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BACHELOR OF DATA SCIENCE

PROGRAM OVERVIEW & CURRICULUM DETAILS

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1. Introduction

With the current data deluge, companies, governments, and non-profit organizations alike are striving to convert information into actionable information and insight. The sheer “volume”, “velocity” and “variety” of today’s data pose unique challenges and also creates unique opportunities. Present data sets require more programming, mathematics/statistics, modelling skills, and domain knowledge than a traditional undergraduate curriculum offers.

In every facet of modern life, from online shopping and social networks to scientific research and finance, we collect immensely detailed information. Data scientists are concerned with turning this data into intelligence through the application of cutting-edge techniques in Statistics, Mathematics and Computer Science.

Global demand for combined statistical and computing expertise outstrips supply, with evidence-based predictions of a major shortage in this area for at least the next 15 years. For graduates of Data Science, this shortage presents opportunities to forge careers in a large number of areas involving quantitative data analysis and computational skills. These include commerce (e-commerce), finance, government, genomics, and other areas of “big science", entertainment and sport, education, and academic research. Career opportunities include business intelligence analyst, data mining engineer, data architect and data scientist. Graduates will also be highly adaptable to new data-related challenges as they arise, perhaps in hitherto unforeseen fields.

In line with the guidelines provided by HEC Pakistan, the BS (Data Science) program has been designed in such a way that it focuses on computation, simulation, visualization, prediction of complex phenomena (e.g., customer behavior, economic trends, and medical data) and complex mathematical models to facilitate interpretation of data. The Center of Excellence in IT (CEIT) at IMSciences has highly research-active faculty, who encourage students to be involved in their applied/research work. BS-Data Science degree is excellent preparation for the job market of the future and Data Science majors take up careers in every imaginable field. Our graduates have enjoyed excellent job placements, both within Pakistan and internationally. Many have chosen to make their own successful companies.

1.1 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.

1.2 Eligibility Criteria

- FA/F. Sc or Equivalent qualifications with at least second division, securing 50% marks in aggregate.
- The students who have not studied Mathematics at intermediate level must pass deficiency courses of Mathematics of 6 credit hours within one year of their regular studies.
- Qualifying the admission test and interview is compulsory. A candidate scoring less than 40% marks in the test and interview will stand disqualified for admission.
- Candidates who have secured at least 40% in the NTS-NAT are also eligible to apply.
- The merit of a candidate shall be measured by a 50 % weight age to the marks obtained in HSC or equivalent, 40 % to the marks obtained in the written test, and 10% to the marks obtained in the interview.
- A candidate shall be given a special credit of thirty marks for admission in each program mentioned above if he/she has studied Computer Science and/or statistics at intermediate level (for BS-Data Science program only) at intermediate level or has done A level.
- The Hafiz Quran shall be given a special credit of 20 marks.
- The credit marks shall be added to the marks obtained at HSC or equivalent, subject to fulfilment of basic eligibility criteria of 50% marks.

1.3 Degree Requirements

For a BS-Data Science 4-year degree, a student is required to complete a minimum of 130-140 credit hours including a 6-credit hour research thesis/project. The normal duration for completion of BS-Data Science degree is 8 semesters over a period of 4 years. The maximum duration for obtaining BS-Data Science degree shall be 7 years.

1.4 Program Education Objectives (PEOs)

Following are the Program Education Objectives (PEOs) of BS-Data Science.

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.

1.5 Program Learning Outcomes (PLOs)[1] of BS-Data Science

1. Completion of an accredited program of study designed to prepare graduates as Data Science professionals (**Academic Education**).
2. Apply knowledge of mathematics, statistics, natural sciences, computing fundamentals, and a data specialization to the solution of complex data science problems. **(Computing and Data Science Knowledge).**
3. Identify, formulate, research literature, and analyze/solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, statistics, computing sciences, and relevant domain disciplines (**Problem Analysis**).
4. 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 (**Design/ Development of Solutions**)
5. Create, select, adapt, and apply appropriate techniques, resources, and modern computing/data science tools including prediction and modelling for complex data science problems. (**Modern Tool Usage**)
6. Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings (**Individual and Teamwork**)
7. Communicate effectively with the computing community and with society about complex computing/data science activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions (**Communication**)
8. Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice (**Computing Professionalism and Society**)

[1] Adopted from Washington Accord

9. Understand and commit to professional ethics, responsibilities, and norms of professional computing practice (**Ethics**)
10. Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional (**Lifelong Learning**)

Upon completion of BS-Data Science degree, all the students should have attained the aforementioned ten SOs.

1.6 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-DATA SCIENCE

COMMON COURSES			
Course Group	**Min. No. of Credit Hours**	**Min. No. of Courses**	**Percentage**
General Education	19	7	14.2 %
Mathematics & Science Foundation	15	5	11.2 %
Computing Core	39	11	29.3 %
Institute Electives	12	4	09.0 %
Common Courses	**85**	**27**	**64.0 %**
DOMAIN COURSES			
Computer Science Core	18	5	13.5 %
DS Core (Domain Core)	18	6	13.5 %
DS Electives (Domain Electives)	12	4	09.0 %
Domain Courses	**48**	**15**	**36.0 %**
TOTAL	**133**	**42**	**100%**

General Education Courses

Course Code	Course Title	Credit Hours	Contact Hours
CSC 301	Introduction to Information & Communication Technologies	3 (2-1)	2-3
ENG 301	English (General)	3 (3-0)	3-0
ENG 302	English (Functional)	3 (3-0)	3-0
ENG 401	English (Academic)	3 (3-0)	3-0
HSS 305	Fundamentals of Islamic Studies/ Ethics	2 (2-0)	2-0
HSS 301	Fundamentals of Pakistan Studies	2 (2-0)	2-0
CSC 595	Professional Practices	3 (3-0)	3-0
TOTAL		**19 (18-1)**	**18-3**

Mathematics and Science Foundation Courses

Course Code	Course Title	Credit Hours	Contact Hours
MTH 311	Calculus & Analytical Geometry	3 (3-0)	3-0
MTH 315	Linear Algebra	3 (3-0)	3-0
STA 415	Probability & Statistics	3 (2-1)	2-3
MTH 505	Differential Equations	3 (3-0)	3-0
PHY	Applied Physics	3 (3-0)	3-0
TOTAL		**15 (14-1)**	**14-3**

Computing Core Courses

Course Code	Course Title	Credit Hours	Contact Hours
CSC 305	Programming Fundamentals	4 (3-1)	3-3
CSC 321	Discrete Structures	3 (3-0)	3-0
CSC 315	Object Oriented Programming	4 (3-1)	3-3
CSC 451	Database Systems	4 (3-1)	3-3
CSC 401	Data Structures & Algorithms	4 (3-1)	3-3
CSC 556	Information Security	3 (3-0)	3-0
CSC 575	Computer Networks	4 (3-1)	3-3
CSC 465	Operating Systems	4 (3-1)	3-3
SWE 401	Software Engineering	3 (3-0)	3-0
FYP 611	Final Year Project - I	3 (0-3)	0-9
FYP 612	Final Year Project - II	3 (0-3)	0-9
TOTAL		**39 (27-12)**	**27-36**

Institute Elective Courses

(Must be any FOUR courses or 12 credit hours, not limited to the areas listed below, Institutions may add/replace courses)

Course Code	Course Title	Credit Hours	Contact Hours
ACC 301	Fundamentals of Accounting	3 (3-0)	3-0
BUS 301	Introduction to Business	3 (3-0)	3-0
ENI 301	Entrepreneurship	3 (3-0)	3-0
FIN 301	Fundamentals of Business Finance	3 (3-0)	3-0
HRM 301	Fundamentals of Human Resource Management	3 (3-0)	3-0
HSS 311	Fundamentals of Sociology	3 (3-0)	3-0
HSS 415	Fundamentals of Psychology	3 (3-0)	3-0
HSS 505	Logic and Critical Thinking	3 (3-0)	3-0
MGT 301	Principles of Management	3 (3-0)	3-0
POL 301	Introduction to Political Science	3 (3-0)	3-0
POL 501	International Relations	3 (3-0)	3-0
LAN 512	Regional Language (Pashto)	3 (3-0)	3-0
LAN 513	Regional Language (Sindhi)	3 (3-0)	3-0
LAN 514	Regional Language (Punjabi)	3 (3-0)	3-0
LAN 521	Foreign Language (French)	3 (3-0)	3-0
LAN 522	Foreign Language (Chinese)	3 (3-0)	3-0
LAN 523	Foreign Language (German)	3 (3-0)	3-0
LAN 524	Foreign Language (Persian)	3 (3-0)	3-0
CSC 550	Computing and Society	3 (3-0)	3-0
TOTAL		**12 (12-0)**	**12-0**

Domain Courses for BS-Data Science
Computer Science CORE Courses

Course Code	Course Title	Credit Hours	Contact Hours
CSC 601	Artificial Intelligence	4 (3-1)	3-3
CSC 405	Digital Logic Design	4 (3-1)	3-3
CSC 531	Design and Analysis of Algorithms	3 (3-0)	3-0
CSC 411	Computer Organization & Assembly Language	4 (3-1)	3-3
SWE 539	Parallel & Distributed Computing	3 (3-0)	3-0
TOTAL		**18 (15-3)**	**15- 9**

Data Science CORE Courses

Course Code	Course Title	Credit Hours	Contact Hours
STA 421	Advanced Statistics	3 (2-1)	2-3
DSC 301	Introduction to Data Science	3 (2-1)	2-3
CSC 661	Data Mining	3 (2-1)	2-3
DSC 635	Data Visualization	3 (2-1)	2-3
DSC 625	Data Warehousing & Business Intelligence	3 (2-1)	2-3
DSC 642	Big Data Analytics	3 (2-1)	2-3
TOTAL		**18 (12-6)**	**12-18**

Data Science ELECTIVES Courses

(Must be any FOUR courses or 12 credit hours, not limited to the areas listed below, Institute may add/replace courses)

Course Code	Course Title	Credit Hours	Contact Hours
DSC 525	Social Network Analysis	3 (3-0)	3-0
DSC 528	Pattern Recognition	3 (3-0)	3-0
DSC 531	Econometrics for Big Data Analysis – I	3 (2-1)	2-3
DSC 551	Statistical Thinking for Data Science & Analytics	3 (2-1)	2-3
DSC 601	Predictive Analytics for Business	3 (2-1)	2-3
CSC 611	Advanced Database Systems	3 (3-0)	3-0
CSC 685	Machine Learning	3 (2-1)	2-3
DSC 675	Deep Learning and Applications	3 (3-0)	3-0
CSC 501	Theory of Automata	3 (3-0)	3-0
CSC 605	Artificial Neural Networks	3 (3-0)	2-3
DSC 541	Business Process Management	3 (3-0)	3-0
CSC 618	Speech Processing	3 (3-0)	3-0
CSC 631	Cloud Computing	3 (3-0)	3-0
CSC 619	Text Mining	3 (3-0)	3-0
DSC 521	Topics in Data Science	3 (3-0)	3-0
CSC 453	Fundamentals of Internet of Things (IoT)	3 (3-0)	3-0
CSC 637	Selected Topics in Internet of Things (IoT)	3 (3-0)	3-0
CSC 571	Mobile Application Development	3 (3-0)	3-0
CSC 505	Real-Time Systems	3 (3-0)	3-0
CSC 551	E-Commerce	3 (3-0)	3-0
TOTAL (Any four courses or 12 credit hours)		**12 (x-x)**	**x-x**

2. BS-Data Science – Semester-wise Breakdown

4-Year Program (8 Regular Semester of 18 weeks each) (133 Credit Hours)

Semester 1				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 301	Introduction to Information and Communication Technologies	3 (2-1)	2-3	
CSC 305	Programming Fundamentals	4 (3-1)	3-3	
ENG 301	English (General)	3 (3-0)	3-0	
HSS 301	Fundamental of Pakistan Studies	2 (2-0)	2-0	
MTH 311	Calculus and Analytical Geometry	3 (3-0)	3-0	
PHY 305	Applied Physics	3 (3-0)	3-0	
Total		**18(16-2)**	**16-6**	

Semester 2				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite(s)**
CSC 315	Object Oriented Programming	4 (3-1)	3-3	Programming Fundamentals
CSC 321	Discrete Structures	3 (3-0)	3-0	
ENG 302	English (Functional)	3 (3-0)	3-0	English (General)
HSS 305	Fundamentals of Islamic Studies	2 (2-0)	2-0	
MTH 315	Linear Algebra	3 (3-0)	3-0	Calculus and Analytical Geo.
DSC 301	Introduction to Data Science	3 (2-1)	2-3	
Total		**18(16-2)**	**16-6**	

Semester 3				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 401	Data Structures and Algorithms	4 (3-1)	3-3	Programming Fundamentals
CSC 405	Digital Logic Design	4 (3-1)	3-3	Applied Physics
STA 415	Probability and Statistics	3 (2-1)	2-3	
MTH 505	Differential Equations	3 (3-0)	3-0	Calculus and Analytical Geo.
SWE 401	Software Engineering	3 (3-0)	3-0	
Total		**17(14-3)**	**14-9**	

Semester 4				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 411	Computer Organization & Assembly Language	4 (3-1)	3-3	DLD, Prog. Fundamentals
CSC 451	Database Systems	4 (3-1)	3-3	
CSC 465	Operating Systems	4 (3-1)	3-3	Data Structures & Algo.
CSC 601	Artificial Intelligence	4 (3-1)	3-3	OOP, Data Structure & Algo.
STA 421	Advanced Statistics	3 (2-1)	2-3	Probability and Statistics
Total		**19(14-5)**	**14-15**	

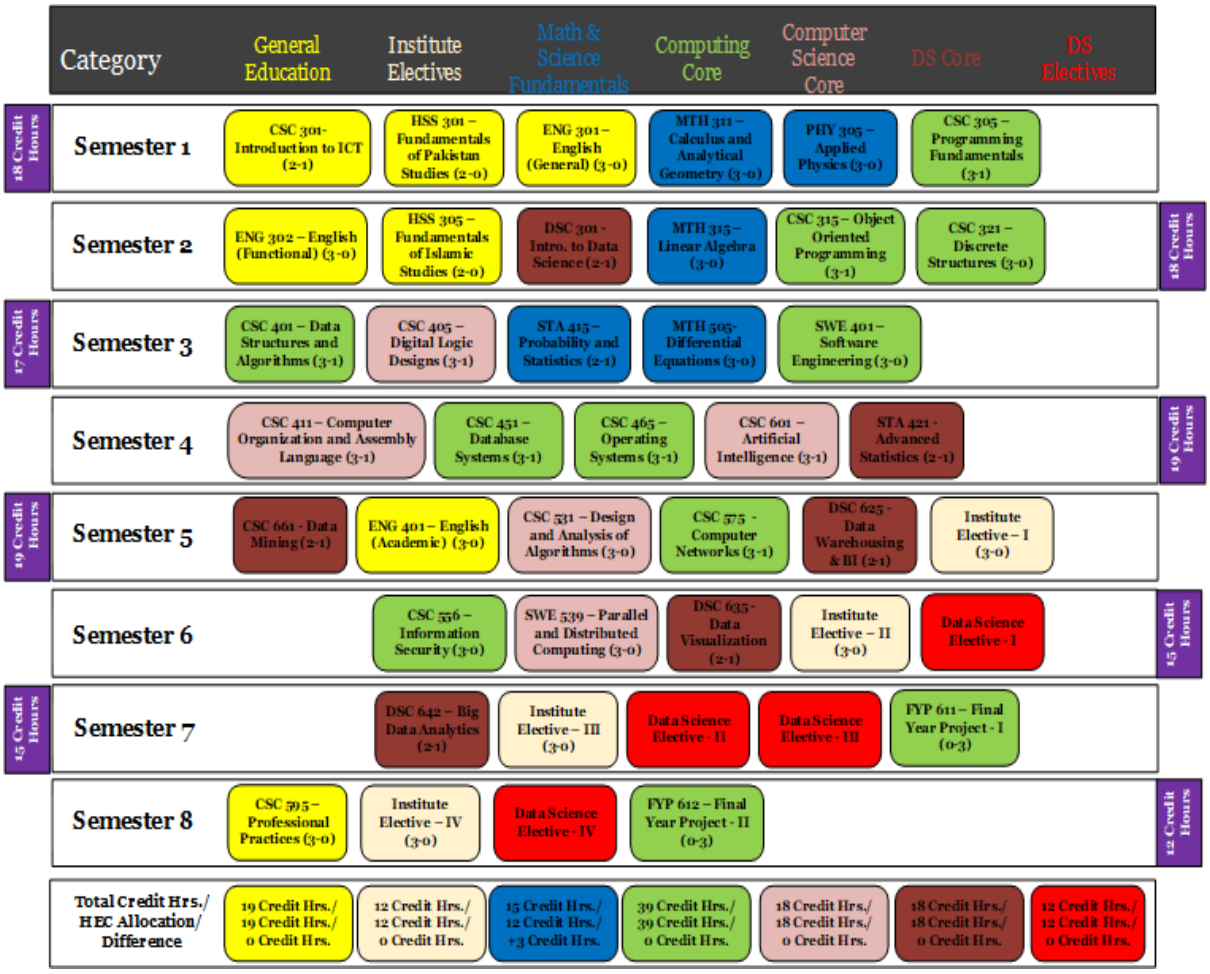
Semester 5				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 661	Data Mining	3 (2-1)	2-3	Adv. Stat, Intro. to DS
ENG 401	English (Academic)	3 (3-0)	3-0	English (Functional)
CSC 531	Design and Analysis of Algorithms	3 (3-0)	3-0	Data Structures & Algo.
CSC 575	Computer Networks	4 (3-1)	3-3	
DSC 625	Data Warehousing & Business Intelligence	3 (2-1)	2-3	Intro. to Data Science
-	Institute Elective – I	3 (3-0)	3-0	
Total		**19(16-3)**	**16-9**	

Semester 6				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 556	Information Security	3 (3-0)	3-0	
SWE 539	Parallel and Distributed Computing	3 (3-0)	3-0	OOP, Operating Systems
DSC 635	Data Visualization	3 (2-1)	2-3	Data Warehouse & BI
-	Institute Elective – II	3 (3-0)	3-0	
-	DS Elective – I	3 (x-x)	x-x	
Total		**15(x-x)**	**x-x**	

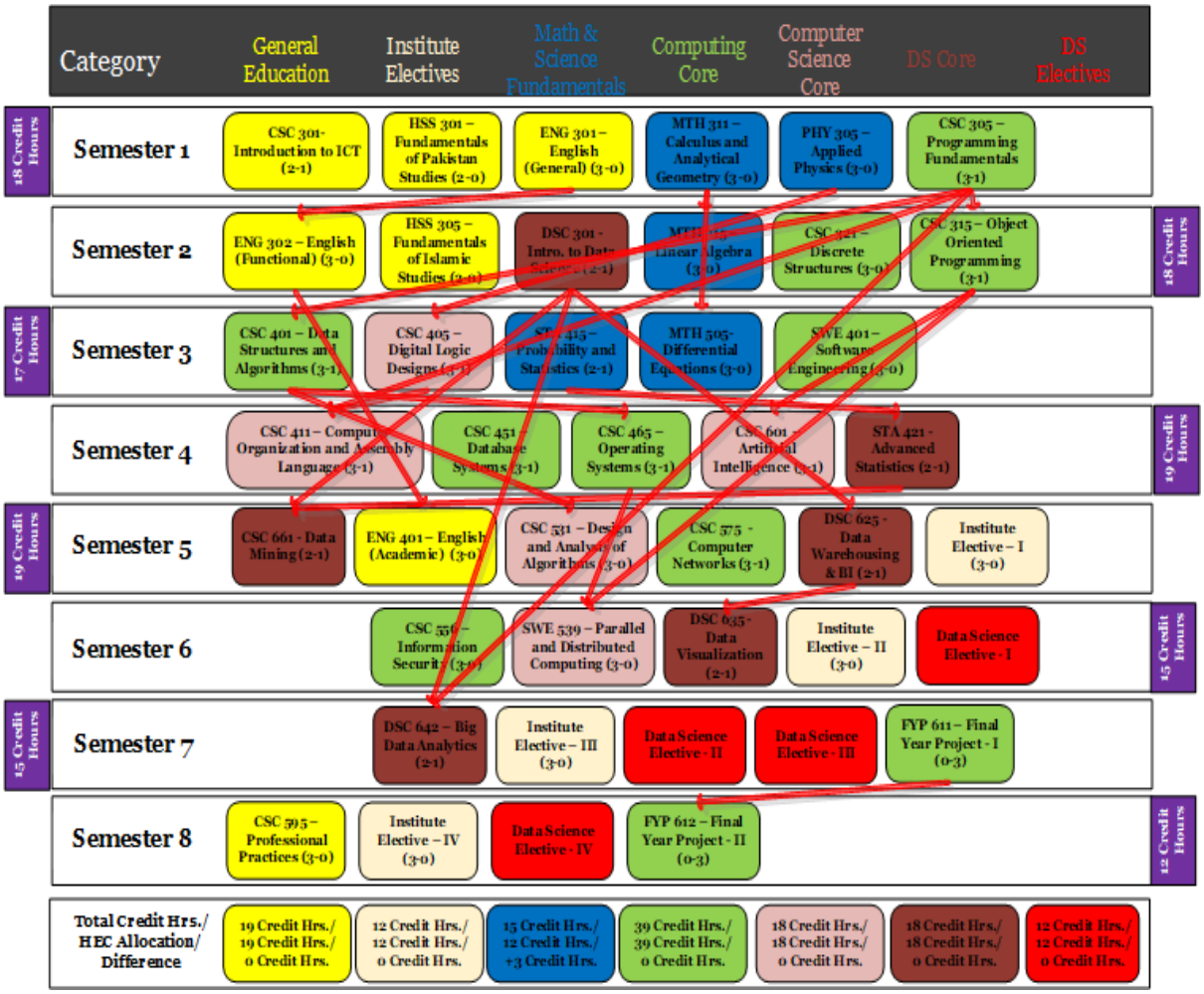
Semester 7				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
DSC 642	Big Data Analytics	3 (2-1)	2-3	Intro. to DS., Prob. & Stat., Prog. Fundamentals
-	Institute Elective - III	3 (3-0)	3-0	
-	DS Elective – II	3 (x-x)	x-x	
-	DS Elective - III	3 (x-x)	x-x	
FYP 611	Final Year Project - I	3 (0-3)	0-9	
Total		**15(x-x)**	**x-x**	

Semester 8				
Course Code	**Course Title**	**Credit Hours**	**Contact Hours**	**Pre-requisite**
CSC 595	Professional Practices	3 (3-0)	3-0	
-	Institute Elective - IV	3 (3-0)	3-0	
-	DS Elective - IV	3 (x-x)	x-x	
FYP 612	Final Year Project - II	3 (0-3)	0-9	Final Year Project - I
Total		**12(x-x)**	**x-x**	

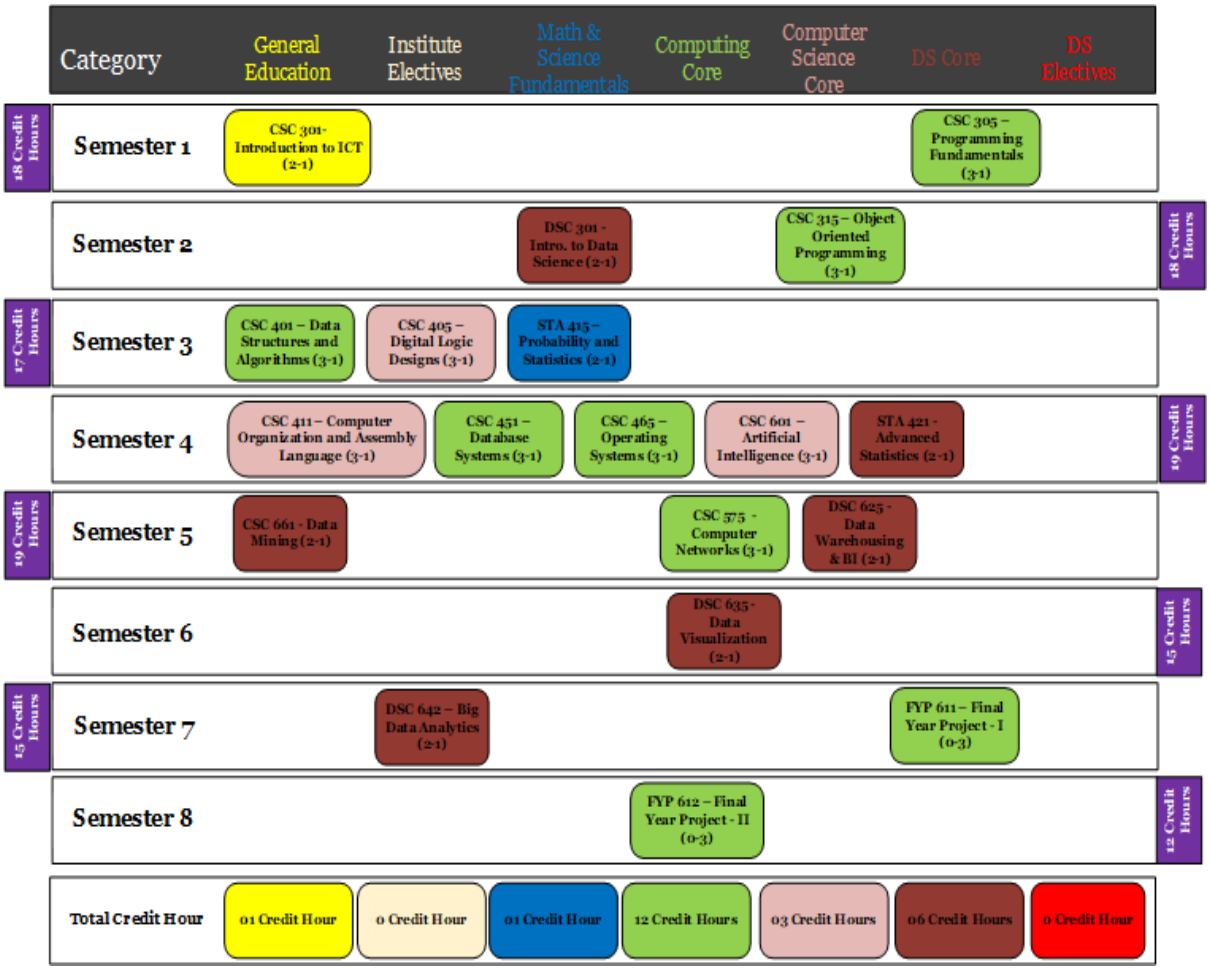
2.1 Detail overview of courses in BS-Data Science



2.2 Dependency Graph for Courses of BS-Data Science



2.3 Distribution of Labs for Courses of BS-Data Science



3. Course Outlines

Following are the course outlines of all the courses in BS-Data Science.

Introduction to Information & Communication Technology

Credit Hours	3 (2-1)	Prerequisites	None

Course Introduction:

This is an introductory course in Computer Science designed for beginners. Apart from leading the participants through a whirlwind history of computing, the course also develops a feel for web programming through a series of lectures that help the students develop their own web page. Main objective of the course is to build an appreciation for the fundamental concepts in computing and to become familiar with popular PC productivity software.

Course Objectives

Upon successful completion of a major in Introduction to ICT, students will be able to;

- Demonstrate proficiency in problem-solving techniques using the computer.
- Identify and describe major hardware components, basics of storage devices, number systems, machine cycle, microcomputer processor and use communications and networking terminology further include Internet operations and its uses.
- Students will be able to develop understanding of Computer programming is by its nature inherently mathematical.
- Learning programming language is challenging and difficult and hard work for most students but upon completing this course the students should be able to understand the basic concepts related to programming.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
1. Understand basics of computing technology	C1	Knowledge
2. Do number systems conversions and arithmetic.	C2	Understanding
3. Have knowledge of types of software	C2	Understanding
4. Have knowledge of computing related technologies	C3	Apply

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

Course Content:

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 Computers (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, and 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.

Teaching Methodology:
Lecturing, Written Assignments, Project, Practical Labs, Final Exam
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Waring, R. (2017) Communication Technology. Seed Learning. 2. Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA 3. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017. 4. Zawacki-Richter, Olaf, and Colin Latchem. "Exploring four decades of research in Computers & Education." Computers & Education 122 (2018): 136-152. 5. Sinha, Pradeep K., and Priti Sinha. Computer fundamentals. BPB publications, 2010. 5. Goel, Anita. Computer fundamentals. Pearson Education India, 2010.

English General

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

General English and Intensive English courses are designed to help students make rapid progress in English and focus on the four key language skills – reading, writing, listening, and speaking – with lots of additional work on vocabulary, grammar, and pronunciation.

Course Objectives:

- To evaluate information and its sources critically.
- To incorporate selected information into one's knowledge base.
- To use information effectively to accomplish a specific purpose

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Enrich the thought and culture and provides us with the most important international vehicle of expression.	C1	Remember
2. Enhance English language skills of the students and develop their critical thinking.	C3	Apply
3. Demonstrate ability to think critically	C3	Apply

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

Course Content:

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:

Lecturing, Written Assignments, Project, Practical Labs, Final Exam

Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute, 2000 2. Comprehensive objective general English: For all competitive exams (with practice sets): For Bank (PO/MT/Clerk), RBI, LIC, SSC (CGL, MTS, LDC), UPSC, IES, SCRA, RRB, NDA, cds, Armed Forces, MBA, Nift Jimper, Hotel Management, MCA, Clat, CTET, B. Ed. & other examinations (2016). New Delhi: Source Books a unit of Viva Books Private Limited. 3. 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. 4. Smalley, R. L., M. K Ruetten and D. Kozyrev. 2001. Refining Composition Skills. 4th Ed. Heinle & Heinle Inc., Boston, MA, USA. 5. Vawdrey C. 1993. Practical Business English. 2nd Ed. Richard d Irwin Publishing, New York City, NY, USA.

English Functional			
Credit Hours	3 (3-0)	**Prerequisites**	English General

Course Introduction:
Functional English is usage of the English language required to perform a specific function. This is typically taught as a foundation subject when a good command of English is required for academic study and career progression.
Course Objectives:
• Strengthen the language skills in order for the students to use language effectively as a tool to succeed in academic activities which they will be carrying out as part of their academic activities. • Enhance the development of all the four language skills but explicitly focuses on listening, reading, and writing; and the efforts made in these areas are perceived to implicitly target proficiency and accuracy in the target language, English. The language skills are coincided with study skills which are directly required by students as basic skills to pursue other subjects more meaningfully
Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Deliver effective presentations and participate actively in group discussions	C3	Apply
2. Complete Academic Writing tasks using writing process and strategies according to genres	C5	Evaluate
3. Use Language Skills and Strategies in different situations, for a variety of functions	C5	Evaluate

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

Course Content:
Basics of Grammar, Parts of speech and use of articles, Sentence structure, Active and passive voice, Practice in unified sentence, Analysis of phrase, Clause and sentence structure, Transitive and intransitive verbs, Punctuation and spelling, Comprehension, Answers to questions on a given text, General topics and everyday conversation, Translation skills (Urdu to English), Paragraph writing, Presentation skills, Extensive reading is

required for vocabulary building
Teaching Methodology:
Lecturing, Written Assignments, Project, Practical Labs, Final Exam
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41. 2. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19453402 2. 3. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492 4. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

English Academic			
Credit Hours	3 (3-0)	**Prerequisites**	English Functional

Course Introduction:

English for Academic Purposes (EAP), commonly known as Academic English, entails training students, usually in a higher education setting, to use language appropriate for study. It is one of the most common forms of English for Specific Purposes (ESP).

Course Objectives:

The primary objectives for this course are to:

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

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Interact with academic content: reading, writing, listening, and speaking.	C1	Knowledge
2. Demonstrate ability to think critically.	C3	Apply
3. Utilize information and digital literacy skills.	C3	Apply

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

Course Content:

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:

Lecturing, Written Assignments, Project, Practical Labs, Final Exam

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Effective Communication Skills: The Foundations for Change, John Nielsen, 2008, ISBN = 1453506748
2. Smalley, R. L., M. K Ruetten and D. Kozyrev. 2001. Refining Composition Skills. 4th Ed. Heinle & Heinle Inc., Boston, MA, USA.
3. Schriver, K. A. 1997. Dynamics in Document Design. 3rd Ed. Wiley Inc. 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. Masami, I. 2004. Algebraic Theory of Automata and Languages. World Scientific, River Edge, NJ, USA.

Fundamentals of Islamic Studies			
Credit Hours	2 (2-0)	**Prerequisites**	None

Course Introduction:

An Introduction to the academic understanding of Islam. Topics may include Faith, rituals, law (Shari'ah), jurisprudence (Fiqh), theology (Kalam), and stories from the Islamic heritage. Non-Western multicultural course.

Course Objectives:

This course will:

- Enable the learners to develop knowledge and interest towards Shariah, Quran, and Hadith.
- Assist the learners in character building and to develop Islamic approach & thinking amongst the students.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain the basic concepts of Shariah, Quran, and Hadith.	C2	Outlook towards profession, ethics, and society
2. Demonstrate the Islamic approach and thinking through their positive and religious character	C3	Reflection and critical thinking skills

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

Course Content:

Basic Concepts of Quran, History of Quran, Uloom-ul –Quran, Verses of Surah Al-Baqra Related to Faith(Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab Al-Nabi(Verse No-1-18), Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Basic Concepts of Hadith, History of Hadith, Kinds of Hadith, Uloom –ul-Hadith, Sunnah & Hadith, Legal Position of Sunnah, Basic Concepts of Islamic Law & Jurisprudence, History & Importance of Islamic Law & Jurisprudence, Sources of Islamic Law & Jurisprudence, Nature of Differences in Islamic Law, Basic Concepts of Islamic Culture & Civilization, Historical Development of Islamic Culture & Civilization, Characteristics of Islamic Culture & Civilization, Islamic Culture & Civilization and Contemporary Issues

Teaching Methodology:

Lecturing, Written Assignments, Final Exam

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Principles of Islamic Jurisprudence by Ahmad Hassan, Islamic Research Institute, IIUI
2. Muslim Jurisprudence and the Quranic Law of Crimes, By Mir Waliullah, Islamic Books Services
3. Waliullah M., 1982. Muslim Jurisprudence and the Quranic Law of Crimes. 2nd Ed. Islamic Book Service, Karachi, Pakistan.

Fundamentals of Pakistan Studies

Credit Hours	2 (2-0)	**Prerequisites**	None

Course Introduction:

Pakistan Studies is the integrated, coordinated, and systematic area of study that draws upon various social science disciplines such as history, geography, anthropology, economics, political science, and sociology in relation to Pakistan. It is one of the compulsory courses at the secondary school and higher secondary school levels of education. The social science departments of many universities offer it as a degree course, but there are also university departments dedicated to the education and research in Pakistan Studies.

Course Objectives:

The course aims to:

- Familiarize the students to their past and present, focusing on the history and ideology of Pakistan, its contemporary issues and foreign policy.
- Inculcate in students the sense of belonging to Pakistan in order to make them useful members of the society who can benefit the country by expanding developments in different fields.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Demonstrate the basic knowledge of the historical and ideological perspectives of Pakistan, its current challenges, and its relationship with the neighboring countries.	C2	Individual and Teamwork
2. Identify the role of different systems, treaties and conventions established to cater human rights at national and international level.	C4	Life-long Learning

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

Course Content:

Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah., Factors leading to Muslim separatism, People and Land, Indus Civilization, Muslim advent, Location and Geo-Physical features, Economic institutions and issues, Society and social structure, Ethnicity, Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan, Political and constitutional phases: (1947-58, 1958-71, 1971-77, 1977-88, 1988-99, 1999 onward).

Teaching Methodology:

Lecturing, Written Assignments, Project, Practical Labs, Final Exam

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Professional Practices

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

Professional Practice is a term used to describe activities, which will help you apply your knowledge to your industry, job role or workplace.

Course Objectives:

The primary objectives are:

1. Introduce the basic concepts and importance of ethics that can be mapped in the professional lives.
2. Highlight the Impact of social media and social implications of computing and networked communication regarding ethics and morality
3. The making and implementation of framework for ethical decision making
4. An understanding of professional ethical theories and code of ethics (IEEE/ACM)
5. Demonstrate the concepts of intellectual property and privacy, their rights, laws, and their types
6. Highlight the concepts of anonymity, security policies, computer crimes, social engineering, and to provide the guidelines for a sustainable practitioner.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Know the scope of computing field after graduating in it and what are the common things in every organization.	C1	Knowledge
2. Distinguish between various fields of computing.	C2	Problem Solving
3. Describe the core of any profession.	C3	Understanding
4. Write and analyze software contracts as an employer or to an employer.	C3	Analysis
5. Know the business and professional environment of software house.	A2	Ethics

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

Course Content:

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:

Lecturing, Written Assignments, Project, Practical Labs, Final Exam

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Habash, R. (2019) Professional practice in engineering and Computing: Preparing for future careers. Boca Raton: CRC Press.
2. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition (January 3, 2009).
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (3rd Edition) by Sara

Baase, Prentice Hall; 3rd Edition (2008). ISBN-10: 0136008488.

Calculus & Analytical Geometry

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

This freshmen level course has been designed to introduce the ideas and concepts of Calculus that would serve as a foundation for subsequent computer engineering courses. The primary objective is to endow the knowledge of basic concepts of calculus and geometry. Purpose of this course is to build the student's knowledge of differential/integral calculus of multi-variable functions based on their experience of differential/integral calculus and analytic geometry of functions of one independent variable, at the Intermediate level.

Course Objectives:

- The primary objective is to endow the knowledge of basic concepts of calculus and geometry.
- Purpose of this course is to build the student's knowledge of differential/integral calculus of multivariable functions based on their experience of differential/integral calculus and analytic geometry of functions of one independent variable, at the Intermediate level.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Comprehend key concepts of single variable calculus, differential calculus, integral, multivariate calculus, and analytical geometry.	C2	Understanding
2. Apply the fundamentals of functions, limits and continuity, derivative, integration, Partial differentiation to engineering problems.	C3	Knowledge
3. Solve problems of analytical geometry using rectangular co-ordinates systems in 3 dimensions.	C3	Problem Solving

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

Course Content:

Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of funding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential calculus; Concept and idea of differentiation, Geometrical and Physical meaning of derivatives, Rules of differentiation, Techniques of differentiation, Rates of change, Tangents and Normal lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation; Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity, Integral calculus; Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve, Analytical Geometry; Straight lines in R3, Equations for planes

Teaching Methodology:

Lecturing, Written Assignments

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Calculus and Analytic Geometry by Kenneth W. Thomas.

2. Calculus by Stewart, James.
3. Calculus by Earl William Swokowski; Michael Olinick; Dennis Pence; Jeffery A. Cole.

Linear Algebra

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

This Course covers matrix theory and linear algebra emphasizing topics useful in other disciplines is a requirement for mathematics, and it's highly recommended for engineering majors. Topics include systems of linear equations and their solutions, matrices and matrix algebra, inverse matrices; determinants; real n-dimensional vector spaces, abstract vector spaces and their axioms, linear transformation; dot/ cross products, Subspaces, linear independence, bases for vector spaces, dimension, matrix rank, eigenvectors, eigenvalues, and matrix diagonalization. Some applications of linear algebra will be discussed, such as Kirchhoff's laws.

Course Objectives:

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

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Apply the basic operation of matrix algebra.	C3	Application
2. Demonstrate the concepts of two and three-dimensional geometry.	C3	Understanding
3. Discuss the area, volumes of bounded regions by using multiple integrals.	C3	Knowledge

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

Course Content:

System of Linear Equations and Matrices, Introduction to system of linear equations, Matrix form of system of Linear Equations, Gaussian Elimination method, Gauss-Jorden Method, Consistent and inconsistent systems, Homogeneous system of equations, Vector Equations, Introduction to vector in plane, Vector form of straight line, Linear Combinations, Geometrical interpretation of solution of Homogeneous and Non-homogeneous equations, Applications of Linear Systems, Traffic Flow Problem, Electric circuit Problem, Economic Model, Linear transformations, Introduction to linear transformations, Matrix transformations, Domain and range of linear transformations, Geometric interpretation of linear transformations, Matrix of linear transformations, Inverse of a matrix, Definition of inverse of a matrix, Algorithm to find the inverse of matrices, LU factorization, Introduction to determinants, Geometric meaning of determinants, Properties of determinants, Crammer Rule, Cofactor method for finding the inverse of a matrix, Definition of vector spaces, Subspaces, Spanning set, Null Spaces and column spaces of linear transformation, Linearly Independent sets and basis, Bases for Null space and Kernel space, Dimension of a vector space, Introduction to Eigen value and Eigen vectors, Computing the Eigen values, Properties of Eigen values, Diagonalization, Applications of Eigen values.

Teaching Methodology:

Lecturing, Written Assignments

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Elementary Linear Algebra by Howard Anton Linear Algebra and its Applications by Gibert Strang

Probability & Statistics			
Credit Hours	3 (2-1)	**Prerequisites**	None

Course Introduction:

This course introduces probability and statistics with applications. Topics include basic probability models; combinatory; random variables; discrete and continuous probability distributions; statistical estimation and testing; confidence intervals; and an introduction to linear regression.

Course Objectives:

- The successful completion should develop understanding of the systems which involve uncertainty.
- Further, it should lay down the analyzing and evaluating techniques for these systems.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
On completion of this course, the student will be able to:		
1. Explain the basic concept of Statistics and Probability and their need in engineering/Science.	C2	Explanation
2. Analyze random variables, probability distributions and sampling distributions.	C4	Analyze
3. Apply different probability and statistics techniques in engineering problems	C3	Apply

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

Course Content:

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, F- Quantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P- Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two- Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

Teaching Methodology:

Lecturing, Written Assignments, Presentation, Final Exam
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Report Writing, Presentation, Final Exam
Reference Materials:
1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying E. Ye, Pearson; 9th Edition (January 6, 2011). ISBN-10: 0321629116 2. Probability and Statistics for Engineers and Scientists by Anthony J. Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10:0495107573 3. Schaum's Outline of Probability and Statistics, by John Schiller, R. Alu Srinivasan and Murray Spiegel, McGraw-Hill; 3rd Edition (2008). ISBN-10:0071544259

Differential Equations			
Credit Hours	3 (3-0)	**Prerequisites**	Calculus and Analytical Geometry
Course Introduction:			
A description of how something continuously changes over time. Some differential equations can have an analytical solution such that all future states can be known without simulation of the time evolution of the system. However, most can have a numerical solution with only limited accuracy.			
Course Objectives:			
1. The course develops students' fundamental skills of solving ordinary differential equations, and developing differential equations for real-world problems			

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Identify, analyze, and subsequently solve physical situations whose behavior can be described by ordinary differential equations.	C 2,3	Understanding & Apply
2. Determine solutions to first order separable differential equations	C2	Understanding
3. Determine solutions to first order linear differential equations.	C2	Understanding
4. Determine solutions to first order linear differential equations.	C2	Understanding
5. Determine solutions to first order linear differential equations.	C2	Understanding
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		
Course Content:		
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:
Lecturing, Written Assignments
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Advanced Engineering Mathematics Michael, G.1996, Prentice Hall Publishers. 2. Advanced Engineering Mathematics, 7th edition, Erwin, K. 1993, John Wiley & Sons Inc. 3. A First Course in Differential Equation Zill. Prindle. Weber. Schmidt.1996. Brooks/Cole Publishing. 4. Differential Equations with Boundary-Value Problems, Dennis. G. Zill, Michael, R. Cullen. 1996, Brooks/Cole Publishing, 5. Elementary Differential Equations with Applications C. H. Edwards. David, E. 1993. Penney, Prentice Hall.

Applied Physics			
Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

The course covers topics in Physics that are directly related to Mechanical Engineering like Mechanics, Electromagnetic waves, Alternating current circuits and solid-state physics.

Course Objectives:

- Understanding of the fundamental concepts/laws in physics by explaining and discussing the physics as well as their relevance to everyday events and circumstances in a broad interdisciplinary context.
- Demonstrate teamwork skills/ ability to collaborate by working in groups on a laboratory experiment
- Reveal critical thinking/ analytical reasoning ability by setting up mathematical descriptions of physical systems and to calculate measurable quantities that provide an understanding of the physical environment in terms of the concepts listed in the course content.
- Ability to apply knowledge/skills to real world settings

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Define how to calculate and measure Voltage, Current and Resistance, connectivity etc. using digital mustimeter and express knowledge of handling Power Trainer, Function Generator and Oscilloscope	P1	Knowledge
2. Use the knowledge acquired in lab and course to construct and investigate basic electronic circuit like dc power supply to harvest knowledge of all its intermediate stages	C6	Understanding

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

Course Content:

Electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charge isolated conductor, Electric potential energy, Electric potentials, Calculating the potential from the field and related problem Potential due to point and continuous charge distribution, Potential due to dipole, equipotential surfaces, Calculating the field from the potential , Electric current, Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot-Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroid's, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf, Induced electric field, Induced electric fields, The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.
Teaching Methodology:
Lecturing, Written Assignments, Project, Experiments, Report Writing
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Report Writing, Experiments, Final Exam
Reference Materials:
1. Fundamentals of Physics (Extended), 10th edition, Resnick and Walker 2. Ntalianis, K. et al. (2019) Applied Physics, System Science and Computers III: Proceedings of the 3rd international conference on applied physics, system science and computers (APSAC2018), September 26-28, 2018, Dubrovnik, Croatia. Cham: Springer. 3. Narciso Garcia, Arthur Damask, Steven Schwarz., "Physics for Computer Science Students", Springer Verlag, 1998

Programming Fundamentals			
Credit Hours	4 (3-1)	**Prerequisites**	None

Course Introduction:

Programming is an increasingly important skill, whether you aspire to a career in software development, or in other fields. This course is the first in the specialization Introduction to Programming in C, but its lessons extend to any language you might want to learn. This is because programming is fundamentally about figuring out how to solve a class of problems and writing the algorithm, a clear set of steps to solve any problem in its class. This course will introduce you to a powerful problem-solving process—the Seven Steps—which you can use to solve any programming problem. In this course, you will learn how to develop an algorithm, then progress to reading code and understanding how programming concepts relate to algorithms.

Course Objectives:

The objective of course is to.

- Introduce a disciplined approach to Problem solving methods and algorithm development.
- Teach the syntax and vocabulary of a modern programming language like C++. The significant philosophies and logical programming, including models for I/O, processing, and all related terminology will be taught. Simple programs will be constructed, using a number of different logical, calculation and algorithm.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand basic problem-solving steps and logic constructs	C2	Understanding
2. Apply basic programing concepts	C3	Apply
3. Design and implement algorithms to solve real world problems.	C6	Create

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

Course Content:

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

Teaching Methodology:

Lecturing, Written Assignments, Project, Practical Labs, Final Exam

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Materials:

1. Starting out with Python, 4th Edition, Tony Gaddis.
2. Starting out with Programming Logic & Degins, 4th Edition, Tony Gaddis,
3. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
4. Object Oriented Programming in C++ by Robert Lafore

5. Introduction to Computation and Programming Using Python: With Application to Understanding Data, 2nd Edition by Guttag, John
6. Practice of Computing Using Python, 3rd Edition by William Punch & Richard Enbody
7. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel
8. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Discrete Structures

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

Discrete Structures is the study of objects that have discrete as opposed to continuous values including the foundations of logic, algorithms and their complexity, mathematical reasoning, relations, graphs, trees and combinatorics.

Course Objectives:

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

1. To design hardware circuits by using gates.
2. To convert expressional statement into mathematical models.
3. To apply the knowledge and skills obtained to investigate and solve a variety of discrete mathematical problems.
4. To produce convincing argument, conceive and/or analyze basic mathematical proofs and discriminate between valid and unreliable arguments.
5. To make effective use of appropriate technology using graphs, trees, and relations in computer science problems (Data Base, Artificial intelligence, Game Theory, Algorithm Analysis)

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs, and Trees etc.	C2	Understanding
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.	C3	Apply
3. Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C3	Apply
4. Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular.	C4	Analyze

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

Course Content:

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, Practical labs, Semester Project, Presentations
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Reference Materials:
1. Discrete Mathematics and Its Applications, 7th edition by Kenneth H. Rosen 2. Discrete Mathematics with Applications, 4th Edition by Susanna S. Epp 3. Discrete Mathematics, 7th edition by Richard Johnson Baugh 4. Discrete Mathematical Structures, 4th edition by Kolman, Busby & Ross 5. Discrete and Combinatorial Mathematics: An Applied Introduction by Ralph P. Grimaldi 6. Logic and Discrete Mathematics: A Computer Science Perspective by Winifred Grassman

Object Oriented Programming

Credit Hours	4 (3-1)	**Prerequisites**	Programming Fundamentals

Course Introduction:

This course introduces advanced programming skills and focuses on the core concepts of object-oriented programming and design using a high-level language, either Python or Java. Object-oriented programming represents the integration of software components into a large-scale software architecture. Software development in this way represents the next logical step after learning coding fundamentals, allowing for the creation of sprawling programs. The course focuses on the understanding and practical mastery of object-oriented concepts such as classes, objects, data abstraction, methods, method overloading, inheritance, and polymorphism. Practical applications in the domain of data science and as seen in stacks, queues, lists, and trees will be examined.

Course Objectives:

At the end of the course, the students will be able to:

- Explain the steps in creating an executable program for a computer, including the intermediate representations and their purpose.
- Apply good programming style and understand the impact of style on developing and maintaining java programs.
- Explain the benefits of object-oriented design and understand when it is an appropriate methodology to use for java programming.
- Design object-oriented solutions for small systems involving multiple objects.
- Implement solutions in Java and exception handling techniques.
- Working with methods overloading, passing arguments to objects, returning objects and constructors.
- Explain the relevance of ethics in the context of Software Engineering.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand principles of object-oriented paradigm.	C2	Understanding
2. Identify the objects & their relationships to build object-oriented solution	C3	Apply
3. Model a solution for a given problem using object-oriented principles	C3	Apply
4. Examine an object-oriented solution.	C4	Analyze

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain
Course Content:
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.
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Reference Materials:
1. Starting Out with C++ from Control Structures to Objects, 9th Edition, Tony Gaddis 2. C++ How to Program, 10th Edition, Deitel & Deitel. 3. Object Oriented Programming in C++, 3rd Edition by Robert Lafore 4. Java: How to Program, 9th Edition by Paul Deitel 5. Beginning Java 2, 7th Edition by Ivor Horton 6. An Introduction to Object Oriented Programming with Java, 5th Edition by C. Thomas Wu

Database Systems			
Credit Hours	4 (3-1)	**Prerequisites**	Data Structure and algorithms
Course Introduction:			
A study of database models including the hierarchical, network, relational and object-oriented models, and the examination of such practical issues as database design, setup, and manipulation. Other selected topics include data integrity, data security, backup and recovery procedures, database administration, etc. Several programming projects are assigned involving the use of a database management system.			
Course Objectives:			
The main objective of this course is to provide students with the background to design, implement, and use database management systems. After the completion of this course students will be able to: • Model and design Database • Write Structured Queries and optimize them • Implement Constraints and Triggers • Use and develop semi structured databases			
Course Learning Outcomes (CLOs):			
At the end of the course the students will be able to:		**Domain**	**BT Level***
1. Explain fundamental database concepts. 2. Design conceptual, logical, and physical database schemas using different data models.		C2 C5	Understanding Evaluate

3. Identify functional dependencies and resolve database anomalies by normalizing database tables.	C2	Understanding
4. Use Structured Query Language (SQL) for database definition and manipulation in any DBMS	C4	Analyze

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

Course Content:

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.

Teaching Methodology:

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

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Materials:

1. Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition by Thomas Connolly and Carolyn Begg Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom
2. Database System Concepts, 6th Edition by Avi Silberschatz, Henry F. Korth and S. Sudarshan.
3. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke

Data Structures and Algorithms

Credit Hours	4 (3-1)	**Prerequisites**	Object Oriented programing

Course Introduction:

An overview of data structure concepts, arrays, stack, queues, trees, and graphs. Discussion of various implementations of these data objects, programming styles, and run-time representations. Course also examines algorithms for sorting, searching and some graph algorithms. Algorithm analysis and efficient code design is discussed.

Course Objectives:

At the end of the course, the students will be able to:

- Introduce the concept of data structures and algorithms
- Understand and use various efficient storage mechanisms of data for an easy access in a program development.
- Design and implement various basic and advanced data structures.
- Understand and use Searching and Sorting techniques.
- Develop applications using efficient data structures like Stacks, Queues, Lists, Graphs and Trees.
- Demonstrate the concept of protection and management of data.
- Improve the logical ability by writing algorithms and systematic approach in solving problems with the help of a suitable data structure.

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Implement various data structures and their algorithms and apply them in implementing simple applications.	C2,3	Understanding, Apply
2. Analyze simple algorithms and determine their complexities.	C4,5	Analyze, Evaluate
3. Apply the knowledge of data structures to other application domains.	C3	Apply
4. Design new data structures and algorithms to solve problems.	C6	Create
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Course Content:

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.

Teaching Methodology:

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

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Materials:

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

Information security

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

The subject of computer networking is enormously complex, involving many concepts, protocols, and technologies. To cope with the scope and complexity these protocols and technologies are woven together in an intricate manner in what is called the layered protocol stack (or suite). The layered organization allows breaking down complex functions required for computers networking into manageable tasks. This course is an introduction to computer networking using a top-down approach—that is, by beginning at the highest layer of the protocol stack (application layer) and proceeding down through different layers towards the lowest one (the physical layer). The course places emphasis on the application layer (a "high growth area" in networking). The course uses the Internet's architecture and protocols as the primary vehicle for studying fundamental computer networking concepts. More than often, the course will also include concepts and protocols from other network architectures. But the main focus is on the Internet, a fact reflected in organizing the course around the Internet's five-layer architecture.

Course Objectives:

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

- Build an understanding of the fundamental concepts of computer networking.
- Familiarize the student with the basic taxonomy and terminology of the computer networking area.
- Introduce the student to advanced networking concepts, preparing the student for entry Advanced courses in computer networking.
- Allow the student to gain expertise in some specific areas of networking such as the design and maintenance of individual networks.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain key concepts of information security such as design principles, cryptography, risk management, and ethics	C2	Explain
2. Discuss legal, ethical, and professional issues in information security	A2	Discuss
3. Apply various security and risk management tools for achieving information security and privacy	C3	Apply
4. Identify appropriate techniques to tackle and solve problems in the discipline of information security	C4	Identify

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

Course Content:

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:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Computer Security: Principles and Practice, 3rd edition by William Stallings
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord
3. Computer Security, 3rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition

Computer Networks

Credit Hours	4 (3-1)	**Prerequisites**	None

Course Introduction:

This course is to provide students with an overview of the concepts and fundamentals of data communication and computer networks.

Course Objectives:

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

1) Understand the TCP/IP protocol suite and the working of the Internet.
2) Form an understanding of the principles upon which the global Internet was designed.
3) Understand basic terminology so that students can understand networking research papers.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe the key terminologies and technologies of computer networks	C2	Describe
2. Explain the services and functions provided by each layer in the Internet protocol stack.	C2	Explain
3. Identify various internetworking devices and protocols and their functions in a networking	C1	Identify
4. Analyze working and performance of key technologies, algorithms, and protocols	C4	Analyze
5. Build Computer Network on various Topologies	P3	Build

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

Course Content:

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.

Teaching Methodology:

Lecturing, Written Assignments, Project, lab tasks

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam

Reference Materials:

1. Computer Networking: A Top-Down Approach Featuring the Internet, 6th edition by James F. Kurose and Keith W. Ross
2. Computer Networks, 5th Edition by Andrew S. Tanenbaum

3. Data and Computer Communications, 10th Edition by William Stallings
4. Data Communication and Computer Networks, 5th Edition by Behrouz A. Forouzan

Operating Systems

Credit Hours	4 (3-1)	**Prerequisites**	Programming Fundamentals, Data Structure and Algorithms

Course Introduction:

To help students gain a general understanding of the principles and concepts governing the functions of operating systems and acquaint students with the layered approach that makes design, implementation, and operation of the complex OS possible.

Course Objectives:

Make the students be able to:

1. Build an understanding about the fundamental concepts of operating systems.
2. Know about the structure of an operating system, its components, design strategies, algorithms and schemes used to design and implement different components of an operating system
3. Familiarize with the basic taxonomy and terminology of operating systems.
4. Study any advance courses that involve operating system concepts.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems	C2	Understanding
2. Identify the core functions of operating systems and how they are architected to support these functions,	C1	Identify
3. 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	C5	Evaluate
4. Demonstrate the knowledge in applying system software and tools available in modern operating systems.	C3	Apply

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

Course Content:

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

Teaching Methodology:

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

Course Assessment:

Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Operating Systems Concepts, 9th edition by Abraham Silberschatz 2. Modern Operating Systems, 4th edition by Andrew S. Tanenbaum 3. Operating Systems, Internals and Design Principles, 9th edition by William StallingsWu

Software Engineering			
Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

This course introduces students to the different software development lifecycle (SDLC) phases used in developing, delivering, and maintaining software products. Students will also acquire basic software development skills and understand common terminology used in the software engineering profession.
Students will also learn and practice using traditional coding standards/guidelines. Python software development libraries and debugging tools will be explored and used in projects to familiarize students with basic tasks involved in modifying, building, and testing software. The course will also lay the foundation for achieving academic and career success in Software Engineering.

Course Objectives:

During this course, students will be able to:

- List and describe the fundamental phases of the Software Development Lifecycle (SDLC)
- Define and describe fundamental software engineering terminology and coding practices
- Explore/explain relationships between software engineering and other engineering disciplines
- (Systems Engineering, Electrical and Computer Engineering, Industrial Engineering)
- Modify/build a software program that introduces students to software development tools /environments
- Troubleshoot and debug changes made to an existing software program
- Develop an original Python software program, learning basic Python language syntax
- Build a foundation for academic success in the Software Engineering degree program.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe various software engineering processes and activities	C1	Knowledge
2. Apply the system modeling techniques to model a medium size software system	C3	Apply
3. Apply software quality assurance and testing principles to medium size software system.	C4	Analyze
4. Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis	C2	Understanding

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

Course Content:

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:
Lecturing, Written Assignments, Project, Report Writing.
Course Assessment:
Mid-Term Exam, Home Assignments, Quizzes, Presentation, Final Exam
Reference Materials:
1. Software Engineering, Sommerville I., 10th Edition, Pearson Inc., 2014 2. Software Engineering, A Practitioner's Approach, Pressman R. S.& Maxim B. R., 8th Edition, McGraw-Hill, 2015.

Artificial Intelligence

Credit Hours	4 (3-1)	**Prerequisites**	Discrete Structures

Course Introduction:

This course teaches what every student should know about Artificial Intelligence. AI is a fast-moving technology with impacts and implications for both our individual lives and society as a whole. In this course, students will get a basic introduction to the building blocks and components of artificial intelligence, learning about concepts like algorithms, machine learning, and neural networks. Students will also explore how AI is already being used, and evaluate problem areas of AI, such as bias. The course also contains a balanced look at AI's impact on existing jobs, as well as its potential to create new and exciting career fields in the future. Students will leave the course with a solid understanding of what AI is, how it works, areas of caution, and what they can do with the technology.

Course Objectives:

At the end of the course, the students will be able to:

- Build an understanding of the fundamental concepts of artificial intelligence.
- Familiarize the student with the basic taxonomy and terminology of the artificial intelligence.
- Allow the student to gain insight in some specific areas of machine learning and system design.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand key components in the field of artificial intelligence	C2	Understanding
2. Implement classical artificial intelligence techniques	C3	Apply
3. Analyze artificial intelligence techniques for practical problem solving	C4	Analyze

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

Course Content:

Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, first order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint Satisfaction Problems; Adversarial Search (Min-max algorithm, Alpha beta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning) ;Uncertainty handling

(Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems)
Teaching Methodology:
Lectures, Assignments, labs, Projects, Presentations, etc. Major component of the course should be covered using conventional lectures. Practical contact hours are compulsory (~45 hours in a semester).
Course Assessment:
Exams, Assignments, Quizzes, Project, Presentations. Course will be assessed using a combination of written examinations and project(s). Practical evaluation, using rubrics, is encouraged, and suggested to make up around 20% of the course.
Reference Materials:
1. Stuart Russell and Peter Norvig, Artificial Intelligence. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2010. 2. Hart, P.E., Stork, D.G. and Duda, R.O., 2001. Pattern classification. John Willey & Sons. 3. Luger, G.F. and Stubblefield, W.A., 2009. AI algorithms, data structures, and idioms in Prolog, Lisp, andJava. Pearson Addison-Wesley.

Digital Logic Design			
Credit Hours	4 (3-1)	**Prerequisites**	Applied Physics

Course Introduction:

This is core course that presents basic tools for the design of digital circuits. It serves as a building block in many disciplines that utilize data of digital nature like digital control, data communication, digital computers etc.

Course Objectives:

The objective of this course includes:

- To understanding importance of logic gates.
- To understand concepts and terminologies of digital logic design.
- To understand the operating logic of the gates in combinational and sequential logic circuits.
- To Introduce to application of digital logic.
- To enable student to design digital circuitry, analyze and interpret data

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Acquire knowledge related to the concepts, tools, and techniques for the design of digital electronic circuits	C1	Knowledge
2. Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques	C3	Apply
3. Apply the acquired knowledge to simulate and implement small-scale digital circuits	C4	Analyze
4. Understand the relationship between abstract logic characterizations and practical electrical implementations.	C2	Understanding

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

Course Content:

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 Programmable Logic Devices (CPLD, FPGA); Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Reference Materials:
1. Digital Fundamentals by Floyd, 11/e. 2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e.

Design and Analysis of Algorithms			
Credit Hours	3 (3-0)	**Prerequisites**	Data Structures and Algorithms

Course Introduction:
This core course covers good principles of algorithm design, elementary analysis of algorithms, and fundamental data structures. The emphasis is on choosing appropriate data structures and designing correct and efficient algorithms to operate on these data structures.
Course Objectives:
The main objectives of this course are to: • Analyze the asymptotic performance of algorithms. • Write rigorous correctness proofs for algorithms. • Demonstrate a familiarity with major algorithms and data structures. • Apply important algorithmic design paradigms and methods of analysis.
Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain what is meant by “best”, “expected”, and “worst” case behavior of an algorithm	C1	Knowledge
2. Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.	C5	Evaluate
3. Determine informally the time and space complexity of simple algorithms	C4	Analyze
4. List and contrast standard complexity classes	C2	Understanding
5. Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms	C3	Apply
6. Use of the strategies (brute-force, greedy, divide-and-conquer, and dynamic programming) to solve an appropriate problem	C3	Apply
7. Solve problems using graph algorithms, including single source and all-pairs shortest paths, and at least one minimum spanning tree algorithm	C3	Apply

8. Trace and/or implement a string-matching algorithm	C3	Apply

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

Course Content:

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

Reference Materials:

1. Introduction to Algorithms (3rd edition) by Thomas H. Corman, Charles E.
2. Leiserson, Ronald L. Rivest and Clifford Stein Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos, Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne

Computer Organization and Assembly Language

Credit Hours	4 (3-1)	**Prerequisites**	Programming Fundamentals

Course Introduction:

Computer Organization and Assembly Language Programming deals with lower-level computer programming—machine or assembly language, and how these are used in the typical computer system. The book explains the operations of the computer at the machine language level.

Course Objectives:

At the end of the course, the students will be able to:

- Understand the internal working and organization of various building blocks of a digital computer as well as simple assembly language programming techniques.
- Understand the Assembler and Debugger, Manipulate and translate machine and assembly code.
- Describe actions inside the processing chip.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Acquire the basic knowledge of computer organization, computer architecture and assembly language	C1	Knowledge
2. Understand the concepts of basic computer organization, architecture, and assembly language techniques	C2	Understanding

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

Course Content:
Introduction to computer systems: Information is bits + 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
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam
Reference Materials:
1. Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e), Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University 2. Robert Britton, MIPS Assembly Language Programming, Latest Edition, 3. Computer System Architecture, M. Morris Mano, Latest Edition, 4. Assembly Language Programming for Intel- Computer, Latest Edition

Parallel and Distributed Computing			
Credit Hours	3 (3-0)	**Prerequisites**	Operating Systems
Course Introduction:			
This course covers general introductory concepts in the design and implementation of parallel and distributed systems, covering all the major branches such as Cloud Computing, Grid Computing, Cluster Computing, Supercomputing, and Many-core Computing. The specific topics that this course will cover are: 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, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, and synchronization.			
Course Objectives:			
The primary goal of parallel computing is to increase available computation power for faster application processing and problem solving.			
Course Learning Outcomes (CLOs):			
At the end of the course the students will be able to:		**Domain**	**BT Level***

1. Learn about parallel and distributed computers. 2. Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library 3. Analytical modelling and performance of parallel programs. 4. Analyze complex problems with shared memory programming with open MP.	C1 C2 C3 C4	Knowledge Understanding Apply Analyze
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		
Course Content:		
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, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE).		
Teaching Methodology:		
Lectures, Written Assignments, Practical labs, Semester Project, Presentations		
Course Assessment:		
Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam		
Reference Materials:		
1. Distributed Systems: Principles and Paradigms, A. S. Tanenbaum and M. V. Steen, Prentice Hall, 2nd Edition, 2007 2. Shen, H. et al. (2022) Parallel and distributed computing, applications and technologies: 22nd International Conference, PDCAT 2021, Guangzhou, China, December 17-19, 2021, Proceedings. Cham: Springer International Publishing AG. 3. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K Hwang, J Dongarra and GC. C. Fox, Elsevier, 1st Ed.		

Advanced Statistics

Credit Hours	3 (3-0)	**Prerequisites**	Probability and Statistics

Course Introduction:

Statistical methods are 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. Data Science extracts knowledge from data based on hidden patterns which can be made explicit by incorporating the statistical algorithms in it. This course is designed to prepare students on statistical techniques with a purview of artificial intelligence and data science.

Course Objectives:

Understanding and application of advanced statistical models in data science

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe what part of statistics is meant for data scientist and what the applications of statistics in data science are.	C1	Knowledge
2. Apply Statistical techniques in real life problems.	C3	Apply
3. Analyze, Correlate, forecast data by using different statistical techniques	C2	Understanding
4. Apply basic data science statistical techniques by using SPSS on real world datasets.	C3	Apply

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

Course Content:

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, Presentations

Course Assessment:

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

Reference Materials:

1. Probability and Statistics for Computer Scientists, 2nd Edition, Michael Baron.
2. Probability for Computer Scientists, online Edition, David Forsyth
3. Discovering Statistics using SPSS for Windows, Andy Field

Introduction to Data Science

Credit Hours	3 (3-0)	**Prerequisites**	Artificial Intelligence

Course Introduction:

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

Course Objectives:

1. 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.
2. To explain the significance of exploratory data analysis in data science.
3. To identify common approaches used for Feature Generation as well as Feature Selection.
4. To discuss the Ethical and Privacy issues.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe what Data Science is and the skill sets needed to be a data scientist.	C2	Understanding
2. Apply EDA and the Data Science process in a case study.	C3	Apply
3. Comprehend the fundamental constructs of Python programming language.	C2	Understanding
4. Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C3	Apply

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

Course Content:

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, Intro to Python; Exploratory Data Analysis and the Data Science Process; Basic Machine Learning Algorithms: Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes; Feature Generation and Feature Selection; Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis; Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs; Data Visualization: Basic principles, ideas and tools for data visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Foundations of data science, Blum, A., Hopcroft, J., & Kannan, R., Vorabversion eines Lehrbuchs, 2016.
2. An Introduction to Data Science, Jeffrey S. Saltz, Jeffrey M. Stanton, SAGE Publications, 2017.
3. Python for everybody: Exploring data using Python 3, Severance, C.R., CreateSpace Independent Pub Platform. 2016.
4. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2015.

Data Mining

Credit Hours	3 (2-1)	**Prerequisites**	Advance Statistics, Introduction to Data Science

Course Introduction:

Data Mining has emerged at the confluence of artificial intelligence, statistics, and databases as a technique for automatically discovering hidden patterns in large datasets. The main purpose of this course is the ability to analyze and construct knowledge from data.

The aims of this course are to:

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

Build on the programming and problem-solving skills developed in previous subjects studied by the student, to achieve an understanding of the development of Classification, Prediction, and Clustering applications.

Course Objectives:

The course introduces students with basic applications, concepts, and techniques of data mining and to develop their skills for using recent data mining software to solve practical problems in a variety of disciplines.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Apply preprocessing techniques on any given raw data.	C3	Apply
2. Select and apply proper data mining algorithm to discover interesting patterns	C3	Apply
3. Analyze and extract patterns to solve problems and point out how to deploy solution	C4	Analyze
Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy	C4	Analyze

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

Course Content:

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
Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:
1. Raja, R. et al. (2022) Data Mining and Machine Learning Applications. Beverly, MA: Scrivener Publishing. 2. Bhargava, N. et al. (2021) Artificial Intelligence and data mining approaches in security frameworks. Hoboken: Wiley-Scrivener. 3. Jiawei Han & Micheline Kamber, Jian Pei (2011). Data Mining: Concepts and Techniques, 3rd Edition. 4. Pang-Ning Tan, Michael Steinbach, and Vipin Kumar (2005). Introduction to Data Mining. 5. Charu C. Aggarwal (2015). Data Mining: The Textbook

Data Visualization

Credit Hours	3 (2-1)	**Prerequisites**	Data Warehousing & Business Intelligence

Course Introduction:

Data Visualization is a process of obtaining detailed insights hidden in the data. It is a necessary component in the pipeline of any data science project. This course teaches skills specifically in terms of how to effectively present the data and findings. Further, this course provides hands on skills using R for data exploration and visualization.

Course Objectives:

1. Develop skills to both design and critique visualizations.
2. Understand why visualization is an important part of data analysis.
3. Understand the components involved in visualization design.
4. Understand the type of data impacts the type of visualization.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Provides knowledge about importance, necessity, and justification of performing exploratory data analysis and visualization	C2	Understanding
2. Introduce various type of charts along with their alternatives solution to show same data from versatile aspects.	C2	Understanding
3. Improving the competency of the students to analyze different problems and select the most appropriate solution.	C3	Apply
4. Use of R, various recent tools, and technologies to develop hands-on skills for exploratory data analysis and visualization.	C3	Apply

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

Course Content:

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)

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Dougherty, J. and Ilyankou, I. (2021) Hands-on Data Visualization: Interactive storytelling from spreadsheets to code. Beijing ; Boston ; Farnham: O'Reilly.
2. "Exploratory Data Analysis with R" by Roger D. Peng

Data Warehousing and Business Intelligence			
Credit Hours	4 (3-1)	**Prerequisites**	Introduction to Data Science

Course Introduction:

Gives an overview about importance & significance of Data Warehousing (DWH) and Business Intelligence (BI). Discusses the main concepts and solutions for DWH and BI. The key concepts underpinning the logical design, physical design and implementation of data warehouses are appraised. Data collection, data extraction, cleansing, transformation and loading methods are considered along with query optimization techniques. Differentiation between OLAP & OLTP. Data Warehousing supports information processing by providing a solid platform of integrated, historical, and consistent data for performing enterprise- wide data analysis.

Course Objectives:

To provide a comprehensive and holistic view of business intelligence and its enabling technologies

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process	C2	Understanding
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.	C2	Understanding
3. Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas	C3	Apply
Use Analytic SQL to aggregate, analyze and report, and model data.	C3	Apply

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

Course Content:

Introduction to Data Warehouse and Business Intelligence; Necessities and essentials of Business Intelligence; DW Life Cycle and Basic Architecture; DW Architecture in SQL Server; Logical Model; Indexes; Physical Model; Optimizations; OLAP Operations, Queries and Query Optimization; Building the DW; Data visualization and reporting based on Datawarehouse using SSAS and Tableau; Data visualization and reporting based on Cube; Reports and Dashboard management on PowerBI; Dashboard Enrichment; Business Intelligence Tools.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. W. H. Inmon, "Building the Data Warehouse", Wiley-India Edition.
2. Ralph Kimball, "The Data Warehouse Toolkit – Practical Techniques for Building Dimensional Data Warehouse," John Wiley & Sons, Inc.
3. Matteo Golfarelli, Stefano Rizzi, "Data Warehouse Design - Modern Principles and Methodologies", McGraw Hill Publisher

Big Data Analytics			
Credit Hours	3 (2-1)	**Prerequisites**	Introduction to Data Science

Course Introduction:

The course objective is to develop understanding about the core concept of Big Data, why Big Data requires a different programming paradigm and mindset, and what are the various programming approaches used, what type of data can be processed.

Course Objectives:

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand the fundamental concepts of Big Data and its programming paradigm.	C2	Understanding
2. Hadoop/MapReduce Programming, Framework, and Ecosystem	C3	Apply
3. Apache Spark Programming	C3	Apply

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

Course Content:

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

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. C.S.R. Prabhu, Aneesh Sreevallabh Chivukula, Aditya Mogadala (2020) Big Data Analytics: Systems, algorithms, applications. S.l.: SPRINGER.
2. Sedkaoui, S. (2020) Data Analytics and big data. London: ISTE.
3. White, Tom. "Hadoop: The definitive guide." O'Reilly Media, Inc., 2012.
4. Karau, Holden, Andy Konwinski, Patrick Wendell, and Matei Zaharia. "Learning spark: lightning-fast big data analysis." O'Reilly Media, Inc., 2015.

Social Network Analysis

Credit Hours	3 (3-0)	**Prerequisites**	

Course Introduction:

Social network analysis has now emerged as a key technique in computer science. Networks can be found everywhere such as network of people, information, places, events, etc. With the advent of social media, such networks are becoming larger with large data set such as Facebook, and Twitter etc. This course will provide understanding in how to make sense from network structure, how to analyze links, and how to design algorithms to analyze the networks. The focus of this course is on interactive demonstrations and hands-on analysis of real-world data sets to identify important nodes in the network, to discover communities, to trace information dissemination and opinion formation. Latest papers published in recent conference proceedings and journals are be discussed.

Course Objectives:

Upon completion of this course:

- Students have clearly understood the state of the arts of computer science aspects of social network analysis.
- Students have developed skill to understand, implement and run algorithms for large networks.
- Students have ability to perform experiments on large networks to verify the performance of the techniques for solving typical computer science related problems.
- Students have ability to write scientific paper in which network algorithms are described, analyze, and compare.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Apply basic methods and functions of Python libraries to analyze network data and complex graph's structure	C3	Create
2. Apply the basics of social network analysis at the network level.	C2	Analyze
3. Collect and preprocess network data	C1	Knowledge
4. Design a research study on interactions between individuals and actors	C2	Design

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

Course Content:

Introduction to Network Science, Descriptive Network Analysis, Mathematical Models of Networks, Node Centrality and Ranking on Networks, Network Communities, Network Structure and Visualization, social media and Information Flow in Networks, Diffusion of Innovation, Institutions and Aggregate Behavior in Networks.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Easley, D., & Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning About a Highly Connected World. New York: Cambridge eText. Retrieved from

http://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edsebk&AN=324125.
2. Goldenberg, D. (2021). Social Network Analysis: From Graph Theory to Applications with Python. https://doi.org/10.13140/RG.2.2.36809.77925/1.
3. Newman, M. E. J. (2010). Networks: An Introduction. Oxford: OUP Oxford. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=nlebk&AN=458550.
4. James H. Fowler, & Nicholas A. Christakis. (2009). Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives: Vol. First edition. Little, Brown Spark.
5. Zinoviev, D., & Tulton, A. O. (2018). Complex Network Analysis in Python: Recognize - Construct - Visualize - Analyze - Interpret. Pragmatic Bookshelf.

Pattern Recognition

Credit Hours	3 (3-0)	**Prerequisites**	Artificial Intelligence

Course Introduction:

An introduction to pattern classification and structural pattern recognition. Topics include feature extraction, Bayesian decision theory, nearest-neighbor rules, clustering, support vector machines, neural networks, classifier combination, and syntactic pattern recognition techniques such as stochastic context-free grammars. The course is part lecture and part seminar: students will present some course material to the class as well as complete and present a research paper. In addition, programming assignments will provide students with practical experience in constructing pattern recognition systems such as optical character recognizers (OCR).

Course Objectives:

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

- Explain and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques.
- Summarize, analyze, and relate research in the pattern recognition area verbally and in writing.
- Apply performance evaluation methods for pattern recognition and analyze comparisons of techniques made in the research literature.
- Apply pattern recognition techniques to real-world problems such as document analysis and recognition.
- Implement simple pattern classifiers, classifier combinations, and structural pattern recognizers.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand, describe, and critique advanced pattern recognition, machine learning and deep learning techniques.	C1	Understanding
2. Identify and select suitable modelling, learning and prediction techniques to solve a complex data problem.	C2	Knowledge
3. Design and implement a refined machine learning solution.	C4	Design
4. Appraise ethical and privacy issues of artificial intelligence techniques.	C3	Create

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

Course Content:

Introduction to Pattern Recognition, Feature Detection, Classification, Random Vectors, Expectation, Correlation, Covariance, Review of Probability Theory, Conditional Probability and Bayes Rule, Random

Vectors, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations, Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient Statistics, Coping with Missing or Noisy Features, Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation, Parzen Estimation, Unsupervised Learning, Clustering, Vector Quantization, K-means, Mixture Modeling, Expectation-Maximization, Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks, Decision Trees, Multi-layer Perceptrons, Reinforcement Learning with Human Interaction, Genetic Algorithms, Combination of Multiple Classifiers "Committee Machines".
Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:
1. Wu, J. (2021) Essentials of pattern recognition: An accessible approach. Cambridge, UK: Cambridge University Press. 2. Zak, A. (2019) Pattern recognition: Selected methods and applications. IntechOpen. 3. Marsland, S. Machine Learning: An Algorithmic Perspective. CRC Press. 2009. (Also uses Python.) 4. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4. Academic Press, 2008. 5. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press. 2009

Predictive Analysis for Business

Credit Hours	3 (3-0)	**Prerequisites**	

Course Introduction:

This course presents a set of topics in developing analytical methodologies that make prediction and forecasting about future events of interest to individual business and industry in general. Students are introduced to managerial techniques and analytical models that reveal valuable relationships in economic and business data for supporting short-term and long-term planning. Students will learn how to build the models, how to interpret the predictions and forecasts produced from the models, and how to evaluate the reliability of the model results.

Course Objectives:

After completing this course, students are expected:

- To grasp good qualitative and quantitative skills of developing forecasts using averaging and regression-based models and evaluating the forecasts for accuracy and parsimony.
- To provide analytical solution to a business forecasting problem using appropriately selected model and data and discover meaningful business knowledge from the solution.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Critically evaluate the role of data in supporting management decision-making and gaining competitive advantage.	C1	Problem solving
2. Discuss and evaluate Business Analytics framework, techniques and tools used in gathering, analyzing, and managing data and apply them to enhance decision-making.	C2	Business Knowledge
3. Examine datasets using visual analytic techniques and communicate findings using dashboards and data driven visual reports.	C3	Business Communication
4. Analyze the ethical impact of big data and analytics on responsible business practices.	C5	Analysis

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

Course Content:

Introduction to Business Forecasting, Qualitative vs. Quantitative Methods, Characteristics of Time Series Data, Naive Average Forecasting, Moving Average Forecasting Model, Smoothing Forecasting, Model Applications in Business, Simple Linear Regression Forecasting Model, Multiple Linear Regression Forecasting, Model Applications in Business, Autoregressive Forecasting (AR) Model ,Autoregressive Moving Average (ARMA), Model Applications in Business, ARMA Model (Continued), Autoregressive Integrated Moving Average (ARIMA) Model, Dealing with periodic fluctuation Applications in Business

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. James, Witten, Hastie and Tibshirani. An Introduction to Statistical Learning with Applications in R. (A free copy can be obtained at http://www-bcf.usc.edu/~gareth/ISL/)
2. Kuhn an Johnson. Applied Predictive Modeling.

3. Burkov, A. (2019) The hundred-page machine learning book. Quebec City: Andriy Burkov.
4. Kelleher, J.D., Namee, M.B. and D'Arcy, A. (2020) Fundamentals of machine learning for Predictive Data Analytics: Algorithms, worked examples, and case studies. Cambridge, MA: The MIT Press.

Advanced Database Systems

Credit Hours	3 (3-0)	**Prerequisites**	Database Systems

Course Introduction:

This course focuses on research and applications in advanced database systems for Cloud and Big Data Computing. It provides an opportunity to learn about Cloud Computing and Advanced Database Systems and apply that learning on a popular cloud platform. The course topics include how database systems have addressed the four Vs of Big Data: volume, variety, velocity, and veracity. We also consider maintaining the virtue of our data, a fifth V if you will, by addressing issues of security, privacy, and social responsibility.

Course Objectives:

The course objectives are the following:

- To provide the students with a better understanding of the essential techniques used in a Database Management System, either by revisiting them or by studying new approaches.
- To provide students with knowledge to choose, design, and implement a database management system in a complex domain, making the best use of the available tools and techniques.
- To provide students with knowledge to analyze and tune a given database management system, given a workload and usage patterns.
- To allow the students to learn and experiment advanced database techniques, models, and products, and to provide them with the knowledge to take decisions concerning implementation issues.
- To provide students with knowledge to analyze, modify if necessary and experiment algorithms that make up the database internals.
- To expose students to advanced topics and techniques that appear promising research directions.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe database management system internals. Understand and describe internal algorithms in detail.	C2	Understanding
2. Identify and be able to use recent and advanced database techniques.	C1	Knowledge
3. Decide on configuration issues related to database operation and performance. Identify which parameters are tunable and what are the implications.	C6	Decision-making
4. Analyze, describe, and use other models than the Relational.	C3	Analysis

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

Course Content:

Database systems concepts and architecture. Concepts used in UML, EER, and XML. Transformation of conceptual models to a relation. Properties of normalization up to 4NF. Views, implementation of integrity constraints. Centralized, decentralized, and distributed databases. Transaction handling. Concurrency and recovery. Query optimization. Advanced and embedded SQL. Triggers and stored procedures. The problem of using different architectures in client and server-side applications. Techniques for efficient storing, accessing, securing, and recovering of data. Implementation of advanced structures in relational, hybrid, and object-oriented databases. Techniques for distributed databases.

Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:

1. Carpenter, J. & Hewitt, E. (2022). Cassandra: the definitive guide (2nd ed.). O'Reilly Media, Inc. The second edition is available used or in overstock at a much lower price from the third edition. The second edition is sufficient for our needs.
2. Damji, J., Lee, D., Wenig, B., & Das, T. (2020). Learning Spark: lightning-fast big data analysis (2nd ed.) O'Reilly Media, Inc.
3. Harrison, G. (2016). Next generation databases: NoSQL, newSQL, and big data. Apres. Look for it used or in overstock on the Internet for a much lower price.
4. Perkins, L., Redmond, E., & Wilson, J. (2018). Seven databases in seven weeks: a guide to modern databases and the NoSQL movement. Pragmatic Bookshelf.

Machine Learning

Credit Hours	3 (2-1)	**Prerequisites**	Programming for Artificial Intelligence

Course Introduction:

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

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

Course Objectives:

The main objective of this course is to make students comfortable with tools and techniques required in handling large amounts of datasets. They will also uncover various deep learning methods in NLP, Neural Networks etc.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe basic machine learning concepts, theories, and applications.	C1	Knowledge
2. Apply supervised learning techniques to solve classification problems of moderate complexity.	C3	Apply
3. Apply unsupervised learning techniques to solve clustering problems of moderate complexity	C3	Apply
4. Apply reinforcement learning algorithms to environments with complex dynamics.	C3	Apply
5. Develop a reasonable size project using suitable machine learning technique	C6	Create

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

Course Content:

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 Agglomerative Clustering. k-means partitioned clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and un-labeled 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.
Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:
1. Deisenroth, M.P., Faisal, A.A. and Ong, C.S. (2020) Mathematics for Machine Learning. Cambridge, United Kingdom: Cambridge University Press. 2. Huyen, C. (2022) Designing machine learning systems: An iterative process for production-ready applications. O'Reilly Media, Incorporated. 3. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press,2012

Deep Learning & Applications			
Credit Hours	3 (3-0)	**Prerequisites**	Data Structures & Probability and Statistics
Course Introduction:			
This course aims to present the core fundamentals behind the much talked about field of Deep Learning. We will delve into selected topics of Deep Learning, from discussing basics of neural networks, to understanding how CNN and RNN works with common examples and publicly available datasets. Special highlight of the course is the lecture on Interpretability of Neural Networks, which will help students to understand how to trust a neural network's recommendation. In the final weeks of the course, we shall get an introductory exposure to Generative Adversarial Networks and Reinforcement Learning, which will help build the foundation for more advanced courses in Artificial Intelligence.			
Course Objectives:			
Upon completion of this course students will be able to: • Describe the major differences between deep learning and other types of machine learning algorithms. • Explain the fundamental methods involved in deep learning, including the underlying optimization concepts (gradient descent and backpropagation), typical modules they consist of, and how they can be combined to solve real-world problems.			
Course Learning Outcomes (CLOs):			
At the end of the course the students will be able to:		**Domain**	**BT Level***

1. Differentiate between the major types of neural network architectures (multi-layered perceptron, convolutional neural networks, recurrent neural networks, etc.) and what types of problems each is appropriate for.	C1	Knowledge
2. Select or design neural network architectures for new data problems based on their requirements and problem characteristics and analyze their performance.	C3	Problem Solving
3. Describe some of the latest research being conducted in the field and open problems that are yet to be solved.	C2	Understanding

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

Course Content:

Introduction to Deep Learning (DL), Potential student projects, Differences from Machine Learning (ML), Evolution of ML and DL, Importance of Artificial Neural Networks (ANNs), Shallow ANNs, Single layer, Multi-layer, Perceptron Rule, Gradient Descent, Backpropagation, Loss Functions, Hyper parameter tuning, Deep ANNs and Regularization, Optimization Algorithms, Batch Normalization, Practical Aspects, DL Pipeline and Strategy, Convolutional Neural Networks, ConvNets, Edge Detection, Padding, Convolution Operator, CNN architecture, Parameter Sharing, Object Localization and Detection, Le-Net, AlexNet, VGG, Residual Networks, Inception Net, Recurrent Neural Networks (RNN), Sequence Modeling, Building the RNN, Backpropagation through time, LSTM, Attention Networks, Natural Language Processing, Word Embedding Applications, Generative Models – Restricted Boltzmann Machines and Deep Belief Networks, Generative Models – Auto encoders, Variational, Stacked, Denoising, Generative Models – Generative Adversarial Networks.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Elgendy, M. (2020) Deep Learning for Vision Systems. Shelter Island, NY: Manning Publications Co.
2. Morales, M. and Isbell, C. (2020) Grokking Deep Reinforcement Learning. Shelter Island New York: Manning.
3. Deep Learning with Python, by Francois Challet, Manning Publications
4. Introduction to Machine Learning by Ethem Alpadyn (latest edition)
5. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy

Theory of Automata

Credit Hours	3 (3-0)	**Prerequisites**	None

Course Introduction:

Theory of Automata is an exciting, theoretical branch of computer science. It established its roots during the 20th Century, as mathematicians began developing - both theoretically and literally - machines which imitated certain features of man, completing calculations more quickly and reliably

Course Objectives:

Introduce concepts in automata theory and theory of computation. Identify different formal language classes and their relationships. Design grammars and recognizers for different formal languages. Prove or disprove theorems in automata theory using its properties.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc;	C1	Knowledge
2. Prove properties of languages, grammars, and automata with rigorously formal mathematical methods	C2	Understanding
3. Design of automata, RE and CFG	C3	Apply
4. Transform between equivalent NFAs, DFAs and Res	C4	Analyze)
5. Define Turing machines performing simple tasks.	C6	Create
6. Differentiate and manipulate formal descriptions of languages, automata, and grammars with focus on regular and context-free languages, finite automata, and regular expressions.	C3	Apply

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

Course Content:

Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: CFGs, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Teaching Methodology:

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

Course Assessment:

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

Reference Materials:

1. Singh, A. (2020) Formal languages and automata theory. S.I.: Amazon LLC, Patna, ACT.
2. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich, 2011
3. An Introduction to Formal Languages and Automata, by Peter Linz, 4th edition, Jones & Bartlett Publishers, 2006
4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Kavier, 2005, New Age Publishers

Artificial Neural Networks

Credit Hours	3 (3-0)	**Prerequisites**	Programming for Artificial Intelligence

Course Introduction:

This course will introduce Artificial Neural Networks, their basic architecture and how they mimic the human brain using simple mathematical models. Many of the important concepts and techniques around brain computing and the major types of ANN will also be introduced. Emphasis is made on the mathematical models, understanding learning laws, selecting activation functions and how to train the networks to solve classification problems. Students would be able to understand and use different types of neural networks and would be able to use different activation functions and construct layered networks to solve classification problems.

Course Objectives:

The objective of this course is to trace the historical developments of artificial intelligence leading to artificial neural networks (ANN). The course introduces the basic concepts and models of ANN for solving simple pattern recognition problems.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand the fundamentals of neural networks in AI	C2	Understanding
2. Explain how simple ANNs can be designed	C2	Understanding
3. Apply ANN for classification Problems	C3	Apply
4. Differentiate between different Networks and their learning laws	C4	Analyze

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Course Content:

Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification, Gradient descent (Delta) rule, Hebbian, Neo-Hebbian and Differential Hebbian Learning, Drive Reinforcement Theory, Kohonen Self Organizing Maps, Associative memory, Bi-directional associative memory (BAM), Energy surfaces, The Boltzmann machines, Backpropagation Networks, Feedforward Networks; Introduction to Deep learning and its architecture.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Aggarwal, C.C. (2019) Neural networks and deep learning: A textbook. New York: Springer.
2. Neural Network Design, 2nd Edition, Martin T. Hagan, Howard, B. Demuth, Mark
3. Hudson Beale and Orlando De Jesus, Publisher: Martin Hagan; 2 edition (September 1, 2014), ISBN-10: 0971732116
4. Fundamentals of Artificial Neural Networks, Mohammad Hassoun, Publisher: A Bradford Book (January 1, 2003), ISBN-10: 0262514672

Business Process Management

Credit Hours	3 (3-0)	**Prerequisites**	

Course Introduction:

This course looks at ways in which business processes can be analyzed, redesigned, and improved. A business process is a set of activities that jointly realize a business goal in an organizational and technical environment. These processes take place in a single organization but may need to interact with processes in other organizations. Business process management (BPM) is concerned with the concepts, methods, and techniques that support the design, administration, configuration, enactment, and analysis of business processes. BPM is concerned with the explicit representation of processes – once they are defined, processes can be analyzed, improved, and enacted. Software in the form of business process management systems can be used to coordinate business process activities.

Course Objectives:

Upon completion of this course, students will be able to:

- Synthesize the principles of organizational strategy and process design.
- Explain the role of IT in BPM.
- Document processes using a process mapping tool using BPMN.
- Analyze the performance of existing processes and identify process improvement.
- Propose business solutions in written and verbal forms for process innovation and redesign projects.
- Create a BPM implementation strategy and implementation plan for an organization.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain how Business Process Management enables organizational strategy and design using Information Technology and other resources.	C6	Global and cultural competence
2. Document processes using a Business Process Management Notation tool.	C1	Knowledge
3. Analyze the performance of processes using a variety of quantitative and qualitative tools and methods.	C2	Problem solving
4. Propose and plan a process improvement solution.	C7	Leadership development

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Course Content:

Introduction What is BPM? The evolution of BPM, The enterprise view, What is a business process, Process discovery; Process scoping, Why processes can "break"!, Swim lane diagrams, Modelling and assessing the As-Is process, Managing Processes, Six sigma, BPM Technology.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Brocke, vom J., Mendling, J. and Rosemann, M. (2021) Business Process Management Cases Volume 2: Digital Transformation - strategy, processes and execution. Berlin, Heidelberg: Springer.

2. Sharp A. and McDermott P. 2009. Workflow Modeling: Tools for process improvement and application Development 2nd edition. Artech House, Boston | London. ISBN: 13: 978 1 59693 192 3.

Speech Processing

Credit Hours	3 (3-0)	**Prerequisites**	

Course Introduction:

This course offers a theoretical and practical understanding of how human speech is processed using computers. Speech Processing lies at the intersection of acoustic phonetics, digital processing of speech signals and Machine Learning. Knowledge of these domains is essential to developing a thorough understanding of the rapidly developing fields of speech recognition (speech-to-text), speech synthesis (text-to-speech), spoken dialog systems, and Chabot (e.g., Siri, Alexa, Cortana). Students will learn about the processes underlying human speech production, perception, and techniques for speech analysis and synthesis. Delivered concepts will be reinforced through rigorous programming assignments, where students will implement their own speech analysis and classification systems from scratch. As projects, students will develop local language speech recognition and synthesis systems using state-of-the-art toolkits. This course lays the foundation for advanced courses and research on speech processing.

Course Objectives:

This course aims to:

- Familiarize you with modeling the vocal tract as a digital, linear time-invariant system.
- Convey details of a range of commonly used speech feature extraction techniques.
- Provide a basic understanding of multidimensional techniques for speech representation and classification methods.
- Familiarize you with the practical aspects of speech processing, including robustness, and applications of speech processing, including speech enhancement, speaker recognition and speech recognition.
- Give you practical experience with the implementation of several components of speech processing systems.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand the processes of human speech generation, transmission, and perception, and the mathematical models describing these physical processes.	C1	Understanding
2. Develop a theoretical and practical (basic) understanding of the relevant branches of linguistics (articulatory and acoustic phonetics, and phonology), and signal processing (time and frequency-based analyses)	C3	Development
3. Understand the Speech Processing pipeline from the design and collection of speech corpora, various feature extraction techniques, rule-based and Machine Learning based processing models, and appropriate evaluation techniques	C1	Knowledge
4. Develop a hands-on understanding of time and frequency-based speech processing techniques, Speech	C4	Create

Recognition, and Speech Synthesis		

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Course Content:

Introduction & Time-frequency analysis, Speech Modelling, Linear Predictive Analysis, Speech Enhancement, Human auditory system + Machine Learning Frontends, Introduction to Statistical Machine Learning, Speaker Recognition, Sequence Modelling + Speech recognition – I, Sequence Modelling + Speech recognition - II

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Dey, N. (2019) Intelligent Speech Signal Processing. London: Elsevier.
2. Quatieri, T. F. (2002). Discrete-Time Speech Signal Processing, Prentice-Hall, New Jersey.
3. Mitra, S. K. (2010). Digital Signal Processing: A Computer-Based Approach, McGraw-Hill.

Cloud Computing

Credit Hours	3 (3-0)	Prerequisites	

Course Introduction:

The course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. Its focus is on parallel programming techniques for cloud computing and large-scale distributed systems, which form the cloud infrastructure. The topics include overview of cloud computing, cloud systems, parallel processing in the cloud, distributed storage systems, virtualization, security in the cloud, and multicore operating systems. Students will study state-of-the-art solutions for cloud computing developed by Google, Amazon, Microsoft, Yahoo, VMWare, etc. Students will also apply what they learn in one programming assignment and one project executed over Amazon Web Services.

Course Objectives:

Upon successful completion of this course, students will learn:

- The fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability benefits, as well as current and future challenges.
- The basic ideas and principles in data center design; cloud management techniques and cloud software deployment considerations.
- Different CPU, memory and I/O virtualization techniques that serve in offering software, computation, and storage services on the cloud; Software Defined Networks (SDN) and Software Defined Storage (SDS).
- Cloud storage technologies and relevant distributed file systems, NoSQL databases and object storage.
- The variety of programming models and develop working experience in several of them.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
1. Analyze the trade-offs between deploying applications in the cloud and over the local infrastructure.	C3	Analyze
2. Deploy applications over commercial cloud computing infrastructures such as Amazon Web Services, Windows Azure, and Google App-Engine.	C4	Apply
3. Solve a real-world problem using cloud computing through group collaboration.	C2	Problem Solving
4. Identify security and privacy issues in cloud computing.	C1	Knowledge

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Course Content:

Definition and evolution of Cloud Computing. Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Cases. Benefits, Risks, and Challenges of Cloud Computing. Economic Models and SLAs. Topics in Cloud Security. Historical Perspective of Data Centers. Datacenter Components: IT Equipment and Facilities. Design Considerations: Requirements, Power, Efficiency, & Redundancy. Power Calculations, PUE and Challenges in Cloud Data Centers. Cloud Management and Cloud Software Deployment Considerations. Virtualization (CPU, Memory, I/O). Case Study: Amazon EC2. Software Defined Networks (SDN). Software Defined Storage (SDS). Introduction to Storage Systems. Cloud Storage Concepts. Distributed File Systems (HDFS, Ceph FS). Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB). Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph). Distributed Programming for the Cloud. Data-Parallel Analytics with Hadoop MapReduce (YARN). Iterative Data-Parallel Analytics with Apache Spark. Graph-Parallel Analytics with GraphLab 2.0 (PowerGraph)

Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:
1. Marinescu, Dan (2017) Cloud Computing Theory and Practice (2nd Ed.) 2. IEEE Transactions on Cloud Computing 3. Journal of Cloud Computing: Advances, Systems and Applications (JoCCASA)

Text Mining			
Credit Hours	3 (3-0)	**Prerequisites**	Data Structure

Course Introduction:

Given the dominance of text information over the Internet, mining high-quality information from text becomes increasingly critical. The actionable knowledge extracted from text data facilitates our life in a broad spectrum of areas, including business intelligence, information acquisition, social behavior analysis and decision-making. In this course, we will cover important topics intext mining including basic natural language processing techniques, document representation, text categorization and clustering, document summarization, sentiment analysis, social network and social media analysis, probabilistic topic models and text visualization.

In addition, as we are in the era of Big Data, we will provide you opportunities to gain hands-on experience of handling large-scale data set, i.e., Big Data.

Course Objectives:

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

- Develop key text and data mining knowledge and understanding through presentations, hands-on coding lessons and the production of research material via their project.
- Practice the use of computational methods to analyze text collections as a technique to answer scholarly research questions.
- gain autonomy, accountability and learn to work with others by collaborating in small groups on the practical elements of the course and during the preparation stage of their project, developing their communication skills, and gaining valuable skills in working with others.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain and use text preprocessing techniques	C2	Understanding
2. Describe a text analytics system together with its components, optional and mandatory ones	C1	Knowledge
3. Explain how text could be analyzed	C2	Understanding
4. Evaluate results of text analytics	C3	Problem Solving
5. Analyze and reflect on the various techniques used in text analytics and the parameters needed as well as the problem solved	C3	Analysis
6. Plan & execute a text analytics experiment	C4	Create

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Course Content:
The Text Mining course is focusing on the importance and the difficulty of analyzing text. The Text Mining course is designed to provide students with knowledge relevant to both preprocessing of text as well as analytics of text. The Text Mining course, however, focuses on wide range of algorithms, techniques, and tools. These include standard methods, such as: tokenization, TF-IDF, n-grams, Named Entity Extraction, Sentiment Analysis, and Topic Modeling. Furthermore, recent trends in machine learning and deep learning are also covered, including: Word2Vec, Semantic Hashing, and Recurrent Neural Networks for Natural Language Processing. Various examples and use cases are used across the course.
Teaching Methodology:
Lectures, Written Assignments, Projects Presentations
Course Assessment:
Sessional Exam, Home Assignments, Quizzes, Presentations, Final Exam
Reference Materials:
1. Aggarwal, C.H.A.R.U.C. (2019) Machine Learning For Text. S.L.: Springer. 2. Lamba, M. and Madhusudhan, M. (2022) Text mining for information professionals an uncharted territory. Cham, Switzerland: Springer. 3. Miner, G. (2016) Practical text mining and statistical analysis for non-structured text data applications. Amsterdam: Academic Press. 4. Mining Text Data. Charu C. Aggarwal and ChengXiang Zhai, Springer, 2012.

Fundamentals of Internet of Things (IoT)			
Credit Hours	3 (3-0)	**Prerequisites**	
Course Introduction:			
Internet of Things (IoT) course is all about understanding and then developing solid skills to build IoT systems. This is a very hands-on intensive and interactive course. Much of the course material will be delivered in using the flipped lectures-based model where pre-work will be given to students before they come to sessions. Largely, the sessions are based on hands-on workshops where students will perform different programming and development tasks.			
Course Objectives:			
Upon successful of completion of this course, students will be able to: • Use the FIT IOT-LAB for development of testbeds for network computer communications. • IBM BLUEMIX for Cloud Development. • Arduino and Raspberry Pi for building embedded systems. • TelosB Motes. • SDN based IoT.			
Course Learning Outcomes (CLOs):			
At the end of the course the students will be able to:		**Domain**	**BT Level***
1. Explain and define Internet of Things in different contexts. 2. Take account of the key components that make up an IoT system.		C2 C1	Understanding Knowledge

3. Differentiate between the levels of the IoT stack and be familiar with the key technologies and protocols employed at each layer of the stack.	C3	Analyze
4. Apply the knowledge and skills acquired during the course to build and test a complete, working IoT system involving prototyping and programming.	C4	Apply
5. Understand where the IoT concept rightly fits within the broader ICT industry and possible future trends.	C2	Understanding

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Course Content:

ADCs/DACs, PVM and Voltage Dividers. Understanding the OSI model and the seven abstraction layers. Networking and TCP/IP. Control and Management plane improvements with SDN. Openness. Network Automation and Virtualization. SDN and OpenStack. ONOS SDN Controllers. Applications and APIs. Protocols. Arduino and Raspberry Pi Programming. Elements of an IoT ecosystem. Technology and business drivers. IoT applications, trends, and implications. Sensing components and devices. Sensor modules, nodes, motes, and systems. Wireless technologies for the IoT. Edge connectivity and protocols. Wireless sensor networks. Local processing on the sensor nodes. Connecting devices at the edge and to the cloud. Processing data offline and in the cloud.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.
2. Keysight Technologies, The Internet of Things: Enabling Technologies and Solutions for Design and Test Application Note, 2016.

Mobile Application Development

Credit Hours	3 (3-0)	**Prerequisites**	Object Oriented Programming

Course Introduction:

Mobile Application Development is market-oriented course in the undergraduate programs of Department of Computer Science at Capital University of Science and Technology. Today, mobile applications are used not only as a standalone application but also with most of web or desktop applications. These applications are highly user focused and designed for every walk of life. Moreover, with the growing strength and cheap availability of mobile devices it has emerged as an important tool in both local and international job market. The course is designed to impart both conceptual and practical knowledge, which is accompanied with hands-on training primarily focused on Android OS, Apple iOS, and related tools. The course demonstrates standard practices and tools used in market to develop robust mobile applications.

Course Objectives:

Upon completing requirements for this course, the student will be able to:

- Create a mobile application using the Swift programming language.
- Debug a mobile application written in the Swift programming language.
- Test a mobile application written in the Swift programming language.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Describe Mobile Application Development fundamentals and flow on multiple devices and publishing it online	C1	Knowledge
2. Produce Mobile Application using provided assets with basic functionality	C5	Create
3. Make Mobile application that uses hardware and software resources like sensors and configuration etc. and evaluate functionality	C5	Create

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Course Content:

• Introduction to the course and course objectives. Setting up environment. App Fundamentals. Components of an Application. Introduction to Android and iOS Platform. Developing single screen layout apps. Traversing in screens and data transfers. Storage persistence. Multithreading. Background Services. Notifications services. Testing Applications for data persistence. Exporting installable app. Cloud Services for sign-in in notifications. Using online data storage. Testing an App from usability perspective. Story boarding an app

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Deitel, P., & Deitel, H. (2017). Android how to program (3rd ed.). Upper Saddle River, NJ: Pearson Education. ISBN-13: 978-0-13-444430-7. Type: Textbook

Real-Time Systems

Credit Hours	3 (3-0)	**Prerequisites**	

Course Introduction:

This course covers the principles of real-time systems, Modeling of a Real-Time System, Task assignment and scheduling, Resource management, Real-time operating systems, RTOS services, Programming language with real-time support, System design techniques, Inter task communication, Fault tolerant techniques, Reliability evaluation methods; Performance analysis, Case studies of real-time systems.

Course Objectives:

The objective of this course is to

- Develop an understanding of various Real Time systems Application
- Obtain a broad understanding of the technologies and applications for the emerging and exciting domain of real-time systems
- Get in-depth hands-on experience in designing and developing a real operational system.

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Explain fundamental principles for programming of real time systems with time and resource limitations.	C2	Understanding
2. Describe the foundation for programming languages developed for real time programming.	C1	Knowledge
3. Use real time system programming languages and real time operating systems for real time applications.	C4	Apply
4. Analyze real time systems with regard to keeping time and resource restrictions.	C3	Analyze

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Course Content:

Introduction to task scheduling. Issues in Real Time Computing. Structure of a Real Time System, Task classes. Performance Measures for Real Time Systems. Task Assignment and Scheduling. Classical uniprocessor scheduling algorithms. RM algorithm with different cases. Priority ceiling. Precedence constraints- using of primary and alternative tasks. Uniprocessor scheduling of IRIS tasks. Task assignment. Utilization balancing. Next fit. Bin packing Algorithm. Myopic off-line algorithm Focused addressing and bidding, Buddy strategy, Fault Tolerant Scheduling. Aperiodic scheduling. Spring algorithm, Horn algorithm Bratley Sporadic scheduling. Introduction to Real Time Communication VTCSMA. Case Study-Air traffic controller system. Air traffic controller system. Case Study -Distributed air defense system. Distributed air defense system. Real-time modeling-Introduction. Petri nets and applications in real-time modeling. Applications in real-time modeling. Case Study-Air traffic controller system. Two-phase Approach to improve Predictability. Maintaining Serialization Consistency. Maintaining Serialization Consistency. Databases for Hard Real Time System. Main Memory Databases Transaction Priorities Transaction Aborts Concurrency control issues. Disk Scheduling Algorithms. Disk Scheduling Algorithms.

Teaching Methodology:

Lectures, Written Assignments, Projects Presentations

Course Assessment:

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

Reference Materials:

1. Cooling, J.E. (2019) The complete edition - software engineering for real-time systems: A software engineering perspective toward designing real-time systems. Birmingham, UK: Packt Publishing.
2. Shirvaikar, M.U.K.U.L. (2017) Real Time Systems. Cognella Academic Publish.
3. Jermann Kopetz, Real-Time Systems Design Principles for Distributed Embedded Applications, Springer Verlag, 2011.
4. Benjamin M. Brosgol, A Comparison of the Concurrency Features of Ada 95 and Java.
5. The Real-time for Java Expert Group, The Real-Time Specification for JavaTM.
6. Greg Bollella and James Gosling, The Real-Time Specification for Java (summary).