	3
• Describe the cloud service (IaaS, Saas, Paas) & deployment models (Public, Private,	C	5	4

Hybrid), and its infrastructure - VMs, Networking, Storage			
• Create a Cloud account and work hands-on with Cloud services, such as Object Storage	P	3	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Overview of cloud computing: Definition and Essential Characteristics of Cloud Computing; History and Evolution of Cloud Computing; Key Considerations for Cloud Computing; Key Cloud Service Providers and Their Services; Cloud Adoption - No longer a choice; Cloud Adoption - Some case studies; Internet of Things in the Cloud; Artificial Intelligence on the Cloud; Block chain and Analytics in the Cloud. Cloud Computing Models: IaaS - Infrastructure as a Service; PaaS - Platform as a Service; SaaS - Software as a Service; Public Cloud; Private Cloud; Hybrid Cloud. Components of Cloud Computing: Overview of Cloud Infrastructure; Virtualization and Virtual Machines Explained; Types of Virtual Machines; Bare Metal Servers; Secure Networking in Cloud; Containers; Basics of Storage on Cloud; File Storage; Block Storage; Object Storage Overview; Object Storage - Tiers and APIs; CDN - Content Delivery Networks. Emergent Trends and Practices: Hybrid Multi-cloud; Micro services; Server-less Computing; Cloud Native Applications; DevOps on the Cloud; Application Modernization. Cloud Security and Monitoring: What is Cloud Security; Identity and Access Management; Cloud Encryption; Cloud Monitoring Basics and Benefits; Case Studies in Different Industry Verticals; Career Opportunities and Job Roles in Cloud Computing.

Teaching Methodology:

Lectures, Written Assignments, Semester Project, Presentations

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Final Exam

Textbook:
1. Dowling, J. 2019. Introduction to Cloud Computing. Royal Institute of Technology. KTH.
Suggested Readings:
1. Hurwitz, J., Kaufman, M., and Halper, F. Cloud Services for Dummies, IBM Limited Edition. John and Wiley Sons. Hoboken. New Jersey, USA. 2. Krutz, R. L., and Vines, R. D. 2010. Cloud security: A comprehensive guide to secure cloud computing. Wiley Publishing. 3. Lee-Post, A., and Pakath, R. 2014. Cloud computing: a comprehensive introduction. In Security, Trust, and Regulatory Aspects of Cloud Computing in Business Environments. pp. 1-23. IGI Global.

Mathematics and Science Foundation Courses

MATH-306	**CALCULUS & ANALYTICAL GEOMETRY**		**3(3-0)**
Learning Objectives			
• To provide foundation and basic ground for calculus and analytical geometry background			
Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** importance of calculus	C	2	2
• **Apply** derivatives, partial derivatives or integrals	C	3	2
• Design and implement algorithms to **solve** practical problems.	C	3	4
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain			
SDGS addressed in the course:	4 (Quality Education) 9 (Industry, Innovation, and Infrastructure)		
Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system			

Course Contents
Theory
Complex numbers; De Moivre's theorem and its applications; Simple cartesian curves; Functions and graphs; Symmetrical properties; Curve tracing; Limit and continuity; Differentiation of functions; Derivative as slope of tangent to a curve and as rate of change; Application to tangent and normal; Linearization; Maxima/Minima and point of inflexion; Taylor and maclurin expansions and their convergence; Integral as anti-derivative; Indefinite; Integration of simple functions; Methods of integration; Integration by substitution; Partial fractions; Definite integral as limit of a sum, application to area; Arc length; Volume and surface of revolution. Derivatives of Inverse Trigonometric Functions. Numerical Integration. Applications of Integrals. Transcendental Functions. Inverse Tragicomic Functions. Integrals.
Teaching Methodology:
Lectures, Written Assignments, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam
Text Book:
1. Larson, R., R. P. Hostetler. B. H. Edwards and D. E. Heyd. 1986. Calculus with analytic geometry. Lexington, Massachusetts, USA: DC Heath.
Suggested Readings:
1. Callahan, J. J. 2010. Advanced Calculus: A Geometric View. Springer Science & Business Media. Northampton, UK 2. Dineen, S. and S. Dineen. 2001. Multivariate Calculus and Geometry. 2nd Ed. Springer, New York, YK, USA. 3. Erwin, K. 2013. Advanced Engineering Mathematics. 10th Ed. Jones and Bartlett Learning, Burlington, MA, USA. 4. Schenck, H. 2003. Computational Algebraic Geometry. Cambridge University Press, Cambridge, UK

MATH-405	**LINEAR ALGEBRA**	**3(3-0)**
Learning Objectives		
• To provide fundamentals of solution for system of linear equations. • To apply operations on system of equations, matrix properties, solutions and study of their properties.		

Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** the importance of linear algebra	C	2	2
• **Apply** algebraic operation will be required to solve practical	C	3	2
• Design and implement symbolic simulator to **solve** system of equations through programming language.	C	3	4
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain			

SDGS addressed in the course:	4 (Quality Education) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Vectors; Vector spaces; Matrices and determinants; Cofactor and inverse; Rank; Linear independence; Positive definite matrix; Linear transformations; Operations on matrices; Inner products; Orthogonally and least squares; Eigen value & eigenvectors;

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Exam, Home Assignments, Quizzes, Presentations, Final Exam

Text Book:

1. Cheney, W. and D. Kincai. 2009. Linear algebra: Theory and Applications. Jones & Bartlett Learning, Burlington, MA, USA.

Suggested Readings:

1. David, K. H. 2007. Elementary Linear Algebra with Applications. 9th Ed. Prentice Hall, Prentice Hall, Harlow, UK.
2. Gilbert, S. S., B. C. Andy and B. Andrew, B. 2005. Linear Algebra and Its Applications. 4th Ed. Thomson Brooks/Cole, Belmont, CA, USA.
3. Hoffman, K. and R. A. Kunze. 2015. Pearson India Education Services, Noida, India.
4. Steven, J. L., I. Bica and T. Hohn. 2014. Linear Algebra with Applications**.** Pearson Learning Solution, New York, NY, USA.

STAT-412	**PROBABILITY & STATISTICS**	**3(3-0)**

Learning Objectives

- To provide foundation and basic ground for calculus and analytical geometry background

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** the importance of probability and statistics	C	2	2
• **Apply** probabilities related to both discrete	C	3	2
• **Compare** and analyze data sets using descriptive statistics.	C	3	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	4 (Quality Education) & 8 (Decent work & Economic Growth)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents
Theory
Introduction to statistics; Descriptive statistics; Statistics in decision making; Graphical representation of data stem-and lead plot, box-cox plots; Measures of central tendencies and dispersion, moments of frequency distribution; Counting techniques; Introduction to probability, sample space, events, laws of probability; Conditional probability and Baye's theorem with application to random variable (Discrete and continuous) binomial; Poisson; Geometric; Negative binomial distributions; Exponential gamma and normal distributions; Regression and correlation; Estimation and testing of hypotheses; Elementary statistical packages for explanatory data analysis.
Teaching Methodology:
Lectures, Written Assignments, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam
Text Book:
1. Lay, L. D. 2015. Probability and Statistics for Engineering and the Sciences, 9th Ed. Cengage Learning, Boston, MA, USA.
Suggested Readings:
1. Mendenhall, W., R. J. Beaver and B. M. Beaver. 2012. Introduction to Probability and Statistics. Cengage Learning, Boston, MA, USA. 2. Ronald, W. and Y. Myer. 2008. Probability & Statistics for Engineers & Scientists. 8th Ed. Prentice Hall, Upper Saddle River, NJ, USA. 3. Sandra, K. M. 2010. Statistics, McGraw-Hill, New York, NY, USA. 4. Serdobolskii, V. 2008. Multiparametric Statistics. Elsevier, Amsterdam, Netherlands.

MATH-511	**DIFFERENTIAL EQUATIONS**		**3(3-0)**
Learning Objective			
• The course develops students' fundamental skills of solving ordinary differential equations and developing differential equations for real-world problems.			
Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**

• Identify, analyze and subsequently solve physical situations whose behavior can be described by ordinary differential equations.	C	2, 3	2, 3
• Determine solutions to first order separable differential equations	C	2	3
• Determine solutions to first order linear differential equations.	C	2	3
• Determine solutions to first order exact differential equations.	C	2	3
• Determine solutions to second order linear homogeneous and non-homogeneous differential equations with constant coefficients.	C	2	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course	4 (Quality Education

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system.

Course Contents

Theory

Ordinary differential equations of the first order; Geometrical considerations; Isoclines; Separable equations; Equations reducible to separable form; Exact differential equations; Integrating factors; Linear first-order differential equations; Variation of parameters; Ordinary linear differential equations; Homogeneous linear equations of the second order; Homogeneous second order equations with constant coefficients; General solution; Real roots; Complex roots; Double root of the characteristic equation; Differential operators; Cauchy equation; Homogeneous linear equations of arbitrary order; Homogeneous linear equations of arbitrary order with constant coefficients; Non-homogeneous linear equations; Modeling of electrical circuits; Systems of differential equations; Series solutions of differential equations; Partial differential equations; Method of separation of variables; Laplace equations and their solutions by Fourier series method.

Teaching Methodology

Lectures, Written Assignments, Presentations

Course Assessment

Sessional Exam, Home Assignments, Quizzes, Final Exam

Text Book
1. Dennis, G. Z. and R. C. Michael. 1996. Differential Equations with Boundary Value Problems. Brooks/Cole Publishing, New York City, NY, USA.
Suggested Readings
1. Edwards, C. H. and E. David. 1993. Elementary Differential Equations with Applications. Penney, Prentice Hall, Upper Saddle River, NJ, USA. 2. Erwin, K. 1993, Advanced Engineering Mathematics. 7th Ed. John Wiley & Sons Inc, Hoboken, NJ, USA. 3. Michael, G. 1996. Advanced Engineering Mathematic, Prentice Hall Publishers, Upper Saddle River, NJ, USA. 4. Prindle, Z. and W. Schmidt. 1996. A First Course in Differential Equation. Brooks/Cole Publishing, New York City, NY, USA.

University Elective Courses

	ENTREPRENEURSHIP	**3(3-0)**

Learning Objectives

- This course provides an understanding of the entrepreneurship process
- The course gives students the tools. Necessary to think creatively, to plan out whether their idea is marketable to investors.
- This will be accomplished through a combination of readings, cases studies and projects designed to convey the unique environment of the entrepreneurs and new ventures.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** processes, and resources within a diverse organization	C	2	2
• **Apply** knowledge of leadership concepts in an integrated manner	C	3	2
• **Analyze** the internal/external factors affecting a business.	C	3	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	8 (Decent Work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Evolution and importance of entrepreneurship; Difference between intrapreneurship and entrepreneurship; Entrepreneurial process; Agribusiness ventures, practices and characteristics; Methods of new idea generation; Opportunities, innovations; change, fantasies, Environment of small businesses in agriculture; Sources and resolutions, corporate entrepreneurship in business sector; Risk failure and new venture unit; Feasibility and concepts of planning; Stages of growth model; Responsibility of feasibility plan; Product and services concepts; Product servicing concepts and commercial opportunities (macro over view); Products and technology; Identification of opportunities; Product development life cycle; Product protection; Trade mark and patents; Validity of property rights and accessing government information; Human resources side of enterprise; Infrastructure of services, Types of service venture; Success factors; Marketing and new venture development; Situation analysis for new ventures, Marketing concepts, startup of marketing research; Market focused on organization; Sources of market intelligence; Competitive analysis and implications of market research; Marketing strategies; Functions and product concepts; Changing international ventures; Entrepreneurial team and business formation, Human resource and relations, Board of directors, Legal aspects; Evaluation of acquisition opportunities and methods of valuation; Financial resources and asset management, Different types of financing, buy or lease, Organization cycle and growth of organization; Strategic management for success of enterprise; Looking towards agricultural entrepreneurial career, Agricultural business plan contents and details.

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam

Text Book:

1. Dollinger, M. 2007. Entrepreneurship: Strategies and Resources. 2nd Ed. Prentice Hall Inc. Upper Saddle River, NJ, USA.

Suggested Readings:

1. Kuratko, D. and R. Hodgetts. 2006. Entrepreneurship: A Contemporary Approach. 7th Ed. Prentice Hall, Inc., Upper Saddle River, NJ, USA.

2. Naqi, S. M. 2012. Entrepreneurs. 3rd Ed. A-One Publishers, Lahore, Pakistan.
3. Peters, M. and R. D. Hishrich. 2009. Entrepreneurship. 8th Ed. Irwin/McGraw-Hill, New York City, NY, USA.
4. Wills, W. J. and M. E. Newman. 1998. Agribusiness Management and Entrepreneurship. 2nd Ed. Interstate Publishers, Boston, MA, USA.

	PRINCIPLES OF ECONOMICS	**3(3-0)**

Learning Objectives

This course will enable the students to:

- Make students understand the key sectors of economy of Pakistan and contemporary issues in agriculture, industry and financial and social sector.
- Make students understand current policies in trade, commerce, fiscal/monetary policy, industry and agriculture.
- Let the students have a comprehensive knowledge about the current statistics of the various aspects of the economy.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** processes, and resources within a diverse organization	C	2	2
• **Apply** knowledge of leadership concepts in an integrated manner	C	3	2
• **Analyze** the internal/external factors affecting a business.	C	3	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	8 (Decent Work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to Pakistan economy; Concept of economic development and economic growth; What is the difference between the both terms; Measurement of economic development; Determinants of economic development; What are the major determinants of economic development; What are the main measurement of economic development and common

characteristics of under-develop economics; Theories of development; What is the theory of vicious circle of poverty; What is demand side vicious circle of poverty and supply side vicious circle of poverty; Capital formation; Main sources of capital formation; Importance of capital formation, causes of low capital formation in Pakistan, suggestions how to improve it; Explain the small & large industry growth, how it is growing. Problems of small & large scale industry; Foreign Trade; Why it is important for economy; Export promotion measures and BOT & BOP. ; Foreign debt and foreign aid; Role, importance, types, problems, solutions; Transportation and communication; How transportation and communication plays an important role in development.
Teaching Methodology:
Lectures, Written Assignments, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam
Text Book:
1. Baye, M. R., J. Prince and J. Squalli. 2006. Managerial Economics and Business Strategy, 5th Ed. McGraw-Hill, NY, USA.
Suggested Readings:
1. Donald. N. S. 2011, Managerial Economics: Concepts and Principles. 1st Ed. Business Expert Press, New York, NY, USA. 2. Ivan. P. 2016. Managerial Economics. 5th Ed. Abingdon, Oxon, Routledge, NY, USA. 3. Keat, P., and P. K. Young. 2008. Managerial Economics. 6th Ed. Prentice Hall, Upper Saddle River, NJ, USA. 4. Thomas, C. and S. C. Maurice. 2010. Business Economics, 10th Ed. Mc Graw-Hill, India.

	ORGANIZATIONAL BEHAVIOUR	**3(3-0)**

Learning Objectives

- To familiarize students with the basic structured programming skills
- To emphasizes upon problem analysis, algorithm designing, and program development and testing

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**

• **Provide** a basic knowledge of main ideas	C	2	2
• **Develop** an understanding of these and of related ideas and concepts	C	3	2
• **Develop** skills in diagnosis and problem solving	C	4	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure) 10 (Reduced Inequalities)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to OB; People-centered organizations and ethical conduct; Organizational culture; Socialization; Mentoring; Key individual differences; Values, attitudes, job satisfaction and counterproductive work behaviours; Social perceptions and attributions; Foundations of motivation; Improving job performance with goals, feedback, rewards, and positive reinforcement; Group dynamics; Developing and leading effective teams; Individual and group decision making; Managing conflict and negotiating; Communicating in the digital age; Leadership, influence, empowerment, and politics; Organizational design.

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam

Text Book:

1. Huczynski, A. and A. D. Buchanan 2010. Organizational Behavior. Financial Times Prentice Hall, Upper Saddle River, NJ, USA.

Suggested Readings:

1. Johnson, C. E. 2011. Meeting the Ethical Challenges of Leadership: Casting Light or Shadow. 4th Ed. SAGE Publications, Thousand Oaks, CA, USA.
2. Kreitner, R. and A. Kinicki.2012. Organizational Behavior. 10th Ed. McGraw- Hill, New York, NY, USA.

3. Parikh, P. 2009. Value Investing and Behavioral Finance. Tata McGraw-Hill Education, India.
4. Robbins, P. and T. A. Judge. 2012. Organizational Behavior. 15th Ed. Prentice Hall, Upper Saddle River, NJ, USA.

	IOT IN DIGITAL AGRICULTURE	**3(2-1)**

Learning Objectives

To enable students to understand:

- Basics of digital latest digital agriculture technologies (DATs)
- Develop an understanding about underlying processes in digital technologies focus on agricultural issues and challenges related to precision management.
- To describe the basics of IoT, the technology used to build smart devices, how they communicate, how they store data, and the kind of distributed systems needed to support them.
- Develop and apply the simple decision support system (DSS) for better utilization of resources in agriculture and crop production.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Know about basics understanding of core concepts of DATs focused on case study and potential impacts	C	2	2
• Describe what IoT is and recognize the factors contributed to the emergence of IoT	C	2	2
• Design and program IoT devices	C	3	2, 3
• Use real IoT protocols for communication	C	2	2
• Develop a simple DSS using IoT to gather agriculture generated data	P	3	4
• Transfer IoT data to the cloud and in between cloud providers	P	3	4
• Define the infrastructure for supporting Commercialization of Product	C	2	7

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain	
SDGS addressed in the course:	2 (Zero Hunger) 9 (Industry, Innovation, and Infrastructure) 11 (Sustainable Cities and Communities)
Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system	
Course Contents	
Theory	
Introduction: Overview and basics concepts of ICT, IoT and DSS in agriculture, Understanding of innovative and latest digital technologies including sensors, unmanned aerial vehicle (UAVs) robotics, communication networks, artificial intelligence, machine learning and big data analysis tools for agriculture and sustainable crop production; Basics of IoT: What is IoT?, IoT standards and protocols, IoT platform and applications, IoT product development for agriculture, IoT security in the Internet; IoT Development Platform: Introduction to Raspberry Pi as the core development platform; IoT Programming for Multi Sensors: Introduction to Python programming for IoT development, Introduction to GrovePi+/PiHat Shields as the multi-sensor platforms; Introduction to the Standard Lightweight IoT Protocol (MQTT): Open source industry IoT communication protocol namely Message Queue Telemetry Transport (MQTT); Polishing IoT systems for product pitching.	
Practical	
Basic hands-on for Raspberry Pi Operating system; Hands-on for using input/output pins for controlling IoT related sensors and devices (e.g., LED, Buttons, etc.) to gather agriculture-generated data; Hands on to setup and deploy multiple sensors for data collections (e.g., sensors: temperature, humidity, soil moisture, greenhouse gases, water, rainfall, light, current, vibration etc.); Hands on to enable sensor connectivity using machine-to-machine (M2M) communication; Hands on to extremely lightweight publish/subscribe messaging transport protocol on Raspberry Pi and PC/Laptop; Hands on to publish/subscribe data from multi-sensors; Hands on controlling/monitoring IoT sensors and systems using Mobile Application; Hands on to enhance the integration of IoT sensors and systems for seamless connectivity; Hands on to polishing the GUI for user-friendly interface; Commercialization pitching of the proposed IoT projects by students.	
Teaching Methodology:	
Lectures, Written Assignments, Practical labs, Semester Project, Presentations.	
Course Assessment:	
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam	

Text Book:
1. Singh, G. and K. Gurjit. 2021. Digital Technologies for Smart Agriculture; Artificial Intelligence and IoT-Based Technologies for Sustainable Farming and Smart Agriculture, edited by Pradeep Tomar and Gurjit Kaur, pp. 54-67. IGI Global
Suggested Readings:
1. Hassan, Q. F. ed., 2018. Internet of things A to Z: Technologies and Applications. John Wiley & Sons, Hoboken, New Jersey 2. Singh, R., A. Gehlot, L.R. Gupta, B. Singh and M. Swain. 2019. Internet of Things with Raspberry Pi and Arduino. CRC Press. 3. Liyanage, M., A. Braeken, P. Kumar and M. Ylianttila. 2020. IoT Security: Advances in Authentication. John Wiley & Sons. UK 4. Serpanos, D. and M. Wolf. 2017. Internet-of-things (IoT) systems: architectures, algorithms, methodologies. Springer. Atlanta. USA

	PRINCIPLES OF ACCOUNTING	**3(3-0)**

Learning Objectives

- To introduce students with knowledge of accounting required to help them to understand the process of financial management required to develop modern accounting information systems.

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Develop and understand the nature and purpose of financial statements in relationship to decision making.	C	2	2
• Develop the ability to use the fundamental accounting equation to analyze the effect of business transactions on an organization's accounting records and financial statements.	C	3	2
• Develop the ability to use a basic accounting system to create (record, classify, and summarize) the data needed to solve a variety of business problems.	C	3	2
• Develop the ability to use accounting concepts, principles, and frameworks to	C	3	2

analyze and effectively communicate information to a variety of audiences.			
• Develop the ability to use accounting information to solve a variety of business problems.	C	3	2
• Develop the ability to interact well with team members	A	3	6, 9

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	8 (Decent Work and Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to accounting; Accounting principles; Book keeping; Basics of financial statements; Adjustments to financial statements; The cash book; Bank reconciliation; Control accounts; Statement of cash flows; Financial activities; Property; Plant and equipment (PPE); Accounting errors; Accounting for partnerships; Balance sheet.

Teaching Methodology:

Lectures, Written Assignments, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam

Text Book:

1. Ghani, M. A. 2006. Principles of Accounting. Pak Imperial Book Depot, Lahore, Pakistan

Suggested Readings:

1. Meighs, R. F., M. A. Meighs, M. Bettner, and R. Whittington. 2006. Accounting: The Basis of Business Decisions. 11th Ed. McGraw-Hill, New York, NY, USA.
2. Horne, V. J. and M. Wachowicz. 2013. Fundamentals of Financial Management. 13th Ed. Prentice Hall, Upper Saddle River, NJ, USA.

3. Kaluza, J. 2008. Accounting: A Systems Approach. 8th Edition, McGraw-Hills, New York. NY, USA.
4. Wild, J. J., K. D. Larson, B. Chiappetta. 2007. Fundamental Accounting Principles. McGraw-Hill, New York, NY, USA.

	PRINCIPLES OF PSYCHOLOGY	**3(3-0)**

Learning Objectives

- To provides an overview of the history and major issues of psychology
- To emphasizes upon learning and perception, personality theories, abnormal behaviour, motivation and emotion, human development, social psychology

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Understand** the major fields of study and theoretical perspectives	C	2	2
• **Differentiate** between the major observational, correlation, and experimental designs.	C	3	2
• **Identify** the major parts of the nervous system	C	3	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	4 (Quality Education) 5 (Gender Equality) 10 (Reduced Inequalities)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Basics concepts of psychology and research methods; Brain and behavior; Human development; Sensation and perception; States of consciousness; Conditioning and learning; Memory cognition, language, creativity and intelligence; Motivation and emotion; Sex, gender, sexuality; Personality, health, stress and coping; Social behavior.
Teaching Methodology:
Lectures, Written Assignments, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Presentations, Final Exam
Text Book:
1. Dennis, C. and O. M. John. 2011. Psychology, Modules for Active Learning. 12th Ed. Wadsworth Publishing, Nelson Education, Toronto, Canada
Suggested Readings:
1. David, G. M. 2009. Psychology. 9th Ed. Worth Publishers, Basingstoke, UK. 2. Kalat, J. W. 2016. Introduction to Psychology. 11th Ed. Cengage Learning, Boston, MA, USA. 3. Kassin, S. 2017. Psychology in Modules. 12th Ed. Pearson Custom Publishing, Australia. 4. Plotnik, R. and H. Kouyoumdjian. 2013. Introduction to Psychology. 10th Ed. Cengage Learning, Belmont, CA, USA.

	REMOTE SENSING AND GIS APPLICATIONS IN ANIMAL SCIENCES	**3(2-1)**

Learning Objectives

During the course, the student should be able to learn:

- Basic concepts and techniques of GIS and Remote sensing
- How precision farming and how it's applied in Animal Sciences and dairy farming
- Digital Image Processing techniques

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Know** applications of GIS in livestock sector	C	1	2

• **Make** interactive agricultural based map in the internet	C	2	2
• **Demonstrate** different GIS devices	C	3	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	2 (Zero Hunger) 8 (Economic Growth) 9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Introduction to GIS and Remote Sensing; GIS and RS Agriculture; Role and functions of GIS and Remote Sensing in Animal Sciences and dairy farming; Applications of GIS in Livestock sector, Precision farming in Agriculture; Integrating GPS field data into the GIS database; Digital Image Processing Techniques in Animal Sciences; GIS and RS applications in disease management; Interactive agricultural based map in the internet.

Practical

Demonstration and use of different GIS devices; Use of basic Remote sensing techniques;

Computer program and software used for Digital Image processing.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Nicolas B., M. Zribi. 2016. Land Surface Remote Sensing in Agriculture and Forest. Elsevier Publishers. New York, NY, USA.

Suggested Readings:
1. Jian, G. L. P. Mason. 2009. Essential Image Processing and GIS for Remote Sensing. Wiley Publishers, Oxford, UK. 2. Keith, R. M. 2013. Resource Management Information Systems. Remote Sensing, GIS and Modelling. CRC Publishers, Boca Raton, Florida, USA. 3. Marinus, G. B. 2001. GIS and Remote Sensing Techniques in Land- and Water management. Springer Publishers. Netherlands. 4. Steven, M. D. and J. A. Clark. 1990. Applications of remote sensing in Agriculture. Butterworth-Heinemann, Oxford, UK.

	INTRODUCTION AND ROLE OF ICT IN AGRICULTURE	**3(2-1)**

Learning Objectives

This course will enable the students to:

- Understand the scope of ICT in agriculture, networking and communication media
- Understand precision and smart farming and how it is applied in Agriculture
- Comprehend how it can be used to mitigate the impacts of climate change

Learning Outcomes

At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• **Know** applications of ICT in agriculture	C	1	2
• **Know** different tools of ICT and networking used in smart farming and precision agriculture.	C	2	2
• **Demonstrate** applications of ICT in agriculture	C	3	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

SDGS addressed in the course:	2 (Zero Hunger) 8 (Economic Growth)

	9 (Industry, Innovation, and Infrastructure)

Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system

Course Contents

Theory

Module I: Role of ICT in agriculture; How ICT technologies can be used in agricultural productivity; Role of ICT in crop management; Fertilizer and pesticide uses, and pest control management; How ICT help in crops and livestock research and development; How ICTs promote sustainable food systems for Sustainable Development in agriculture.

Module II: Introduction to Geographical Information System (GIS), Geographical Positioning System (GPS) and Remote Sensing (RS) and Its applications in disease/pest management, water management and Climate-Smart Agriculture; Precision farming in Agriculture; Integrating Geographical Positioning System field data into the GIS database; Interactive agriculturally based map in the internet, Fundamental of Internet of things (IoT) and its role in smart farming. How smart farming solutions is useful for monitoring the crop field with the help of sensors (light, humidity, temperature, soil moisture, crop health and automating the irrigation system.

Practical

Use of web and mobile applications for weather prediction, soil information, pesticide and fertilizer application; Use of ICT in reducing risk; pest detection and disease identification; Water scheduling. Application of remote sensing and GIS in agriculture. How meaningful data collect through IoT based solution. How farmer or grower can monitor the field condition remotely through ICT technologies.

Teaching Methodology:

Lectures, Written Assignments, Practical labs, Semester Project, Presentations

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Text Book:

1. Willen, Z. 1994. Improving the transfer and use of agricultural information: guide to information technology (English). World Bank discussion papers; no WDP 256 Washington, D.C., USA: World Bank Group.

Suggested Readings:

1. Price, H. 2012. The Really Useful Book of ICT in Early Years. Taylor and Francis Group, London, UK.
2. Rodrigues, M. and A. Rodrizuez. 2013. Information and Communication Technologies for Agricultural Development in Latin America Trends, Barriers and Policies. United Nations Press, Santiago, Chile.
3. Nicolas, B. and M. Zribi. 2016. Land Surface Remote Sensing in Agriculture and Forest. Elsevier Publishers, NY, USA.
4. Keith, R. M. 2013. Resource Management Information Systems. Remote Sensing, GIS and Modelling. CRC Publishers, Florida, USA.
5. Agricultural Internet of Things and Decision Support for Precision Smart Farming, Academic Press,2020