COMSATS University Islamabad

Registrar Secretariat, Academic Unit (PS)

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No. CUI-Reg/Notif-4757/21/3432 December 17, 2021

NOTIFICATION

Scheme of Studies of Bachelor of Science in Artificial Intelligence

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

Nomenclature: Bachelor of Science in Artificial Intelligence BS (AI)

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

3. **Course Work**		**(Min No. of Courses)**	**(Min No. of Credit Hours)**
a)	General Education	07	21
b)	University Electives	04	12
c)	Mathematics & Science Foundation	04	12
d)	Computing Core	11	39
e)	Computer Science Core	05	18
f)	AI Core (Domain Core)	06	18
g)	AI Electives (Domain Electives)	04	12
Minimum No. of Courses Required:		**41**	--
Minimum No. of Credit Hours Required:			**132**

Note: The Regulations relating to Undergraduate Degree Programs approved by the Competent Authority and amended from time to time shall be applicable.

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Muniba Nasir
Additional Registrar

Encl: (Total 31 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 distribution, Registrar Office (Academic Unit), CUI

Cc:

1. PS to Rector CUI
2 PS to Registrar CUI

General Education

Subject/Knowledge Area	Credit Hours	Contact Hours
Introduction to Info. & Comm. Technologies	3(2-1)	2-3
English Composition & Comprehension	3(3-0)	3-0
Communication & Presentation Skills	3(3-0)	3-0
Technical & Business Writing	3(3-0)	3-0
Islamic Studies/ Ethics	3(3-0)	2-0
Pakistan Studies	3(3-0)	2-0
Professional Practices	3(3-0)	3-0

University Elective

Subject/Knowledge Area	Credit Hours	Contact Hours
Foreign Language	3(3-0)	3-0
Management Related	3(3-0)	3-0
Social Science Related	3(3-0)	3-0
Economy Related	3(3-0)	3-0

Mathematics and Science Foundation

Subject/Knowledge Area	Credit Hours	Contact Hours
Calculus & Analytic Geometry	3(3-0)	3-0
Linear Algebra	3(3-0)	3-0
Probability & Statistics	3(3-0)	3-0
Differential Equations	3(3-0)	3-0

Computing Core

Subject/Knowledge Area	Credit Hours	Contact Hours
Programming Fundamentals	4(3-1)	3-3
Discrete Structures	3(3-0)	3-0
Object Oriented Programming	4(3-1)	3-3
Database Systems	4(3-1)	3-3
Data Structures & Algorithms	4(3-1)	3-3
Information Security	3(3-0)	3-0
Computer Networks	4(3-1)	3-3
Operating Systems	4(3-1)	3-3
Software Engineering Concepts	3(3-0)	3-0
Final Year Project – I	2(0-2)	0-6
Final Year Project – II	4(0-4)	0-12

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Computer Science Core

Subject/Knowledge Area	Credit Hours	Contact Hours
Artificial Intelligence	4(3-1)	3-3
Digital Logic Design	4(3-1)	3-3
Analysis of Algorithms	3(3-0)	3-0
Computer Organization & Assembly Language	4(3-1)	3-3
Parallel & Distributed Computing	3(2-1)	2-3

Artificial Intelligence Core

Subject/Knowledge Area	Credit Hours	Contact Hours
Programming for Artificial Intelligence	3(2-1)	2-3
Machine Learning	3(2-1)	2-3
Artificial Neural Networks	3(2-1)	2-3
Knowledge Representation & Reasoning	3(3-0)	3-0
Computer Vision	3(2-1)	2-3
Natural Language Processing	3(3-0)	3-0

Artificial Intelligence Electives

Subject/Knowledge Area	Credit Hours	Contact Hours
Advance Statistics	3(3-0)	3-0
Theory of Automata & Formal Languages	3(3-0)	3-0
Data Mining	3(2-1)	2-3
Deep Learning	3(3-0)	3-0
Speech Processing	3(3-0)	3-0
Reinforcement Learning	3(3-0)	3-0
Fuzzy Systems	3(3-0)	3-0
Evolutionary Computing	3(3-0)	3-0
Swarm Intelligence	3(3-0)	3-0
Agent Based Modeling	3(3-0)	3-0
Knowledge Based Systems	3(3-0)	3-0
Robotics	3(3-0)	3-0

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General Education

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC101	Introduction to ICT	3(2,1)	-
AIC410	Professional Practices in AI	3(3,0)	-
HUM100	English Comprehension and Composition	3(3,0)	-
HUM102	Report Writing Skills	3(3,0)	HUM100
HUM103	Communication Skills	3(3,0)	HUM100
HUM110	Islamic Studies **	3(3,0)	-
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.

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)	-

Mathematics & Science Foundation

Course Code	Course Title	Credit Hours	Pre-requisite(s)
MTH104	Calculus and Analytic Geometry	3(3,0)	-
MTH262	Statistics and Probability Theory	3(3,0)	-
MTH242	Differential Equations	3(3,0)	MTH104
MTH231	Linear Algebra	3(3,0)	-

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Computing Core

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC103	Programming Fundamentals	4(3,1)	-
CSC102	Discrete Structures	3(3,0)	-
CSC211	Data Structures and Algorithms	4(3,1)	CSC103
CSC241	Object Oriented Programming	4(3,1)	CSC103
CSC270	Database Systems	4(3,1)	CSC211
CSC323	Principles of Operating Systems	4(3,1)	CSC211
CSC291	Software Engineering Concepts	3(3,0)	-
CSC340	Computer Networks	4(3,1)	-
CSC432	Information Security	3(3,0)	-
AIC498	Final Year Project-I*	2(0,2)	CSC291, HUM102
AIC499	Final Year Project-II	4(0,4)	AIC498

**Final Year Project-I will be graded independently*

Computer Science Core Courses

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC262	Introduction to Artificial Intelligence	4(3,1)	-
CSC301	Design and Analysis of Algorithms	3(3,0)	CSC211
CSC325	Computer Organization & Assembly Language	4(3,1)	
CSC334	Parallel and Distributed Computing	3(2,1)	CSC323
EEE241	Digital Logic Design	4(3,1)	-

Artificial Intelligence Core

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC270	Programming for Artificial Intelligence	3(2,1)	CSC103
AIC354	Machine Learning Fundamentals	3(2,1)	AIC270
AIC372	Knowledge Representation and Reasoning	3(3,0)	AIC262
AIC380	Artificial Neural Networks	3(2,1)	AIC262
AIC341	Introduction to Computer Vision	3(2,1)	MTH231
AIC365	Natural Language Processing	3(3,0)	-

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Artificial Intelligence Electives (Any 4 Courses)

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC333	Statistical Methods for AI	3(3,0)	-
CSC312	Theory of Automata	3(3,0)	CSC102
DSC306	Data Mining	3(2,1)	-
AIC467	Deep Learning	3(3,0)	-
AIC378	Speech Processing	3(3,0)	-
AIC456	Reinforcement Learning	3(3,0)	-
AIC468	Fuzzy Systems	3(3,0)	-
AIC469	Evolutionary Computing	3(3,0)	-
AIC471	Swarm Intelligence	3(3,0)	-
AIC332	Agent Based Modeling	3(3,0)	-
AIC470	Knowledge Based Systems	3(3,0)	-
CSC421	Robotics	3(3,0)	-
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)	-
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
AIC480	Topics in AI	3(3,0)	-

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Tentative Study Plan for BS (AI)

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	MTH100	Mathematics I*	3(3, 0)	
6		University Electives 1/4		

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	CSC291	Software Engineering Concepts	3(3, 0)	

Semester – 3				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC241	Object Oriented Programming	4(3, 1)	CSC103
2	HUM103	Communication Skills	3(3, 0)	HUM100
3	MTH231	Linear Algebra	3(3, 0)	
4	MTH104	Calculus and Analytic Geometry	3(3, 0)	
5	AIC262	Introduction to Artificial Intelligence	4(3, 1)	

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	AIC270	Programming for Artificial Intelligence	3(2, 1)	CSC103
5		University Electives 2/4		

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	AIC410	Professional Practices in AI	3(3, 0)	
4	MTH262	Statistics and Probability Theory	3(3, 0)	
5	AIC372	Knowledge Representation and Reasoning	3(3, 0)	AIC262
6		Artificial Intelligence Elective Courses 1/4		

Semester – 6				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	MTH242	Differential Equations	3(3, 0)	MTH104
2	CSC301	Design and Analysis of Algorithms	3(3, 0)	CSC211
3	CSC334	Parallel and Distributed Computing	3(2, 1)	CSC323
4	AIC354	Machine Learning Fundamentals	3(2, 1)	AIC270
5	AIC365	Natural Language Processing	3(3, 0)	
6		Artificial Intelligence Elective Courses 2/4		

Semester – 7				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	CSC432	Information Security	3(3, 0)	
2	AIC380	Artificial Neural Networks	3(2, 1)	AIC262
3	AIC498	Final Year Project-I	2(0, 2)	CSC291, HUM102
4	AIC341	Introduction to Computer Vision	3(2, 1)	MTH231
5		Artificial Intelligence Elective Courses 3/4		

Semester – 8				
S#	**Course Code**	**Course Title**	**Credit Hours**	**Pre-requisite(s)**
1	AIC499	Final Year Project-II	4(0, 4)	AIC498
2		University Electives 3/4		
3		University Electives 4/4		
4		Artificial Intelligence Elective Courses 4/4		

* Non-Credit course. Students with **Pre-Medical background** must have to pass deficiency courses of Mathematics (MTH100 and MTH 101) of 06 credit hours within one year.

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);
- To discuss the four main functions of computer hardware: input, processing, output, and storage;
- To identify and describe major hardware components and processor architecture;
- To identify, describe and use communications and networking terminology further include Internet operations and its uses;
- To describe the major operating system functions and demonstrate usage of operating system services;
- To discuss fundamental concepts of programming using Python;
- To demonstrate basic coding, testing and debugging Python programs;
- To provide an understanding with the implementation of programming concepts;
- To discuss databases and e-commerce concepts;

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; 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: AIC410 **Pre-Requisite:** None

Course Title: Professional Practices in AI

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the fundamental principles of Professional practices;
- To understand the importance of ethics;
- To understand the special ethical considerations for AI.

Course Contents:

The course includes the following topics: Introduction: Artificial Intelligence and Ethics; What are Ethics: Normative Ethical Theories, Ethics and Empirical Evidence, why do we need Ethics? Moral Relativism, Moral Justification and AI, A Distributed Morality? Moral Agents, Moral Motivation, AI, Code of Ethics and the Law; Does AI raise any distinctive questions? Codes of Professional Ethics: The varieties of Ethical Codes; Professional Codes of Ethics; The Context of Codes of Ethics; How AI Challenges Professional Ethics? Developing Codes of Ethics Amidst Fast Technological Change; Pitfalls in Considering the Ethics of AI.

Recommended Books:

1. Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way, Dignum, V., Springer, 2019.
2. Artificial Intelligence: Evolution, Ethics and Public Policy, Sarangi, S., Sharma, P., Routledge India, 2018.
3. Towards a Code of Ethics for Artificial Intelligence (Artificial Intelligence: Foundations, Theory, and Algorithms), Boddington, P., Springer, 2017.

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: 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 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: 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: CSC270 **Pre-Requisite:** CSC211

Course Title: Database Systems

Credit Hours: 4(3, 1)

Course Objectives:

- To understand the fundamental concepts necessary for designing and implementing database systems and database applications;
- To introduce relational and NoSQL database concepts with emphasis on both theoretical and practical learning;
- To apply knowledge of the SQL language and implementing components of relational and NoSQL database systems (DBMS);
- To provide a practical exposure to database programming techniques;
- To create database instances in the cloud for both relational and NoSQL database systems such as MySQL, SQL Server, Amazon Redshift, Google BigQuery and MongoDB.

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: 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: 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: 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: 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: CSC291 **Pre-Requisite:** None

Course Title: Software Engineering Concepts

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the different software process models by illustrating its phases;
- To develop awareness of using different tools and environment supported in software engineering;
- To develop basic understanding of requirement engineering to gather requirements for developing a system;
- To create design of a system by understanding its core concepts;
- To construct the system by understanding different coding techniques;
- To 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: AIC498 **Pre-Requisites:** CSC291, HUM102

Course Title: Final Year Project-I

Credit Hours: 2(0, 2)

Course Objectives:

- To learn, how to design conceptual modeling and an AI system design;
- To employ the knowledge gained from courses throughout the program such as modeling knowledge representation, designing of AI system;
- To develop the project plan, software requirement specification document and software design document for AI systems;
- To enhance communication, presentation and writing skills.

Course Contents:

This course is designed as final year project, which requires students to demonstrate design of AI systems and presentation skills at levels which are commensurate with professional practices. It is desirable that students apply their knowledge of AI throughout the courses such as knowledge representation & reasoning, machine learning, artificial intelligence, neural networks, natural language processing and deep learning to a real-world AI problem from conception to completion. In this part of the project, students shall design a system in the domain of AI including a proper project plan, software requirement specification document and software design document with some initial implementation.

Recommended Books:

Books will be recommended by the faculty member supervising the capstone project

Course Code: AIC499 **Pre-Requisite:** AIC498

Course Title: Final Year Project-II

Credit Hours: 4(0, 4)

Course Objectives:

- To implement the design produced in AIC498 along with testing and evaluation of a complex real-world project in the area of Artificial Intelligence.
- 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 the AI degree program and is central to the development of student professional competencies. This is the second part of a two-semester, final year project. Student teams employ the knowledge gained from courses throughout the program such as programming for AI, knowledge representation & reasoning, machine learning, artificial intelligence, neural networks, natural language processing and deep learning to a real-world AI problem from conception to completion. In this part of the project, students implement the design they produced in AIC498, test their code, and evaluate their final product.

Recommended Books:

Books will be recommended by the faculty member supervising the capstone project

Computer Science Core Courses

Course Code: AIC262 **Pre-Requisite:** None

Course Title: Introduction to Artificial Intelligence

Credit Hours: 4(3, 1)

Course Objectives:

- To discuss the core concepts and algorithms of Artificial Intelligence.
- To apply the basic principles, models, and algorithms of AI to recognize, model, and solve problems in the analysis and design of information systems.
- To design AI functions and components involved in intelligent systems.

Course Contents:

Introduction of AI; Solving problems with searching: Informed Search algorithms, Best-First Search, Best-First Search, Heuristic Functions, Memory Bounded Search; Local Search algorithms: Hill-climbing search, Simulated annealing; Game Playing: Introduction: Games as Search Problems, Perfect Decisions in Two-Person Games, Imperfect Decisions, Evaluation functions, Cutting off search, Alpha-Beta Pruning, Effectiveness of alpha-beta pruning, Minmax algorithm; Representation, reasoning and logic: First-Order Logic: Syntax and Semantics, Knowledge representation, Building a Knowledge Base, Inference in First-Order Logic; Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, The Semantics of Belief Networks, Representing the joint probability distribution, Inference in Belief Networks, The nature of probabilistic inferences; Making Complex Decisions; Learning in Neural and Belief Networks: How the Brain Works' Perceptrons, Multilayer Feed-Forward Networks, Back-propagation learning, Applications of Neural Networks, Bayesian learning, Belief network learning problems, Learning networks with fixed structure; Reinforcement Learning: Passive Learning in a Known Environment, Passive Learning in an Unknown Environment, Active Learning in an Unknown Environment, Exploration, Learning an Action-Value Function, Generalization in Reinforcement Learning.

Recommended Books:

1. Artificial Intelligence: A Modern Approach, Russell, S., and Norvig, P., Prentice Hall, 2020.
2. Artificial Intelligence: A Modern Approach and Machine Learning, Godwin, J, O., Independently published, 2020.
3. Introduction to Artificial Intelligence (Undergraduate Topics in Computer Science), Ertel, W. & Black, N, T., Springer, 2018.

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: 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

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: 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:

Introduction to Programming Language (Python): IDE for the Language (E.G., Jupyter Notebook Or Ipython), Variables, Expressions, Operands and Operators, Loops, Control Structures, Debugging, Error Messages, Functions, Strings, Lists, Object-Oriented Constructs and Basic Graphics in the Language; Special Emphasis is given to Writing Production Quality Clean Code in the Programming Language using Version Control (Git and Subversion); Introducing Libraries/Toolboxes Necessary for Data Analysis: the course should introduce some libraries necessary for interpreting, Analyzing and Plotting Numerical Data (E.G., Numpy, Matplotlib, Anaconda and Pandas for Python) and give examples of each library using simple use cases and small case studies.

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: AIC354 **Pre-Requisite:** AIC270

Course Title: Machine Learning Fundamentals

Credit Hours: 3(2, 1)

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:

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 partition clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and unlabeled 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.

Recommended Books:

1. Machine Learning: An Applied Mathematics Introduction, Wilmott, P., Panda Ohana Publishing, 2019
2. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Géron, A., O'Reilly Media, 2017.
3. Introduction to Machine Learning (Adaptive Computation and Machine Learning series), Alpaydin., E., The MIT Press, 2014
4. Pattern Recognition and Machine Learning, Bishop, C., Springer-Verlag, 2011.
5. Machine Learning, Tom, M., McGraw Hill, 1997.

Course Code: AIC380 **Pre-Requisite:** AIC262

Course Title: Artificial Neural Networks

Credit Hours: 3(2, 1)

Course Objectives:

- To present the fundamentals of neural networks in AI;
- To design simple neural network;
- To apply neural networks on classification problems;
- To present basic concepts of Deep Learning and its architecture.

Course Contents:

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

Recommended Books:

1. Principles of Artificial Neural Networks:Basic Designs to Deep Learning, Graupe, D., World Scientific Publishing Company, 2019.
2. Neural Network Design, Hagan, T. et al., Martin Hagan, 2014.
3. Fundamentals of Artificial Neural Networks, Hassoun, M., Bradford Book, 2003.
4. An Introduction to Neural Networks, Anderson, J., Bradford Book, 1995.

Course Code: AIC372 **Pre-Requisite:** AIC262

Course Title: Knowledge Representation and Reasoning

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the fundamental principles of logic-based Knowledge Representation;
- To model simple application domains in a logic-based language;
- To understand the notion of a reasoning service;
- To discuss the fundamentals of the reasoning algorithms underlying current systems;
- To explain the fundamental trade-off between representation power and computational properties of a logic-based representation language.

Course Contents:

Representing knowledge using logic; The Language of First Order Logic: Syntax, Semantics, Explicit and Implicit belief; Expressing Knowledge: Knowledge Engineering, Vocabulary, Basic and Complex Facts, Terminological Facts, Entailments; Resolution: The propositional case, Handling Variables and Quantifiers, Computational Intractability; Reasoning with Horn Clauses: SLD resolution, Computing SLD Resolution; Procedural Control of Reasoning; Rules in Production Systems; Object Oriented Representation; Structured Descriptions; Ontology languages for the Semantic Web; Non-monotonic logics.

Recommended Books:

1. Knowledge representation and reasoning, Blokdyk, G., 5STARCooks, 2018.
2. Knowledge Representation, Reasoning, and the Design of Intelligent Agents: The Answer-Set Programming Approach, Gelfond, M., Kahl, Y., Cambridge University Press, 2014.
3. Knowledge Representation and Reasoning, Brachman, R., Levesque, H., The Morgan Kaufmann Series in Artificial Intelligence, 2004.

Course Code: AIC341 **Pre-Requisite:** MTH231

Course Title: Introduction to Computer Vision

Credit Hours: 3(2, 1)

Course Objectives:

- To familiarize with both the theoretical and practical aspects of computing with images;
- To describe the foundation of image formation, measurement, and analysis;
- To gain exposure to object and scene recognition and categorization from images;
- To understand the geometric relationships between 2D images and the 3D world;
- To develop the practical skills necessary to build computer vision applications.

Course Contents:

Human Visual System: The retina, Vision in the brain; Image Processing for Computer Vision: Linear Image Processing, Model Fitting, Frequency Domain Analysis; Camera Models and Views: Camera Models, Stereo Geometry, Camera Calibration, Multiple Views; Image Features: Feature Detection, Feature Descriptors, Model Fitting; Lighting: Photometry, Lightness, Shape from shading Image Motion: Overview, Optical Flow; Tracking: Introduction to Tracking, Parametric Models, Non-Parametric Models, Tracking Considerations; Classification and Recognition: Introduction to Recognition, Generative Models for Classification, Discriminative Models for Classification, Action Recognition; Useful Methods: Color Spaces and Segmentation, Binary Morphology,3D Perception.

Recommended Books:

1. Computer Vision: Principles, Algorithms, Applications, Learning, Davies, E. R., Academic Press, 2017.
2. Programming Computer Vision with Python: Tools And Algorithms For Analyzing Images, Jan Erik Solem, O'Reilly, 2012.
3. Computer Vision: A Modern Approach 2nd ed, David Forsyth, Jean Ponce, Prentice Hall, 2011.

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:

Introduction to background knowledge; Various applications of Natural Language Processing (NLP); Zipf'law; Linguistic Essentials; Corpus-Based Work; Collocations; N-grams Models over Sparse Data; Word Sense Disambiguation; Hidden Markov Model (Word Guessing and HMM. Decoding and Training); Maximum Entropy; Part-of-Speech Tagging; Fundamentals of Natural Language Parsing; Grammar and Parsing; Statistical approaches; Text Alignment and Machine Translation; Information Retrieval and Information Extraction; Deep Learning for NLP; Modern Trends in NLP and Speech Recognition; Term Project Presentations.

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.