COMSATS University Islamabad

Registrar Secretariat, Academic Unit (PS)

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No. CUI-Reg/Notif- 4755 /21/3430 December 17, 2021

NOTIFICATION

Scheme of Studies of Bachelor of Science in Computer Science BS (CS)

Academic Council in its 32nd meeting held on October 06, 2021, on the recommendations of 28th meeting of Board of Faculty of Information Sciences and Technology, approved revised Scheme of Studies of Bachelor of Science in Computer Science BS (CS) effective from Spring 2022 at CUI System:

Nomenclature: Bachelor of Science in Computer Science BS (CS)

1. Minimum Duration in year: 04 Years
2. Minimum No. of Semesters: 08

3. **Course Work**		**(Min No. of Courses)**	**(Min No. of Credit Hours)**
Area Covered in BS (CS)			
a)	Computing Core Courses	11	39
b)	Mathematics & Science Foundation Courses	04	13
c)	General Education Courses	07	21
d)	University Elective Courses	04	12
Domain Courses (List Attached)			
a)	Computer Science Core Courses	07	24
b)	Computer Science Elective Courses	05	15
c)	Computer Science Supporting Courses	03	09
Minimum No. of Courses Required:		**41**	--
Minimum No. of Credit Hours Required:			**133**

Note:

1. CSC350-Topics in Computer Science I and CSC483-Topics in Computer Science II may be allowed to offer upon getting prior approval of the contents of these courses from the Head of Department (HoD).
2. The Regulations relating to Undergraduate Degree Program approved by the Competent Authority and amended from time to time shall be applicable.

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Muniba Nasir
Additional Registrar

Encl: (Total 57 pages including this page)

Distribution:

1. All Campus Directors, CUI
2. Dean, Faculty of Information Sciences and Technology, CUI
3. Controller of Examinations, CUI
4. Chairperson, Department of Computer Science, CUI
5. Incharge QEC/CU Online, PS
6. All HoDs/Incharge of Academics/Examinations Sections, CUI Campuses
7. Internal distributions, Registrar Office (Academic Unit), CUI

Cc:

1. PS to Rector CUI
2. PS to Registrar CUI

Computing Core Courses

S. No	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1.	CSC103	Programming Fundamentals	4(3, 1)	-
2.	CSC241	Object Oriented Programming	4(3, 1)	CSC103
3.	CSC102	Discrete Structures	3(3, 0)	-
4.	CSC211	Data Structures and Algorithms	4(3, 1)	CSC103
5.	CSC291	Software Engineering Concepts	3(3, 0)	-
6.	CSC323	Principles of Operating Systems	4(3, 1)	CSC211
7.	CSC340	Computer Networks	4(3, 1)	-
8.	CSC270	Database Systems	4(3, 1)	CSC211
9.	CSC432	Information Security	3(3, 0)	-
10.	CSC498	Senior Design Project I	2(0, 2)	CSC270, CSC291, HUM102, CSC241
11.	CSC499	Senior Design Project II	4(0, 4)	CSC498

Mathematics and Science Foundation

S. No	Course Code	Course Title	Credit Hours	Pre-requisite (s)
1.	MTH104	Calculus and Analytic Geometry	3(3, 0)	-
2.	MTH231	Linear Algebra	3(3, 0)	-
3.	MTH262	Statistics and Probability Theory	3(3, 0)	-
4.	PHY121	Applied Physics for Engineers	4(3, 1)	-

General Education Courses

S. No	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1.	CSC101	Introduction to ICT	3(2, 1)	-
2.	CSC410	Professional Practices	3(3, 0)	-
3.	HUM100	English Comprehension and Composition	3(3, 0)	-
4.	HUM102	Report Writing Skills	3(3, 0)	HUM100
5.	HUM103	Communication Skills	3(3, 0)	HUM100
6.	HUM110	Islamic Studies **	3(3, 0)	-
7.	HUM111	Pakistan Studies	3(3, 0)	-

**Non-Muslim students can opt for HUM114 Ethics 3(3, 0) course in lieu of HUM110 Islamic Studies, if they intend to.

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Computer Science Core Course

S. No	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1.	CSC301	Design and Analysis of Algorithms	3(3, 0)	CSC211
2.	CSC312	Theory of Automata	3(3, 0)	CSC102
3.	CSC325	Computer Organization & Assembly Language	4(3, 1)	
4.	CSC334	Parallel and Distributed Computing	3(2, 1)	CSC323
5.	CSC441	Compiler Construction	3(2, 1)	CSC312
6.	CSC462	Artificial Intelligence	4(3, 1)	CSC102
7.	EEE241	Digital Logic Design	4(3, 1)	-

Computer Science Supporting Courses (Any 3 from the following list)

S. No	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1.	CSC307	Graph Theory	3(3, 0)	CSC102
2.	CSC315	Theory of Programming Languages	3(3, 0)	CSC103
3.	MTH105	Multivariable Calculus	3(3, 0)	MTH104
4.	MTH242	Differential Equations	3(3, 0)	MTH104
5.	MTH375	Numerical Computations	3(2, 1)	MTH231

Computer Science Elective Courses

Track I: Artificial Intelligence

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC354	Machine Learning	3(3, 0)	-
CSC421	Robotics	3(3, 0)	-
CSC454	Pattern Recognition	3(3, 0)	-
CSC455	Computer Vision	3(3, 0)	-
AIC270	Programming for Artificial Intelligence	3(2, 1)	CSC103
AIC365	Natural Language Processing	3(3, 0)	-
CSC331	Digital Image Processing	3(3, 0)	MTH231

Track II: Data Science

Course Code	Course Title	Credit Hours	Pre-requisite(s)
DSC306	Data Mining	3(2, 1)	-
CSC367	Distributed Data Processing	3(3, 0)	-
CSC372	Exploratory Data Analysis & Visualization	3(3, 0)	-
CSC405	Introduction to Artificial Neural Networks	3(3, 0)	-
CSC461	Introduction to Data Science	3(3, 0)	MTH262

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Track III: Software Development

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC303	Mobile Application Development	3(2, 1)	CSC241
CSC336	Web Technologies	3(2, 1)	CSC241
CSC337	Advanced Web Technologies	3(2, 1)	CSC336
CSC412	Visual Programming	3(2, 1)	CSC241
CSC417	E-Commerce and Digital Marketing	3(2, 1)	-
CSC418	DevOps for Cloud Computing	3(2, 1)	-

Track IV: Game Development

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC335	Game Design	3(3, 0)	-
CSC353	Computer Graphics	3(2, 1)	MTH231
CSC356	Human Computer Interaction	3(2, 1)	-
CSC495	Game Development	4(3, 1)	CSC241
CSC496	Game Engine Development	3(2, 1)	CSC495

Track V: Cyber Security

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CYC205	Introduction to Cyber Security	3(3, 0)	-
CYC303	Digital Forensics	3(2, 1)	-
CYC307	Information Assurance	3(3, 0)	-
CYC365	Network Security	3(2, 1)	CSC340
CYC386	Secure Software Design and Development	3(2, 1)	-
CYC390	Vulnerability Assessment & Reverse Engineering	3(2, 1)	-

General Computer Science Electives: **

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC350	Topics in Computer Science I	3(3, 0)	-
CSC483	Topics in Computer Science II	3(3, 0)	-

****Note:** In order to specialize in a particular track, student must select at least ***three*** courses from that track. *CSC350* and *CSC483 (Category of General Computer Science Electives)* can be part of any track.

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University Electives (Any 4 courses)

Course Code	Course Title	Credit Hours	Pre-requisite(s)
MGT100	Introduction to Business	3(3, 0)	-
MGT101	Introduction to Management	3(3, 0)	-
MGT131	Financial Accounting	3(3, 0)	-
MGT210	Fundamentals of Marketing	3(3, 0)	-
MGT350	Human Resource Management	3(3, 0)	-
MGT513	New Product Development	3(3, 0)	-
ECO300	Engineering Economics	3(3, 0)	-
ECO400	Business Economics	3(3, 0)	-
ECO403	Managerial Economics	3(3, 0)	-
ECO111	Principles of Microeconomics	3(3, 0)	-
ECO484	Project Planning and Monitoring	3(3, 0)	-
HUM220	Introduction to Psychology	3(3, 0)	-
HUM221	International Relations	3(3, 0)	-
HUM320	Introduction to Sociology	3(3, 0)	-
HUM430	French	3(3, 0)	-
HUM431	German	3(3, 0)	-
HUM432	Arabic	3(3, 0)	-
HUM433	Persian	3(3, 0)	-
HUM434	Chinese	3(3, 0)	-
HUM435	Japanese	3(3, 0)	-

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Tentative Study Plan for BS (CS)

Below is a tentative eight semester study plan of course offerings. A campus may change the offerings depending upon their available resources.

Semester – 1				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC101	Introduction to ICT	3(2, 1)	
2	HUM100	English Comprehension and Composition	3(3, 0)	
3	HUM110	Islamic Studies	3(3, 0)	
4	HUM111	Pakistan Studies	3(3, 0)	
5	PHY121	Applied Physics for Engineers	4(3, 1)	
6	MTH100	Mathematics I*	3(3, 0)	

Semester – 2				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC103	Programming Fundamentals	4(3, 1)	
2	HUM102	Report Writing Skills	3(3, 0)	HUM100
3	EEE241	Digital Logic Design	4(3, 1)	
4	CSC102	Discrete Structures	3(3, 0)	
5	MTH101	Calculus I*	3(3, 0)	
6		University Electives 1/4		

Semester – 3				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC241	Object Oriented Programming	4(3, 1)	CSC103
2	CSC291	Software Engineering Concepts	3(3, 0)	
3	MTH231	Linear Algebra	3(3, 0)	
4	MTH104	Calculus and Analytic Geometry	3(3, 0)	
5		University Electives 2/4		

Semester – 4				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC211	Data Structures and Algorithms	4(3, 1)	CSC103
2	CSC340	Computer Networks	4(3, 1)	
3	CSC325	Computer Organization and Assembly Language	4(3, 1)	
4	HUM103	Communication Skills	3(3, 0)	HUM100
5		Computer Science Supporting Courses 1/3		
Semester – 5				

S#	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1	CSC270	Database Systems	4(3, 1)	CSC211
2	CSC323	Principles of Operating Systems	4(3, 1)	CSC211
3	CSC410	Professional Practices	3(3, 0)	
4	MTH262	Statistics and Probability Theory	3(3, 0)	
5		Computer Science Supporting Courses 2/3		
6		Computer Science Elective Courses 1/5		

Semester – 6				
S#	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1	CSC312	Theory of Automata	3(3, 0)	CSC102
2	CSC301	Design and Analysis of Algorithms	3(3, 0)	CSC211
3	CSC334	Parallel and Distributed Computing	3(2, 1)	CSC323
4	CSC432	Information Security	3(3, 0)	
5		Computer Science Elective Courses 2/5		
6		Computer Science Elective Courses 3/5		

Semester – 7				
S#	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1	CSC441	Compiler Construction	3(2, 1)	CSC312
2	CSC462	Artificial Intelligence	4(3, 1)	CSC102
3	CSC498	Senior Design Project I	2(0, 2)	CSC270, CSC291, HUM102, CSC241
4		Computer Science Supporting Courses 3/3		
5		Computer Science Elective Courses 4/5		

Semester – 8				
S#	Course Code	Course Title	Credit Hours	Pre-requisite(s)
1	CSC499	Senior Design Project II	4(0, 4)	CSC498
2		University Electives ¾		
3		University Electives 4/4		
4		Computer Science Elective Courses 5/5		

* Non-Credit course. Students with Pre-Medical background must have to pass deficiency courses of Mathematics (MTH100 and MTH101) of 6 credit hours within one year.

Computing Core Courses

Course Code: CSC103 **Pre-Requisite:** None

Course Title: Programming Fundamentals

Credit Hours: 4(3, 1)

Course Objectives:

- To introduce various programming language paradigms;
- To develop the skills to analyze, design, test and translate problems into computer programs;
- To present the fundamental programming concepts, including basic type system;
- To demonstrate basic coding, testing and debugging techniques;
- To provide an implementation of the concepts.

Course Contents:

This course emphasis the basic concepts used in programming. The topics include: Computer Programming; Basic Syntax & Semantics of a Higher-Level Language; Conditional & Iterative Control Structures; Functions & Parameter Passing; Recursion; Arrays; String Processing; Exception Handling; Refactoring; Debugging; Modern Programming Environments; Testing Fundamentals; and File I/O.

Recommended Books:

1. Java How to Program, Deitel, P. & Deitel, H., Prentice Hall, 2019.
2. Java: The Complete Reference, Herbert Schildt, Prentice Hall, 2018.
3. Introduction to Java Programming and Data Structures, Comprehensive Version, Y.D.Liang, Pearson, 2017.
4. Java: Programming Basics for Absolute Beginners, Nathan Clark, CreateSpace Independent Publishing Platform, 2017.

Course Code: CSC241 **Pre-Requisite:** CSC103

Course Title: Object Oriented Programming

Credit Hours: 4(3, 1)

Course Objectives:

- To introduce the object oriented programming paradigm;
- To teach in depth the philosophy of object-oriented design and concepts of encapsulation, abstraction, inheritance and polymorphism;
- To develop understanding of sub typing and generic types;
- To explain the usage of library components;
- To develop code that responds to exception conditions raised during execution;
- To develop understanding of event handlers for use in reactive systems, such as GUIs;
- To demonstrate implementation of the concepts.

Course Contents:

This course emphasizes the concepts of object-oriented techniques used in developing computer-based system. The topics include: Overview of Object-Oriented Programming; Classes & its Concepts; Problem Solving in Object Oriented Paradigm; Inheritance; Polymorphism; Library Components; Object Oriented Concepts of File Handling; Swing Classes; Events & Event Handlers; and Canonical Uses.

Recommended Books:

1. Introduction to Java Programming and Data Structures, Comprehensive Version, Y. Liang, Y. Daniel Liang, Pearson, 2019.
2. Concise Guide to Object-Oriented Programming, Kingsley Sage, Springer, 2019.
3. Absolute Java, Savitch, W. & Mock, K., Pearson, 2016.

Course Code: CSC102 **Pre-Requisite:** None

Course Title: Discrete Structures

Credit Hours: 3(3, 0)

Course Objectives:

- To teach important discrete data structures such as sets, relations, functions, graph and trees;
- To introduce a formal system (propositional and predicate logic) on which mathematical reasoning is based;
- To thoroughly train in the construction and understanding of mathematical proofs;
- To exercise common mathematical arguments and proof strategies;
- To develop the ability to see a problem from a mathematical perspective.

Course Contents:

This course introduces mathematical structures necessary for the development of program logic. It covers the following topics: Set Theory; Propositional & First Order Logic; Rules of Inference; Mathematical Proofs; Counting & Probability; Graphs & Tree Structures; and Discrete Probability.

Recommended Books:

1. Discrete Mathematics and Its Applications, Rosen, K. H., McGraw Hill, 2018.
2. Discrete Mathematics with Applications, Susanna S.E., Cengage Learning, 2019.
3. Discrete Mathematics, John, D., Pearson, 2017.

Course Code: CSC211 **Pre-Requisite:** CSC103

Course Title: Data Structures and Algorithms

Credit Hours: 4(3, 1)

Course Objectives:

- To discuss the issues of time complexity and examine various algorithms from this perspective;
- To introduce the concept and usage of data structures through abstract data structures, including linked lists, stacks, queues, priority queue, trees, and graphs;
- To implement above data structures and their applications;
- Develop an understanding of recursion as they apply to trees and graphs;
- To introduce the concept of memory management and garbage collection.

Course Contents:

This course provides fundamental knowledge of data organization. The topics include: Overview of Data Structures; Static & Dynamic List; Stack; Queue; Tree & its Algorithms; Graph & its Algorithms; Sorting; Searching; Hashing; and Time Complexity of an Algorithm.

Recommended Books:

1. A Common-Sense Guide to Data Structures and Algorithms, Jay Wengrow, Pragmatic Bookshelf, 2020.
2. Data Structures and Algorithm Analysis in C++, Mark Allen Weiss, Addison-Wesley, 2014.

Course Code: CSC291 **Pre-Requisite:** None

Course Title: Software Engineering Concepts

Credit Hours: 3(3, 0)

Course Objectives:

- Introduce the different software process models by illustrating its phases;
- Develop awareness of using different tools and environment supported in software engineering;
- Develop basic understanding of requirement engineering to gather requirements for developing a system;
- Create design of a system by understanding its core concepts;
- Construct the system by understanding different coding techniques;
- Introduce the concepts of verification and validation.

Course Contents:

This course introduces the different software process models by illustrating its phases and principles of software engineering. Topics include Overview of Software Engineering; Software Process Models; Requirement Engineering Concepts; Software Design; Design Modeling; Software Quality Engineering; Software Project Management; Software Maintenance and Software Evolution.

Recommended Books:

1. Software Engineering: A Practitioner's Approach, Roger S. Pressman & Bruce R. Maxim, McGraw-Hill, 2020.
2. Engineering Software Products: An Introduction to Modern Software Engineering, Ian Sommerville, Pearson Education Limited, 2021.
3. Software Engineering, Ian Sommerville, Pearson Education Limited, 2016.
4. Software Engineering with UML, Bhuyan Unhelkar, CRC Press, 2018.

Course Code: CSC323 **Pre-Requisite:** CSC211

Course Title: Principles of Operating Systems

Credit Hours: 4(3, 1)

Course Objectives:

- To discuss the services provided by, and the design of an operating system;
- To explain the structure and organization of the file system and memory management;
- To discuss what a process is and how processes are synchronized and scheduled as well as how access to system resources is managed;
- To present the use of system calls for managing processes, memory and the file system;
- To explain the data structures and algorithms used to implement an OS;
- To explain security and protection issues in computer systems;
- To use C and UNIX commands to develop various system programs under Linux to make use of OS concepts related to process synchronization, shared memory, mailboxes, file systems, etc.

Course Contents:

This course introduces the services and functions performed by operating system for smooth and accurate system operations. Topics include: Operating Systems Overview; Device Organization & System Operations; Operating Systems Principles; Process Management; Process Synchronization; Deadlocks; Multiprocessor Issues; Memory Management; Storage Management; and Security & Protection.

Recommended Books:

1. Operating System Concepts, Silberschatz & Galvin, Addison-Wesley, 2021.
2. Modern Operating Systems, Tanenbaum, A. S., Prentice Hall, 2014.
3. Operating Systems: Internals and Design Principles, Stallings, W., Pearson, 2017.

Course Code: CSC340 **Pre-Requisite:** None

Course Title: Computer Networks

Credit Hours: 4(3, 1)

Course Objectives:

- To discuss the network components, services and technologies;
- To describe the layered architecture of network protocols (e.g. TCP/IP) and explains core functions of each layer including addressing, routing, internetworking, switching, multiplexing, error and flow control, medium access and coding, Wireless and mobile networks;
- To discuss threats to network security and design of secure networks;
- To develop an understanding with the implementation of fundamental concepts of networking.

Course Contents:

This course introduces the concepts of computer networks along with communication standards and protocols. Topics include: Introduction; Physical Components; Internet Backbones; Layered Architecture; Application Layer Services & Protocols; Transport Layer Services; Transport Layer Protocols; Network Layer; The Internet Protocol; Routing Algorithms; Link Layer; Error Detection Techniques; MAC Protocols; Physical Layer; Transmission Impairment; Wireless & Mobile Networks; Cellular Networks; and Security in Computer Networks.

Recommended Books:

1. Computer Networking: A Top-Down Approach, James F. Kurose, Keith Ross Pearson, 2021.
2. Data Communications and Networking with TCP/IP Protocol Suite, Behrouz A. Forouzan, McGraw-Hill, 2021.

Course Code: CSC270 **Pre-Requisite:** CSC211

Course Title: Database Systems

Credit Hours: 4(3, 1)

Course Objectives:

- To explain the basic database concepts, information retrieval and relational theory;
- To develop the relational data model;
- To develop an enterprise data model that reflects the organization's fundamental business rules;
- To apply normalization techniques;
- To discuss the basics of transaction management, concurrency controls, query mechanisms, security and quality issues;
- To use and apply database programming languages and physical database design to gain experience in term project.

Course Contents:

This course introduces the fundamental concepts of database systems. Topics include: Introduction to Databases & Information Systems; Evolution of Database Systems; Components; Architecture; Functions; Relational Model; Relational Algebra; Relational Calculus; Data Modeling; Relational Data Model; Relational Algebra & Calculus; Integrity Constraints; Conceptual Models; Entity-Relationship (E-R) Model; Enhanced E-R Model; Mapping Conceptual Schema to Relational Schema; Functional Dependency & Normalization; Structured Query Language (SQL); Views; Materialized Views; Non-Relational/No SQL Databases; MongoDB as NoSQL Database; Document Model; and Transaction Management.

Recommended Books:

1. Database systems: A Practical Approach to Design, Implementation, And Management, Thomas Connoll y, Carolyn Begg, Pearson, 2015.
2. MongoDB: The Definitive Guide, Shannon Bradshaw, Eoin Brazil, Kristina Chodorow, O'Reilly Media, 2019.
3. Fundamentals of Database Systems, Elmasri, R, Navathe, Pearson, 2016.
4. Database System Concepts, Silberschatz, Korth, Sudarshan, McGraw Hill, 2019.

Course Code: CSC432 **Pre-Requisite:** None

Course Title: Information Security

Credit Hours: 3(3, 0)

Course Objectives:

- To provide familiarity with prevalent network and distributed system attacks, defenses against them, and forensics to investigate the aftermath;
- To develop an understanding of cryptography, how it has evolved, and some key encryption techniques used today;
- To develop an understanding of security policies (such as authentication, integrity and confidentiality), as well as protocols to implement such policies in the form of message exchanges.

Course Contents:

This course introduces the concepts and applications of information security. Topics include: Information Security Overview; Threats & Attacks; Legal & Professional Issues; Security Planning; Risk Analysis; Security Technology; Cryptography; Confidentiality; Authentication Models; Operational Security; and Implementation & Maintenance.

Recommended Books:

1. Principles of Information Security, Michael E., Whitman & Mattord, H. J., Cengage Learning, 2017.
2. Security in Computing, Pfleeger, C.P., Pfleeger, S.L. & Margulies, J., Prentice Hall, 2015.
3. Introduction to Computer Security, Goodrich, M., & Tamassia, R., Pearson, 2021.

Course Code: CSC498 **Pre-Requisites:** HUM102, CSC241, CSC291 & CSC270

Course Title: Senior Design Project I

Credit Hours: 2(0, 2)

Course Objectives:

- To employ the knowledge gained from courses throughout the program such as development of requirements, designing and documentation;
- To develop the project plan, software requirement specification document and software design document for a complex real world problem;
- To enhance communication, presentation and writing skills.

Course Contents:

This course is designed as a capstone project which requires students to demonstrate technical and presentation skills at levels which are commensurate with professional software engineering practices. It is desirable that students apply their knowledge of computing throughout the course such as development of requirements, design, implementation, and quality assurance to develop a software solution to a real-world problem from conception to completion. In this part, students propose a practically useful project (by writing the scope document) and develop software requirement specification document & software design document.

Recommended Books:

As prescribed by the teacher depending on the project's domain

Course Code: CSC499 **Pre-Requisite:** CSC498

Course Title: Senior Design Project II

Credit Hours: 4(0, 4)

Course Objectives:

- To implement the design produced in CSC498 along with testing and evaluation of a complex real-world project in the area of Computer Science;
- To enhance presentation, communication and technical writing skills;
- To establish the ability to become an effective team player.

Course Contents:

The Final Year project is a prominent element of computing degree program and is central to the development of students' professional competencies. This is the second part of a two-semester, final-year capstone project. Student teams employ knowledge gained from courses throughout the program such as the development of requirements, design, implementation, and quality assurance to develop a software solution to a real-world problem from conception to completion. In this part, students implement the design they produced in CSC498, test their code, and evaluate their final product.

Recommended Books:

As prescribed by the teacher depending on the project's domain

General Education Courses

Course Code: CSC101 **Pre-Requisite:** None

Course Title: Introduction to ICT

Credit Hours: 3(2, 1)

Course Objectives:

- To provide basic understanding of information and communication technologies (ICTs);
- Discuss the four main functions of computer hardware: input, processing, output, and storage;
- Identify and describe major hardware components;
- Develop understanding of the basics of storage devices, number systems, machine cycle, and microcomputer processor;
- Identify, describe and use communications and networking terminology further include Internet operations and its uses;
- Describe the major functions and demonstrate usage of operating system services;
- Explain programming and application software;
- Discuss databases and e-commerce concepts;
- Understanding of IT security and other related issues.

Course Contents:

This course covers the basics of Information and Communications Technologies. Topics include: Overview of ICT; Computing Models; Computer Systems & Components; Number Systems & Computer Codes; System & Application Software; Introduction to Databases & Information Systems; Computer Networks & Internet; Security; Future trends in ICT; Problem Solving Concepts; Program Development Lifecycle; and Introduction to Python.

Recommended Books:

1. Understanding Computers: Today and Tomorrow, Comprehensive, Deborah Morley, Charles S. Parker, Cengage Learning, 2017.
2. Python Basics: A Practical Introduction to Python 3, David Amos, Dan Bader, Joanna Jablonski, and Fletcher Heisler, Real Python, 2021.
3. Foundations of Computer Science, Behrouz Forouzan, McGraw-Hill, 2017.
4. Starting Out with Python, Tony Gaddis, Addison-Wesley, 2016.
5. Problem Solving & Programming, Maureen Sprankle, Jim Hubbard, Prentice Hall, 2012.

Course Code: CSC410 **Pre-Requisite:** None

Course Title: Professional Practices

Credit Hours: 3(3, 0)

Course Objectives:

- Develop an understanding of the basic cultural, social, legal, and ethical issues inherent in the discipline of Computing;
- Highlighting the use and significance of professional ethics;
- Discuss intellectual property and privacy rights;
- To professionally communicate and evaluate formal documents;
- Explain the consequences of computing on individuals, organizations, and society.

Course Contents:

This course covers the following topics: Introduction to Ethics; Social Implications of Computing & Networked Communications; Intellectual Property; Information Privacy; Privacy & the Government; Computer & Network Security; Computer Reliability; Professional Ethics; Work & Wealth.

Recommended Books:

1. Ethics for the Information Age, Quinn, M.J., 5th Edition, Pearson Education, 2016.
2. Ethical and Social Issues in Information Age, Kizza J. M., 5th Edition, Springer-Verlag, 2017.
3. Ethics in Information Technology, Reynolds, G., Cengage Course Technology, 2018.
4. A Gift of Fire, Social, Legal, and Ethical Issues for Computing Technology, Baase, S., Pearson Inc, 2017.

Course Code: CSC312 **Pre-Requisite:** CSC102

Course Title: Theory of Automata

Credit Hours: 3(3, 0)

Course Objectives:

- To explain various models of automata and language theory;
- To present the classification of finite state machines and their equivalence;
- To discuss the generation of context free grammar for a specific language;
- To develop an understanding of computation through Turing machine;
- To discuss the theory of un-decidable problems.

Course Contents:

This course provides knowledge of computational theory. Topics includes Closure Properties, Regular languages, Regular Expressions; Finite State Machines: DFA, NFA, Equivalence of DFA & NFA; Pumping Lemma; Context-Free Grammars & Properties; Parsing & Ambiguity; Normal Forms; Designing CFG for a Specific language, Push Down Automata; Conversion among Equivalently Powerful Notations; Turing Machine: Formal Model for Universal Computation, Nondeterministic Turing Machine, and Halting Problem.

Recommended Books:

1. Formal Languages and Automata Theory: Introduction to Abstract and Theories of Computation, Bole, J., Independently published, 2021.
2. Introduction to the Theory of Computation, Michael Sipser, Cengage, 2013.

Course Code: CSC301 **Pre-Requisite:** CSC211

Course Title: Design and Analysis of Algorithms

Credit Hours: 3(3, 0)

Course Objectives:

- To develop an ability to analyze the asymptotic performance of algorithms;
- To discuss rigorous correctness proofs for algorithms;
- To explain the major algorithms and data structures;
- To apply important algorithmic design paradigms and methods of analysis;
- To highlight the significance of NP complete problems.

Course Contents:

This course is designed to provide knowledge of the principles and techniques used in the design and analysis of algorithms. Topics cover: Overview of Algorithm; Proving Correctness of Algorithms; Asymptotic Notations; Solving Recurrence Relations; Sorting & Order Statistics; Brute Force Algorithms & their Analysis; Divide and Conquer; Dynamic Programming; Greedy Algorithms; Graph; and Basic Computability.

Recommended Books:

1. Introduction to the Design and Analysis of Algorithms, Levitin, A., Pearson, 2017.
2. Introduction to Algorithms, Cormen, T. H., Leiserson, C.E., Rivest, R.L. & Stein, C., MIT Press, 2019.

Course Code: CSC462 **Pre-Requisite:** CSC102

Course Title: Artificial Intelligence

Credit Hours: 4(3, 1)

Course Objectives:

- Describe the fundamentals of Artificial Intelligence;
- Implement an appropriate uninformed/informed search algorithm for a problem and characterize its time and space complexity;
- Translate natural language sentences (e.g. English) into logic statements;
- Convert logic statements into a clause form and apply resolution to a set of logic statements to answer a query;
- Explain the basic machine learning tasks and techniques.

Course Contents:

This course gives a broad overview of the fundamental theories and techniques of Artificial Intelligence. Topics include: Overview of Artificial Intelligence; Agents & Environments; Problem-Solving; Adversarial Search; Constraint Satisfaction Problems; Knowledge Representation & Reasoning; Uncertainty; and Automated Planning.

Recommended Books:

1. Artificial Intelligence: A Modern Approach, Russell, S., and Norvig, P., Pearson, 2020.
2. Artificial Intelligence Basics: A Non-Technical Introduction, Taulli, T., Apress, 2019..

Course Code: CSC441 **Pre-Requisite:** CSC312

Course Title: Compiler Construction

Credit Hours: 3(2, 1)

Course Objectives:

- Explain the theory and principles behind language translators;
- To present the overview of automata theory, context free grammar and related tools for the compiler construction;
- Identify and handle various design issues of several programming languages;
- Construct and customize a compiler for a simple language.

Course Contents:

This course provides concepts and theories of compilers. Topics include: Theories of Compilers; Language Translation Phases & Execution; Type Checking & Documentation; Lexical Analysis; Syntax Analysis; Generating Scanners & Parsers from Declarative Specifications; Semantic Analysis; Intermediate Representation; Memory Organization; and Code Generation & Optimization.

Recommended Books:

1. Introduction to Compilers and Language Design, Thain, D., Independently published, 2020.
2. Compilers: Principles, Techniques and Tools, Alfred V.Aho,D. Ullman., Pearson, 2010.
3. Fundamentals of Compiler Design, Adesh K.Pandey, S.K.Kataria, 2015.
4. Compiler Construction. K.V. N. Sunitha. Pearson Edition, 2013.

Course Code: CSC325 **Pre-Requisite:** None

Course Title: Computer Organization & Assembly Language

Credit Hours: 4(3, 1)

Course Objectives:

- To explain the basic characteristics of a microprocessor and its applications;
- To present the basic architecture of the IA-32 processor;
- To provide a comprehensive understanding of 80X86 instruction set;
- To develop an understanding of the basic steps of assembling, linking and executing an assembly program;
- To solve a given problem by writing programs in assembly language.

Course Contents:

This course covers the concepts of computer organization along with programming in Assembly language. Topics include: Preliminary Concepts of Computer Organization; Von Neumann Architecture; IA-32 Microprocessors Organization; Modes of the processors; Non-Von Neumann Architectures; Pipelined vs. Non-Pipelined Systems; Parallel Processing; CISC vs. RISC Processors; Instructions Set Design & Formats; Addressing Modes; Memory System Organization & Architecture; Utilization of Memory Systems in Programming; IO Fundamentals; Data Transfer methods; CPU Performance Calculation; and Assembly Language Programming.

Recommended Books:

1. Assembly Language for x86 Processors, Irvine, K.R., Pearson, 2020.
2. Computer Organization and Architecture, William S., Pearson, 2019.
3. Essentials of Computer Organization and Architecture, Null L., Jones and Bartlett, 2019.

Course Code: CSC334 **Pre-Requisite:** CSC323

Course Title: Parallel and Distributed Computing

Credit Hours: 3(2, 1)

Course Objectives:

- To explain the fundamental concepts of parallel and distributed computing along with its benefits and limitations;
- To provide an understanding of basic concepts of parallel and distributed systems paradigms: Grid Computing, Cloud Computing, cluster and Peer-to-Peer Computing;
- To develop an understanding of the application of parallel and distributed algorithms in problem solving;
- To provide hands-on experience of distributed and parallel programming paradigms using open MPI.

Course Contents:

This course covers the basic concepts and applications of parallel & distributed computing. Topics include: Distributed Systems; Parallel Computing; Virtual Machines & Virtualization; Parallel Algorithms & Patterns; OpenMP; GPU Concepts & Architectures; and GPU Programming Model.

Recommended Books:

1. Parallel and High Performance Computing, Robey, R., Zamora, Y., Manning, 2021.
2. Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Hwang, K., Fox, C. G., Dongarra, J. J., Morgan Kaufmann, 2011.
3. Distributed Systems: Concepts and Design, Coulouris, G., Dollimore, J. & Kindberg, Addison-Wesley, Pearson, 2011.

Course Code: CSC307 **Pre-Requisite:** CSC102

Course Title: Graph Theory

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the fundamental concepts of Graph Theory;
- To provide knowledge for application of Graph Theory in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.

Course Contents:

This course covers the following topics: Basic Concepts in Graph Theory; Trees & Forest; Properties of Graphs & Digraph; Connectivity & Flow; Coloring & Planar Graphs; Independence & Domination of Vertices; Matching in Graph; Hall's Marriage Theorem; Graph Counting; and Applications.

Recommended Books:

1. Fundamentals of Graph Theory, Allan Bickle, AMS, 2020.
2. Graph Theory with Applications to Engineering and Computer Science, Narsingh Deo, Dover Publications, 2016.
3. Recent Advancements in Graph Theory,N. P. Shrimali,Nita H. Shah, CRC Press, 2020.

Course Code: CSC315 **Pre-Requisite:** CSC103

Course Title: Theory of Programming Languages

Credit Hours: 3(3, 0)

Course Objectives:

- To recognize major programming language;
- To explain the stages of programming language interpretation and compilation;
- To explain design concepts, design alternatives and trade-offs, and implementation; considerations for scope, binding, data types, expressions, control structures, subprograms, objects in modern programming languages;
- To understand the principles of language design and implementation;
- To choose a suitable programming language for a given problem or domain;
- To evaluate modern programming languages critically.

Course Contents:

Evolution of the Major Programming Languages, Describing Syntax and Semantics, Lexical and Syntax Analysis, Names, Bindings, and Scopes, Data Types, Expressions and Assignment Statements, Statement-Level Control Structures, Recursive Functions, Subprograms, Abstract Data Types and Encapsulation Constructs, Support for Object-Oriented Programming, Concurrency, Exception Handling and Event Handling, Functional Programming Languages, Logic Programming Languages

Recommended Books:

1. Concepts of Programming Languages, Robert W Sebesta, Pearson, 2019

Track I: Artificial Intelligence

Course Code: CSC354 **Pre-Requisite:** None

Course Title: Machine Learning

Credit Hours: 3(3, 0)

Course Objectives:

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

Course Contents:

This course provides the overview of machine learning along with various learning tasks. Topics include: Overview of Machine Learning; Supervised Learning; Unsupervised Learning; Reinforcement Learning; and Deep Learning.

Recommended Books:

1. Introduction to Machine Learning, Ethem Alpaydin, MIT Press, 2010.
2. Machine Learning, Tom, M., McGraw Hill, 1997.
3. Hands on Machine Learning with Scikit-Learn and TensorFlow, Aurelien Geron, O`Reilly Media, 2017.
4. Deep Learning with PyTorch – Essential Excerpts, Eli Stevens, Luca Antiga, Thomas Viehmann, Manning Publications, 2009.
5. Pattern Recognition and Machine Learning, Bishop, C., Springer-Verlag, 2007.

Course Code: AIC365 **Pre-Requisite:** None

Course Title: Natural Language Processing

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss the basic concepts of Natural Language Processing (NLP);
- To discuss the different algorithms and techniques in NLP;
- To present NLP problem, students should be able to analyze, assess and justify which algorithms are most appropriate for solving the problem;
- To identify the suitable evaluation measures for a given problem.

Course Contents:

This course introduces the key concepts of Natural Language Processing. Topics include: Overview of NLP; Language Modeling; Word Level Analysis; Syntactic Analysis; Discourse Processing; Machine Translation; Information Retrieval; Deep Learning for NLP; and Speech Recognition.

Recommended Books:

1. Introduction to Natural Language Processing, Einstein J, MIT Press, 2019.
2. Natural Language Processing in Action: Understanding, analyzing, and generating text with Python, Lane H, Hapke H, Howard C, Manning Publications, 2019.

Course Code: CSC421 **Pre-Requisite:** None

Course Title: Robotics

Credit Hours: 3(3, 0)

Course Objectives:

- To present the fundamentals of robotic systems;
- To explain the capabilities and limitations of various state-of-the-art robots ;
- To provide an understanding of robot control architectures;
- To explain the theory of robotics navigation and control, path and motion planning;
- To discuss multiple robot coordination and feedback control strategies;
- To introduce the probabilistic robotics.

Course Contents:

This course introduces the fundamental concepts of robotics mechanisms, dynamics, and intelligent controls. Topics include: Introduction to Robotics; Spatial Transformations; Kinematics; Trajectory Planning; Imaging for Robotics; Mechanical Design of Robots; and Robot Control Architectures & Sensing.

Recommended Books:

1. Introduction to Robotics, Craig, J.J., 4rd Edition, Pearson, 2018.
2. Robotics: Everything You Need to Know About Robotics from Beginner to Expert, Peter Mckinnon, CreateSpace Independent Publishing Platform, 2016.

Course Code: CSC454 **Pre-Requisite:** None

Course Title: Pattern Recognition

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the fundamentals of pattern recognition;
- To present the generative methods such as Bayes decision theory, parameter and density estimation;
- To explain the discriminative methods such as support vector machines and nearest neighbor classification;
- To discuss pattern recognition applications;
- To focus on explaining computer vision as a major application of pattern recognition.

Course Contents:

The topics include Overview of Pattern Recognition; Density Estimation; Linear & Nonlinear Discriminant Analysis; Feature Selection & Extraction, and Applications.

Recommended Books:

1. Essentials of Pattern Recognition, An Accessible Approach, Jianxin Wu, Cambridge University Press, 2020.
2. Fundamentals of Pattern Recognition and Machine Learning, Ulisses Braga-Neto, Springer International Publishing, 2020.

Course Code: CSC455 **Pre-Requisite:** None

Course Title: Computer Vision

Credit Hours: 3(3, 0)

Course Objectives:

- To provide an introduction to basic concepts and methodologies for recognition and extraction of features from raster images;
- To provide a foundation for developing applications and for further study in the field;
- To gain practical experience in the design and implementation of image processing algorithms.

Course Contents:

The topics covers includes: Overview of Computer Vision; Multiple Views & Motion; Feature Detection & Matching; Recognition; Geometry for 3D Vision; Motion Analysis; and Deep Networks.

Recommended Books:

1. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer, 2021.
2. Computer Vision Using Deep Learning: Neural Network Architectures with Python and Keras, Verdhan, Vaibhav, Apress, 2021.

Course Code: AIC270 **Pre-Requisite:** CSC103

Course Title: Programming for Artificial Intelligence

Credit Hours: 3(2, 1)

Course Objectives:

- To explain the fundamental constructs of programming language for data analysis and representation;
- To discuss and apply Solve and analyze programming and data analysis problems using standard libraries and/or toolboxes of the programming language.

Course Contents:

This course introduces the programming approaches used for building AI based applications. Topics include: Logic Programming (Python); Simulated Annealing; Tabu Search; Solving Region Coloring Problem; Building an 8 Puzzle Solver; Building an Intelligent Robot Controller using Genetic Algorithm; AI Based Games; Object Detection & Tracking; OpenCV; and Building AI Applications using Deep Learning.

Recommended Books:

1. Artificial Intelligence with Python: Your complete guide to building intelligent apps using Python 3.x, Artasanchez, A. & Joshi, P., Packt Publishing, 2020.
2. Introduction to Logic Programming (Synthesis Lectures on Artificial Intelligence and Machine Learning), Genesereth, M., et al., Morgan & Claypool, 2020.
3. AI for Games, Millington, I., CRC Press, 2019.

Course Code: CSC331 **Pre-Requisite:** MTH231

Course Title: Digital Image Processing

Credit Hours: 3(3, 0)

Course Objectives:

- To explain the image formation process;
- To discuss the basic image acquisition process, and its representation;
- To explain the basic image processing techniques in both spatial and frequency domains;
- To present the usage of these techniques on small (workable) image segments;
- To explain various segmentation approaches, along with their characteristics, differences, strengths, and weaknesses;
- To explain the need for different image morphological algorithms and transformations.

Course Contents:

This course gives an overview of the fundamental theories and techniques of digital image processing. The topics include: Digitized Image & its Properties; Image Enhancement & Restoration; Image Segmentation; Shape Representation & Description; Morphological Image Processing; Linear Discrete Image Transforms; and Image Data Compression.

Recommended Books:

1. Digital Image Processing, Gonzalez, R.C. & Woods, R.E., Pearson, 2018.
2. Digital Image Processing A Complete Guide, Gerardus Blokdyk, 5STARCooks, 2020.

Track II: Data Science

Course Code: CSC461 **Pre-Requisite:** MTH262

Course Title: Introduction to Data Science

Credit Hours: 3(3, 0)

Course Objectives:

- Identify and classify data science problems;
- Understanding of the skills required for data analytics at massive levels – scalable data management on and off the cloud;
- Understanding of the basic techniques of data science, including both SQL and NoSQL solutions for massive data management (e.g., Hadoop, MapReduce and contemporaries);
- Understanding of the algorithms for data mining (e.g., clustering and association rule mining), and basic statistical modeling (e.g., linear and non-linear regression) in the context of big data.

Course Contents:

This course provides the basic concepts and principles of Data Science. The topics include: Overview of Data Science; Landscape; Tools & Applications; Introduction to R & RStudio; Data Visualization Techniques; Data Wrangling; Statistical Modeling; Predictive Modeling; and Data Science Ethics.

Recommended Books:

1. Modern Data Science with R, Benjamin S. Baumer, Daniel T. Kaplan, Nicholas J. Horton, Chapman and Hall, 2021.
2. Introduction to Data Science Data Analysis and Prediction Algorithms with R, Rafael A. Irizarry, CRC Press, 2021.

Course Code: DSC306 **Pre-Requisite:** None

Course Title: Data Mining

Credit Hours: 3(2, 1)

Course Objectives:

- To discuss the application of preprocessing techniques on any given raw data;
- To discuss data mining algorithms to discover patterns;
- To analyze data mining tasks using advance datasets from Kaggle, Google and implementation in python using Jupyter, Spider and Julia.

Course Contents:

The course covers the concepts and techniques of Data Mining. The topics include: Introduction to Data Mining; Classification; Association Analysis; Cluster Analysis; and Anomaly Detection.

Recommended Books:

1. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Anuj Karpatne and Vipin Kumar, Second Edition, Pearson, 2018.
2. Introduction to Data Mining and Analytics, Kris Jamsa, Jones & Bartlett Learning, 2020.
3. Data Mining: Concepts and Techniques, Jiawei Han, Morgan Kaufmann, 2011.

Course Code: CSC405 **Pre-Requisite:** None

Course Title: Introduction to Artificial Neural Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To present the fundamentals of neural networks in AI;
- To design simple neural network;
- To apply neural networks on classification problems;
- To discuss major deep learning algorithms, the problem settings, and their applications to solve real world problems.

Course Contents:

This course provides an overview of artificial neural networks and its applications. The topics include: Overview of Neural Networks; Single and Multilayer Layer Perceptrons; Pattern Association; Radial-Basis Function Networks; Kohonen Self-Organizing Maps; Convolutional Neural Networks; Recurrent Neural Networks; and Applications.

Recommended Books:

1. Principles of Artificial Neural Networks: Basic Designs to Deep Learning, Graupe, D., World Scientific Publishing Company, 2019.
2. Deep Learning: A practitioner Approach, Adam Gibson, Josh Patterson, O'Reilly Media, 2017.
3. Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016.

Course Code: CSC367 **Pre-Requisite:** None

Course Title: Distributed Data Processing

Credit Hours: 3(3, 0)

Course Objectives:

- To identify big data characteristics;
- To compare distributed algorithms for big data processing;
- To develop simple algorithms for distributed big data processing;
- To apply open source technologies for distributed big data processing and storage;
- To develop a distributed recommender system;
- To develop a distributed data stream processing system;
- To analyze big networks.

Course Contents:

This course is about the key concepts of Distributed Data processing. Topics include: Distributed Data; Distributed Data Processing; Distributed Data Processing Architectures & Design; Performance Evaluation; Distributed Data Processing Frameworks & Technologies; and Applications.

Recommended Books:

1. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems, Kleppmann, Martin, O'Reilly, 2017.
2. Streaming Architecture: New Designs Using Apache Kafka and MapR Streams, Ted Dunning , Ellen Friedman, O'Reilly Media, 2018.
3. Spark: The Definitive Guide: Big Data Processing Made Simple, Bill Chambers, Matei Zaharia, O'Reilly Media, 2018.

Course Code: CSC372 **Pre-Requisite:** None

Course Title: Exploratory Data Analysis & Visualization

Credit Hours: 3 (3, 0)

Course Objectives:

- To teach the student about key techniques and theory used in visualization, including data models, graphical perception and techniques for visual encoding and interaction;
- To exposure a number of common data domains and corresponding analysis tasks, including multivariate data, networks, text and cartography;
- Practical experience building and evaluating visualization systems.

Course Contents:

The course will cover the following topics: Exploratory Data Analysis; Working with External & Text Data; Linear Regression Models; Information Visualization & Scientific Visualization; Data transformation & Visual Simplification Techniques; Visualization Building Blocks; Creating Basic Statistical Plots using Libraries; Programming Techniques; Visualization in High Dimension Data; and Interaction Techniques.

Recommended Books:

1. Exploratory Data Analysis Using R, Pearson, R., K., Chapman and Hall/CRC, 2018.
2. Data Visualization - Principles and Practice, Alexandru C. Telea, CRC Press, 2014.
3. Exploratory Data Analysis with R, Roger D. Peng, Lulo, 2016.
4. Better Data Visualizations: A Guide for Scholars, Researchers, and Wonks, Schwabish, J., Columbia University Press, 2021.
5. Information Design Workbook: Graphic Approaches, Solutions, and Inspiration + 30 case studies, Baer, K., Rockport Publishers, 2021.

Track III: Software Development

Course Code: CSC303 **Pre-Requisite:** CSC241

Course Title: Mobile Application Development

Credit Hours: 3(2, 1)

Course Objectives:

- Discuss different mobile application development platforms and architectures;
- Discuss the components of mobile application development;
- Compare different mobile application development tools;
- Describe the constraints that game platforms impose on developers;
- Develop a medium sized mobile application as a team.

Course Contents:

This course introduces the fundamental concepts related to the design and implementation of mobile application that uses JavaScript and React Native. Topics Include: Overview; Concepts of JavaScript; Programming in React Native; GitHub; Concepts of React Navigation; Working with Multiple Screens with React Navigation; Working with Persistent Storage using AsyncStorage; Retrieving Data from Server using API; State Management and Redux; Accessing Device Camera; GPS & Google Maps API; Working with Mobile Sensor; and Ejecting & Publishing Mobile Applications.

Recommended Books:

1. React Native in Action, Nader Dabit, Manning Publications, 2019.
2. Fullstack React Native, Shoemaker, Sophia, Djirdeh, Houssein,, Published by Fullstack.io, 2019.

Course Code: CSC336 **Pre-Requisite:** CSC241

Course Title: Web Technologies

Credit Hours: 3(2, 1)

Course Objectives:

- To explain the fundamental concepts of web architectures and its applications;
- To provide an understanding of Search Engine Optimization (SEO);
- To provide an understanding of planning, designing and publishing a multi-page website;
- To provide hands-on experience of client-side technologies such as HTML, JavaScript, CSS;
- To provide practical experience of development of dynamic clients using modern development technologies, for example PHP, AJAX, MySQL.

Course Contents:

This course introduces the modern web technologies used for the web development. Topics include: Overview of Web Platforms; Web Architectures; Markup Languages; Styling; Client-Side Scripting Languages; Server-Side Technologies; Use of Databases in Web-based Applications; Web APIs; Programming under Platform Constraints; Security Issues; and Web Hosting.

Recommended Books:

1. Web Design Playground: HTML & CSS the Interactive Way, Paul McFedries, Manning, 2019.
2. Beginning PHP and MySQL: From Novice to Professional, Frank M. Kromann, Apress, 2018.
3. Laravel Up and Running, A Framework for Building Modern PHP Apps, Matt. Stauffer, Oreilly, 2019.
4. Web Engineering, Sahil Rai, Kuk University Notes, 2020.
5. Web Programming with HTML5, CSS, and JavaScript, John Dean, Jones & Bartlett Learning 2018.

Course Code: CSC337 **Pre-Requisite:** CSC336

Course Title: Advanced Web Technologies

Credit Hours: 3 (2, 1)

Course Objectives:

- To build a Web Server in Node and understand how it really works;
- To design and develop REST API using Express and Node;
- To implement security on REST API;
- To implement Front End Application using React and Angular;
- To understand how the MERN and MEAN stack works;
- To build a web application and API using Express.JS framework.

Course Contents:

This course is aimed to give students the opportunity to learn current web technologies and programming techniques. Topics include: Technological Race; Concepts of JSON; MEAN Stack; MongoDB; Node.JS; Client Connector & Mongoose; Express JS Framework; REST API; Angular; MEAN Stack Application Development; React JS; and MERN Stack Application Development.

Recommended Books:

1. Beginning Node.js, Express & MongoDB Development, Lim, G., Amazon, 2019.
2. REST API Development with Node.js: Manage and Understand the Full Capabilities of Successful REST Development, Doglio, F., APress, 2018.
3. Pro Angular 9: Build Powerful and Dynamic Web Apps, Freeman, A., APress, 2020.
4. React and Libraries: Your Complete Guide to the React Ecosystem, Elrom, E., APress, 2021
5. Web Development with Node and Express, Ethan Brown,O'Reilly Publishing, 2019.
6. Building Modern Web Applications Using Angular, Kasagoni, S. K., Packt Inc, 2017.
7. Full-Stack React, TypeScript, and Node: Build cloud-ready web applications using React 17 with Hooks and GraphQL, Choi, D., Amazon Kindle Edition, 2020.

Course Code: CSC412 **Pre-Requisite:** CSC241

Course Title: Visual Programming

Credit Hours: 3(2, 1)

Course Objectives:

- To explain the visual concepts of event-driven programming;
- To focus on graphical user interfaces in windows environment, program structure, language syntax, and implementation details for the development of visual programming based applications;
- To concentrate on the recent usage of platforms used in the development;
- To enable students through hands-on practice to develop small-scale applications.

Course Contents:

This course introduces the fundamental concepts related to the design and implementation of application based on visual programing. Topics include: Visual Programming Basics; Fundamentals of Event-driven Programming; Windows Applications; Introduction to WPF & XAML; Markup Extensions; Deploying & Installing Windows Application; Working with Data; Database Connectivity; Threads; Introduction to ASP.NET Core; Entity Framework; Multiple Views & Controllers; and Code First & DB First Approach.

Recommended Books:

1. Microsoft Visual C# Step by Step (Step by Step Developer), Sharp, J., Microsoft Press, 2018.
2. Modern Cross-Platform Development: Build intelligent apps, websites, and services with Blazor, ASP.NET Core, and Entity Framework Core using Visual Studio Code, Packt, 2020.
3. Microsoft Docs, https://docs.microsoft.com.
4. ASP.NET Core in Action, Second Edition, Andrew Lock, Mar 2021.

Course Code: CSC417 **Pre-Requisite:** None

Course Title: E-Commerce and Digital Marketing

Credit Hours: 3 (2, 1)

Course Objectives:

- To create Ecommerce store on different digital platforms;
- To create web blogs and generate traffic;
- To implement different Search Engine optimization techniques;
- To generate business from different channels using SEO and Digital marketing;
- To identify the importance of the digital marketing for marketing success, to manage customer relationships across all digital channels and build better customer relationships;
- To be able to create a digital marketing plan and can execute it.

Course Contents:

This course introduces E-Commerce and the modern digital marketing techniques. Topics Include: Overview of E-Commerce; Development of E-Commerce; E-Commerce Implementation Costs; Digital Marketing; Digital Marketing Technologies; AdWords Campaigns and Website Analytics; Google Analytics; Security threats in E-Commerce Environment; Legal issues in E-commerce; Online Auctions: E-Bay Case Study; Customer Relationship Management (CRM); Application of E-Commerce: Amazon Case study.

Recommended Books:

1. E-Commerce: Business, Technology, Society, by Kenneth C. Loudon, Pearson Edition, 2021.
2. Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation, Ryan, D, Kogan Page Limited, 2020.
3. Learn SEO with smart internet marketing strategies, Adam Clarke, 2021.
4. The Beginner's Guide to Digital Marketing Pulizzi,J, Mcgraw Hill Education, 2015.

Course Code: CSC418 **Pre-Requisite:** None

Course Title: DevOps for Cloud Computing

Credit Hours: 3 (2, 1)

Course Objectives:

- Describe fundamental concepts of Cloud computing
- To develop an ability to deploy cloud key components on cloud service model.
- Able to use different cloud Microservices and serverless computing.
- To develop an ability to understand and deploy DevOps pipeline
- To develop an ability to deploy DevOps pipeline in cloud infrastructure.

Course Contents:

This course introduces the core concepts of implementing DevOps using cloud computing. Topics include: Cloud Computing; Service Models; Multi-Cloud; Deployment Models; Emerging Cloud Trends and Practices; Virtualization & Containerization; Components of a Cloud Infrastructure; Introduction to DevOps and its Roles; Source Control Management; DevOps Utility and Automation; CI/CD; Infrastructure as Code (IAC); SDLC of DevOps; Microservices; Serverless Computing; DevOps Cloud Native; Application Modernization; Deployment to Cloud; Operate and Monitor using DevOps Tools.

Recommended Books:

1. Cloud Computing with Security: Concepts and Practices, Naresh Kumar Sehgal, Pramod Chandra P. Bhatt, John M. Acken, Springer, 2020.
2. Practical DevOps: Implement DevOps in your organization by effectively building, deploying, testing, and monitoring code, Verona, J, Packt Publishing Ltd, 2018.
3. Cloud computing: implementation, management, and security, Ransome, J. F, CRC press, 2017.
4. Design and Implementation of Service Management in DevOps Enabled Cloud Computing Models. In Handbook of Research on End-to-End Cloud Computing Architecture Design, Eigenbrode, S., & Nassar, S, IGI Global, 2017.
5. Hands-On Serverless Computing, Kuldeep Chowhan, Packt Publishing, 2019.

Track IV: Game Development

Course Code: CSC335 **Pre-Requisite:** None

Course Title: Game Design

Credit Hours: 3(3, 0)

Course Objectives:

- To teach students the basic concepts of Games
- To learn the behaviors and roles each component must have in order to make a videogame
- To practice writing storylines, animation production and creation tools
- To understand the interplay between Neuroscience and UX in Video Game Design

Course Contents:

This course introduces the fundaments concepts of game design. Topics include: Brief History of Games; Games and Society; Analysis of Games; Game Design; Game Concepts; Game Architecture; User Analysis; Mechanics and Dynamics; Creating Game Worlds; Game User Experience; and Game Testing.

Recommended Books:

1. Game Thinking: Innovate Smarter & Drive Deep Engagement with Design Techniques from Hit Games, Kim, A, J, GameThinking.io, 2019.
2. The Art of Game Design: A Book of Lenses, Schell, J, Morgan Kaufmann, 2019.
3. The Gamer's Brain: How Neuroscience and UX Can Impact Video Game Design, Hodent, C, CRC Press, 2017.
4. Hands on Game Development without Coding, Lucas Bertolini, Packt Publishing, 2016.

Course Code: CSC353 **Pre-Requisite:** MTH231

Course Title: Computer Graphics

Credit Hours: 3(2, 1)

Course Objectives:

- To introduce the fundamental concepts of computer graphics;
- To explain the graphics pipeline approach;
- To provide an understanding of visualization of 2D & 3D objects using geometric primitives;
- To provide an understanding of basic concepts of projection of 3D objects and camera calibration;
- To explain the fundamental aspects of geometric modeling (e.g. curves & surfaces);
- To develop an understanding of animation techniques related to computer graphics.

Course Contents:

This course covers the key concepts of computer graphics and their applications. Topics Include: Graphics Systems Overview; Pixels for Visual Display; Hardwar, Software & APIs; Interactive Input Methods; Animation; Graphics Pipeline & Modeling; Vector & Raster Graphics; Programming Raster Display Systems; 2-D & 3-D Transformations; Additive & Subtractive Color Models; Clipping & Viewing; Projections; Camera Concepts; Rendering; Lighting; Shading; Material Properties; Illumination Models; Texture & Bump Mapping; Splines & Curves; Scene Graphs; GPU; and Programmable Pipeline.

Recommended Books:

1. Fundamentals of Computer Graphics, Steve Marschner, Peter Shirley, CRC Press, 2021.
2. Interactive Computer Graphics, Edward Angel & Dave Shreiner, Pearson, 2020.

Course Code: CSC356 **Pre-Requisite:** None

Course Title: Human Computer Interaction

Credit Hours: 3(2, 1)

Course Objectives:

- To explain the human factors to be considered in the design of human computer interaction;
- To define different processes for designing interfaces for different contexts;
- To define and implement user-centered approach in software development process and apply suitable techniques for collecting user requirement and analyzing tasks;
- To discuss the evaluation and comparison of user interfaces using different techniques such as laboratory experiments and expert reviews;
- To apply different techniques learned throughout the course on a practical project.

Course Contents:

This course covers the fundamental principles and methods related to Human-Computer Interaction (HCI). Topics include: Overview; Universal Design; PACT Analysis; Evaluation Measures; Conceptualizing Interaction; Data Gathering Techniques; Process for Human Centered Development; Evaluation with & without Users; Cognitive & Social Aspects; Interaction Technologies; and Case Studies.

Recommended Books:

1. Interaction Design beyond Human Computer Interaction, Sharp, H Preece, J. Rogers, Wiley, 2019.
2. Laws of UX: Using Psychology to Design Better Products & Services, Yablonksi, O'Reilly Media, 2020.
3. Designing the User Interface: Strategies for Effective Human-Computer Interaction, Shneiderman, Catherine Plaisant, Pearson, 2018.
4. Designing Interfaces: Patterns for Effective Interaction Design, Tidwell, Brewer, Valencia, O'Reilly Media, 2019.
5. The Design of Everyday Things: Revised and Expanded Edition, Norman D, Basic Books, 2014.

Course Code: CSC495 **Pre-Requisite:** CSC241

Course Title: Game Development

Credit Hours: 4(3, 1)

Course Objectives:

- To discuss the leading trends in game development;
- To describe the concepts related to game play, game flow, interactive narratives, storytelling and apply them in practice to develop an addictive game;
- To practice main tools (game editors) available to develop games and to identify the best one for a specific purpose.

Course Contents:

This course will cover the following topics: Game Development Overview; Game Characters; Gameplay; HUD; Difficulty Balance; Game Development Engine Overview (Unity); Scenes and Game Objects; Graphics & Sound Material and Effects with URP & Shader Graph; Lighting Using the Universal Render Pipeline; Full Screen Effects with Post Processing; Sound & Music Integration; User Interface Design; Creating a UI using Toolkit; Creating Animation with Animator; Cinemachine & Timeline; C# & Visual Scripting; Movement & Spawning; Win & Lose Condition; AI for Game Development; and Releasing the Game.

Recommended Books:

1. Hands-On Unity 2021 Game Development: Create, customize, and optimize your own professional games from scratch with Unity 2021, Borromeo, N. A., Packt Publishing, 2021.
2. Agile Game Development with Scrum, Keith, C., Addison-Wesley, 2020.
3. The Art of Game Design: A Book of Lenses, Schell, J., Morgan Kaufmann, 2008.
4. Fundamentals of Game Design, Adams, E., New Riders, 2010.

Course Code: CSC496 **Pre-Requisite**: CSC495

Course Title: Game Engine Development

Credit Hours: 3(2, 1)

Course Objectives:

- To analyze the structure of game engines by looking at their architecture;
- To explore different design patterns that are applied in an engine;
- To provide realism in games by simulating physical aspect of an engine.

Course Contents:

This course will cover the following topics: Foundations; Tools and Assets Pipeline; Tools of the Trade; Parallelism & Concurrency; Low Level Engine Systems; Game Loop & Real-Time Simulations; Human Interface Devices; The Rendering Engine & Animation Systems; Physics; Audio; and Game Play.

Recommended Books:

1. Game Engine Architecture, Gregory, J., 3rd edition, CRC Press, 2018
2. Game Physics Engine Development: How to Build a Robust Commercial-Grade Physics Engine for your Game, Milington, I., CRC Press, 2010

Track V: Cyber Security

Course Code: CYC205 **Pre-Requisite:** None

Course Title: Introduction to Cyber Security

Credit Hours: 3(3, 0)

Course Objectives:

- To provides students an introduction to common cyber security threats, vulnerabilities, and risks related to web applications, networks, software and mobile applications;
- To provides basic concepts and terminology used in the information and cyber security fields;
- To enable students to differentiate between the various forms of malware and how they affect computers and networks.

Course Contents:

This course provides an overview of cyber security. Topics include: Introduction to Cyber Security; Network Security; Types of Network Attacks; Application Security; Mobile Security; Data Security; Infrastructure Security; Defense Against Cyber Attack; Management of Cyber Security; Cyber Investigators; Cyber Security & Industrial Control Systems; Legal Framework for Cyber Security; and Cyber Security & Automation.

Recommended Books:

1. Introduction to Cyber Security: Guide to the World of Cyber Security, Shinde, A., Notion Press, 2021.
2. Cyber Security, Padallan, J. O., Packt, 2019.
3. Cybersecurity for Beginners, Meeuwisse, R., Cyber Simplicity Ltd, 2017.
4. Cybersecurity Essentials, Brooks, C. J., Grow, C., Craig, P., Short, D., John Wiley & Sons, 2018.

Course Code: CYC303 **Pre-Requisite:** None

Course Title: Digital Forensics

Credit Hours: 3(2, 1)

Course Objectives:

- To describe the fundamentals and importance of digital forensics;
- To teach different techniques and procedures that enables them to perform a digital investigation;
- To conduct a digital investigation in an organized and systematic way;
- To apply open-source forensics tools to perform digital investigation.

Course Contents:

This course provides an overview of digital forensics and its related issues. The topics include: Introduction to Digital Forensics; Digital Forensic Approaches; Forensic Lab Environment Preparation; Computer Forensics; Internet & E-Mail Examinations; Mobile Forensics; Cloud Computing & Digital Forensics; Law Enforcement Incident Response; Report Writing & Presentation; Social Media Forensics; Social Engineering Forensics; and Anti-Forensics.

Recommended Books:

1. Digital Forensics and Incident Response, Gerard Johansen, Packt,2020 Digital Forensics Explained, Greg Gogolin, CRC Press, 2021.
2. Digital Forensics, A. Flaglien, I. M. Sunde, A. Dilijonaite, J. Hamm, J. P. Sandvik, P.Bjelland, K. Franke, S. Axelsson, John Wiley & Sons, Ltd, 2017.
3. The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics, John Sammons, Syngress, 2014.
4. Hacking Exposed Computer Forensics Secrets & Solutions, A. Philipp, D. Cowen, C. Davis, McGraw-Hill Education, 2009.

Course Code: CYC365 **Pre-Requisite:** CSC340

Course Title: Network Security

Credit Hours: 3(2, 1)

Course Objectives:

- To develop core competencies in the fields of Network security and offer the opportunity of learning the current network security landscape.
- To understanding current threats and vulnerabilities and examining ways of developing effective countermeasures.
- To provides a brief overview to network forensics for analyzing network traffic for the purposes of information gathering, legal evidence, or intrusion detection.

Course Contents:

This course introduces the security issues faced by computer networks along with techniques to guard against them. Topics include: Network Security Issues; OSI Security Architecture; Threats & Vulnerabilities; Cryptography; Access Control; Transport-Layer Security; Wireless Network Security; Email Security; IP Security; Malicious Software; Intrusion Detection; Firewalls; and Security Management.

Recommended Books:

1. Network Security Essentials: Applications and Standards, William Stallings, Pearson, 2016.
2. Network Security, Firewalls, and VPNS, by J. Michael Stewart, Denise Kinsey, Jones & Bartlett Learning, 2020.
3. Principles of Computer Security: CompTIA Security+ and Beyond by Wm.A. Conklin et al., McGraw Hill, 2018.

Course Code: CYC386 **Pre-Requisite:** None

Course Title: Secure Software Design and Development

Credit Hours: 3(2, 1)

Course Objectives:

- To develop core competencies in the fields of Secure Software Concepts, Secure Software Requirements, Secure Software Design, Secure Software Implementation/Coding, and Secure Software Testing.
- To describe the software security activities that needs to be incorporated throughout the software development lifecycle.
- To provides comprehensive coverage that includes the people, processes, and technology components of software, networks, and host defenses.

Course Contents:

This course introduces the development methodologies for developing secure software. Topics include: Secure Software Concepts; Secure Software Development Methodologies; Secure SDLC; Secure Software Requirements; Secure Software Design; Architecture; Risk Management; Secure Software Implementation; Defensive Programming; Secure Software Testing; Securing DevOps; AppSec Process; and Applications.

Recommended Books:

1. Secure Software Design, Theodor Richardson , Charles N Thies, Packt, 2019.
2. Secure, Resilient, and Agile Software Development, Mark S. Merkow, CISSP, CISM, CSSLP, CRC Press, 2019.
3. Software Security Engineering: A Guide for Project Managers, Julia H. Allen, Sean J. BarnumRobert J. Ellison, Gary McGraw, Nancy R. Mead, Pearson Education, 2008.

Course Code: CYC307 **Pre-Requisite:** None

Course Title: Information Assurance

Credit Hours: 3(3, 0)

Course Objective:

- To understand the role and interaction of policies, laws, procedures, management issues, and technical issues in protecting information resources.

Course Contents:

The purpose of this course is to provide the concepts and techniques for information assurance in an organization. The topics include: Information Assurance Basics; Information Assurance Planning Process; Risk Mitigation Process; Information Assurance Detection and Recovery Process; and Application of Information Assurance.

Recommended Books:

1. Information Assurance Handbook: Effective Computer Security and Risk Management Strategies, Corey Schou, Steven Hernandez, McGraw-Hill Education, 2014.
2. Information Assurance: Surviving in the Information Environment, Andrew Blyth, Gerald L. Kovacich, Springer, 2014.

Course Code: CYC390 **Pre-Requisite:** None

Course Title: Vulnerability Assessment & Reverse Engineering

Credit Hours: 3(2, 1)

Course Objectives:

- To develop core competencies in the field of vulnerability assessment covering software, networks and Web applications;
- To covers reverse engineering techniques to analyze software, exploit targets, and defend against security threats like malware and viruses.

Course Contents:

The objective of this course is to introduce the concepts of Vulnerability Assessment & Reverse Engineering. Topics include: Vulnerability Management Governance; Significance of Security Assessments; Enumeration & Vulnerability Assessment; Network Access; Privilege Escalation; Vulnerability Scoring & Threat Modeling; Steps in Reverse Engineering; Reverse Engineering Tools; Binary Obfuscation Techniques; Assembly Logic Structures with a Disassembler; Malware Analysis; and Sandboxing & Virtualization.

Recommended Books:

1. Network Vulnerability Assessment, Sagar Rahalkar, Packt, 2018.
2. Practical Reverse Engineering: x86, x64, ARM, Windows Kernel, Reversing Tools, and Obfuscation, Bruce Dang, Alexandre Gazet, Wiley, 2014.