COMSATS University Islamabad

Registrar Secretariate, Academic Unit (PS)

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No: CUI-Reg/Notif-2505/20/3008 **December 30, 2020**

NOTIFICATION

It is hereby notified that the Academic Council in its 31st meeting held on October 8, 2020 approved the revision of Scheme of Studies of Master of Science in Computer Science, effective from Spring 2021;

		Minimum No of Courses	Minimum No of Credit hour
1. **MS Course Work**			
I.	No of Core Courses	4	12
II.	Elective courses	4	12
III.	Research Methodology	01	01
Total credit hour of course work			**25**
2. MS Thesis			**06**
3. Total Credit hour of the Program			**31**

Note:
The Regulations relating to MS Degree programs approved by the BASAR/Academic Council from time to time shall be applicable.
This Issue with the approval of Competent Authority.

Muhammad Hanif
Deputy Registrar

Distribution:
1. All Directors, CUI Campuses
2. Incharge, CUI Islamabad Campus
3. Incharge, CUI Virtual Campus
4. All Deans, CUI System
5. All Chairpersons, CUI System
6. All HoDs, CUI System
7. Controller of Examinations, CUI
8. All HoDs/Incharges of Academics/Examinations Sections, CUI, Campuses
9. Internal Distribution at Registrar Set up, PS

CC:

1. PS to Rector
2. PS to Registrar

Core Courses

Sr. No	Course Code	Course Title	Credit Hours	Pre-requisite (s)
1.	CSC683	Advanced Algorithm Analysis	3(3, 0)	-
2.	CSC602	Advanced Operating Systems	3(3, 0)	-
3.	CSC604	Advanced Computer Architecture	3(3, 0)	-
4.	CSC511	Theory of Programming Languages	3(3, 0)	-
5.	CSC512	Theory of Automata – II	3(3, 0)	-

Pre-Requisite for Thesis

Sr. No	Course Code	Course Title	Credit Hours	Pre-
6.	CSC607	Research Methodology	1(1, 0)	-

MS Thesis

Sr. No	Course Code	Course Title	Credit Hours	Pre-requisite
7.	CSC800	MS Thesis	6(0, 6)	

Elective Courses

Sr. No	Course Code	Course Title	Credit	Pre-requisite
8.	**Computer Networks**			
9.	CSC513	Mobile and Pervasive Computing	3(3, 0)	-
10.	CSC514	Software-Defined Networking and Network Function Virtualization	3(3, 0)	-
11.	CSC515	Communication Networks-Architectures and Protocols	3(3, 0)	-
12.	CSC516	Internet of Things Architecture and Protocols	3(3, 0)	-
13.	CSC517	Content Networking	3(3, 0)	-

14.	CSC518	Smart Grid Networks	3(3, 0)	-
15.	CSC519	Cloud and Fog Computing	3(3, 0)	-
16.	CSC520	Cluster and Grid Computing	3(3, 0)	-
17.	CSC631	Advanced Topics in Computer Networks	3(3, 0)	-
18.	CSC636	Advanced Topics in Wireless Networks	3(3, 0)	-
19.	CSC608	Advanced Wireless Sensor Networks	3(3, 0)	-
20.	CSC609	Advanced Network Programming	3(3, 0)	-
21.	CSC610	Advanced Topics in Distributed Systems	3(3, 0)	-
22.	CSC731	Challenged Networks	3(3,0)	-
	Cyber Security			
23.	CSC523	Cyber Intelligence	3(3, 0)	-
24.	CSC524	Cybercrime Investigation	3(3, 0)	-
25.	CSC525	Information Security Policy Development	3(3, 0)	-
26.	CSC 526	Information Security Project Management	3(3, 0)	-
27.	CSC527	Information Technology Forensics and Investigations	3(3, 0)	-
28.	CSC528	Intrusion detection and firewalls	3(3, 0)	-
29.	CSC529	Reverse Engineering and Malware Analysis	3(3, 0)	-
30.	CSC530	Security and Privacy for the Smart Grid	3(3, 0)	-
31.	CSC531	Privacy and Security in IoT	3(3, 0)	-
	Artificial Intelligence			
32.	CSC532	Agent Based Modeling	3(3, 0)	-
33.	CSC533	Social Network Modeling and Analysis	3(3, 0)	-
34.	CSC534	Soft Computing Techniques	3(3, 0)	-

35.	CSC651	Pattern Recognition	3(3, 0)	-
36.	CSC535	Natural Language Processing	3(3, 0)	
37.	CSC668	Machine Learning	3(3, 0)	-
38.	CSC537	Deep Reinforcement Learning	3(3, 0)	-
39.	CSC538	Data Exploration and Visualization	3(3, 0)	-
40.	CSC539	Text Processing	3(3, 0)	-
41.	CSC540	Robotics	3(3, 0)	-
42.	CSC541	Big Data Analytics	3(3, 0)	-
43.	CSC542	Deep Learning	3(3, 0)	-
44.	CSC652	Advanced Topics in Computer Vision	3(3, 0)	-
45.	CSC666	Advanced Topics in Decision Support Systems	3(3, 0)	-
46.	CSC613	Advanced Topics in Artificial Neural Networks	3(3, 0)	-
47.	CSC614	Advanced Topics in Image Processing	3(3, 0)	-
48.	CSC764	Advanced Topics in Artificial Intelligence	3(3, 0)	-
	Database/ Data Ware house/Data Mining			
49.	CSC677	Advanced Topics in Data Warehousing	3(3, 0)	-
50.	CSC673	Advanced Topics in Distributed Databases	3(3, 0)	-
51.	CSC630	Advanced Data Mining	3(3, 0)	-
52.	CSC634	Advanced Topics in Business Process Design & Intelligence	3(3, 0)	-
	Software Engineering			
53.	CSC543	Formal Methods and Semantics	3(3, 0)	-
54.	CSC544	Agile Software Development	3(3, 0)	-
55.	CSC635	Advanced Software Engineering	3(3, 0)	-

56.	CSC636	Advanced Software Architectures	3(3, 0)	-
57.	CSC639	Advanced Topics in Software Requirement Engineering	3(3, 0)	-
58.	CSC545	Usability and Interaction Design	3(3, 0)	-
	Multimedia and Game Design			
59.	CSC640	Advanced Topics in Multimedia Design and Technologies	3(3, 0)	-
60.	CSC641	Advanced Topics in Game Design and Development	3(3, 0)	-
61.	CSC701	Advanced Topics in Augmented and Virtual Reality	3(3, 0)	-
	Information Security			
62.	CSC546	Information Security	3(3, 0)	-
63.	ISC632	Public Key Cryptography	3(3, 0)	-
64.	ISC634	Elliptic Curve Cryptography	3(3, 0)	-
65.	ISC635	Quantum Cryptography	3(3, 0)	-
66.	ISC636	Cryptanalysis	3(3, 0)	-
67.	ISC738	Advanced Topics in Cryptography	3(3, 0)	-
	General Electives			
68.	CSC546	Probability and Stochastic Processes	3(3, 0)	-
69.	CSC547	Game Theory	3(3, 0)	-
70.	CSC548	Optimization Techniques	3(3, 0)	-
71.	CSC549	High Performance Computing	3(3, 0)	-
72.	CSC550	Professionalism in Computer Science	3(3, 0)	-
73.	CSC551	Data Compression	3(3, 0)	-

74.	CSC552	Multicore and GPU Programming	3(3, 0)	-
75.	CSC659	Advanced Topics in Simulation and Modeling	3(3, 0)	-
76.	CSC702	Advanced Computer Graphics	3(3, 0)	-
77.	CSC703	Advanced Topics in Geometric Modeling	3(3, 0)	-
78.	CSC715	Special Topics in Computer Science- I	3(3,0)	-
79.	CSC716	Special Topics in Computer Science- II	3(3,0)	-

Course Code: CSC 683 **Pre-Requisite:** None

Course Title: Advanced Algorithm Analysis

Credit Hours: 3 (3, 0)

Course Objectives:

- To develop an ability to analyze the asymptotic performance of algorithms;
- To develop an ability to design algorithms for computational problems using various algorithmic design paradigms;
- To employ graphs to model real world problems and analyze them;
- To develop an ability to explain the different ways to analyze randomized algorithms;
- To develop an ability to describe the different methods of amortized analysis (aggregate analysis, accounting, potential method;
- To describe the theory of NP-completeness.

Course Contents:

The emphasis of this core subject is on advanced methods of algorithmic design, analysis, and implementation: Topics to be covered include: Proving correctness of algorithms using loop invariant and induction, Asymptotic notations, Induction and recursion techniques in analyzing recursive algorithms, Amortized Analysis, Divide-and conquer technique, Dynamic Programming, Greedy algorithms, Approximation Algorithms, Graph Theory, Network Flow, Randomized Algorithms, The classes P, NP, P-space, co-NP.

Recommended Books:

1. An Introduction to the Analysis of Algorithms, Sedgewick, R. & Flajolet, P, Addison-Wesley, 2012.
2. Introduction to Algorithms, Cormen, T. H., Leiserson, C.E., Rivest, R.L. & Stein C., MIT Press, 2009.

Course Code: CSC 602 **Pre-Requisite:** None

Course Title: Advanced Operating Systems

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the structure and design issues of advanced operating systems;
- To discuss the mechanisms to handle processes and threads and their communication in distributed environment;
- To explain synchronization and deadlock handling in distributed operating systems;
- To discuss the issues related to distributed memory management and distributed file system;
- To introduce special purpose OS' such as OS for mobile, ubiquitous and real-time systems.

Course Contents:

Topics include: Characterization of modern operating systems: system models, architectural models; Process management: scheduling algorithms, Communication in distributed systems; Client-server model: remote procedure call, group communication; Synchronization: synchronization of logical and physical clocks, identification of the global state, distributed mutual exclusion, atomic transaction; Deadlock management: election algorithms; Distributed memory management; Distributed file System: Concurrency control in distributed systems; Problems of coordination and agreement in distributed Systems; Replication: fault-tolerant services; Mobile and ubiquitous computing; Real-time operating systems: definition, objective and problems, scheduling in real time operating systems: scheduling of periodic, aperiodic and mixed tasks.

Recommended Books:

1. Advanced Operating Systems and Kernel Applications: Techniques and Technologies, Yair Wiseman & Song Jiang, Information Science Reference, 2009.
2. Distributed Operating Systems, Tanenbaum, Dorling Kindersley Pvt Ltd, 2009.

Course Code: CSC 604 **Pre-Requisite:** None

Course Title: Advanced Computer Architecture

Credit Hours: 3(3, 0)

Course Objectives:

- To provide a fundamental knowledge of computer hardware and computer systems;
- To describe the operation of modern and high performance computers;
- To understand different level of parallelism in multiprocessors.

Course Contents:

This is the second Computer Organization course and it focuses on computer hardware design. Topics covered are: Basic Digital System Design including Finite State Machines; Instruction Set Design and Simple RISC Assembly Programming; Quantitative Evaluation of Computer Performance; Circuits for Integer and Floating-Point Arithmetic; Data Path and Control; Micro-Programming; Pipelining; Storage Hierarchy and Virtual Memory; Input/Output; Different Forms of Parallelism including Instruction Level Parallelism, Data-Level Parallelism using both Vectors and Message-Passing Multi-Processors, and Thread-Level Parallelism using Shared Memory Multiprocessors; Basic Cache Coherence and Synchronization.

Recommended Books:

1. Computer Organization and Architecture, Willaim Stallings, Pearson, 2015.
2. Computer Organization & Design: The Hardware/Software Interface, David A. Patterson, John L. Hennessy, Morgan Kaufmann Publishers, 2011.

Course Code: CSC 511 **Pre-Requisite:** None

Course Title: Theory of Programming Languages

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the principles of language design and implementation;
- To discuss the design concepts and implementation considerations for various concepts related to programming languages such as scope, binding, data types, expressions, control structures;
- To discuss the issues related to designing and implementation of OOP concepts;
- To discuss the measure for evaluation of programming languages.

Course Contents:

Topics include: Theory, design, and implementation of programming languages: inductive definitions; Formal semantics: operational, axiomatic, denotational, and translational; Assignment and basic control flow; Functional programming: Caml; Scope and variable binding; Lambda calculus (functions); Simple types: type safety, universal and existential types, dynamic types; Laziness; Continuations; Concurrency and communication: Object-oriented programming: inheritance; Multi-methods; Exceptions and continuations; Curry-howard isomorphism.

Recommended Books:

1. Concepts of Programming Languages, Robert W. Sebesta, Pearson, 2012.
2. Structure and Interpretation of Computer Programs, Harold Abelson, Gerald Jay Sussman & Julie Sussman. The MIT Press, 1996.

Course Code: CSC 512 **Pre-Requisite:** None

Course Title: Theory of Automata – II

Credit Hours: 3 (3, 0)

Course Objectives:

- To provide an exposition to the notion of computability, computational feasibility or tractability;
- To develop an ability to identify and prove the capabilities and limitations of particular models of computation.

Course Objectives:

This course emphasizes theoretical models of computation and their analysis; Topics to be covered include: Turing Machines, Enumerators, Dovetailing, The Church-Turing Thesis, Hilbert's Tenth Problem, Decidable Languages, The Acceptance Problem for DFAs, The Halting Problem, Universal TM, Undicidability of the Halting Problem, Linear Bounded Automata, Computation Histories, Context Free Grammars, Russell's Paradox, Emptiness Problem, Post Correspondence Problem, Computable Functions, Reducibility, Recursion Theorem, Logical Theories, Godel's Theorem, Oracles, Turing Reducibility, A definition of Information, Incompressible Strings, The Class P, The Class NP, Polynomial Time Verifiers, Subset Sum Problem, Satisfiability, NP-Completness, 3-Color Problem, The Cook-Levin Theorem, Independent Sets Problem, Clique, Vertex Cover, Hamiltonian Path Problem, The Subset Sum Problem, The Traveling Salesman Problem, PSPACE-Completeness, TQBF, Prove that TQBF is PSPACE-Complete, FORMULA-GAME, Generalized Geography, LOGSPACE Transducer, Prove the Theorem: NL = co-NL.

Recommended Books:

1. Introduction to the Theory of Computation, Michael Sipser, Cengage Learning, 2006.

Course Code: CSC 607 **Pre-Requisite:** None

Course Title: Research Methodology

Credit Hours: 1(1, 0)

Course Objectives:

- To Describe principle activities, skills and ethics associated with the research process:
- To Describe different type and components of a literature review process;
- To Describe quantitative, qualitative and mixed methods approaches to research:
- To Gain a practical understanding of the various methodological tools used for scientific research:
- To Prepare the key elements of a research proposal/report.

Course Contents:

Topics include: Introduction to Research: Objectives, Importance, Methodology, Types, process and phases. Literature Review: Needs, Types, SLR; Problem Statement: rational development. Problem formulation; Criteria for selecting a problem: Identifying Types of variables in Research: Types of hypothesis, Identifying Target Population, Types of Sampling, Sampling Techniques; Research methods; Quantitative Research Methods; Scientific Methods, Design of Quantitative Surveys and Questionnaire, Techniques to Conduct Quantitative Methods; Qualitative Research; Qualitative Research Methods: Data Analysis. Theory in Qualitative Research Articles; Research Design: Design of Mixed Methods Research, Evaluation of Mixed Methods Research; Research Design for Computing; Case Study: How to Conduct a Case Study, Case Study Protocol, Importance and Benefits of Case Study; Statistical Tests: Types to Conduct Data Analysis, Data Analysis Tools; How to write Good Research Proposal: Contents of Thesis; Important Elements of Research Thesis. Referencing Tools and Latex.

Recommended Books:

1. Research design: Qualitative, quantitative and mixed methods approaches, Creswell, J. W. Thousand Oaks, CA: Sage, 2014.
2. A Gentle Guide to Research, Gordon Rugg & Marian Petre, Open University Press McGraw-Hill Education, 2007.

Course Code: CSC 513 **Pre-Requisite:** None

Course Title: Mobile and Pervasive Computing

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the architecture and protocols related to mobile networks;
- To discuss the wireless sensor network protocols and standards along with routing strategies;
- To discuss major transport and application layer protocols in context of mobile networks;
- To introduce the basic concepts of pervasive computing;
- To introduce the pervasive web and its access from different devices.

Course Contents:

Topics include: Mobile and pervasive computing overview; Mobile networks: cellular wireless networks, GSM architecture, protocols, connection establishment, frequency allocation, routing, mobility management, security; GPRS; Wireless networks: wireless LANs and PANs, IEEE 802.11 standard, architecture, services, network, hiperLAN; Bluetooth; Wi-Fi; WiMAX; Routing; Mobile IP; DHCP; AdHoc; Proactive and reactive routing protocols; Multicast routing; Transport and application layers; Mobile TCP, WAP Architecture; WWW programming model; WDP, WTLS, WTP, WSP, WAE, WTA Architecture; Pervasive Computing: pervasive computing infrastructure, applications; Device technology: hardware, human-machine interfaces, biometrics, and operating systems; Device connectivity: protocols, security, and device management; Pervasive web: application architecture, access from PCs and PDAs, access via WAP.

Recommended Books:

1. Pervasive Computing and Networking, Mohammad S. Obaidat, Mieso Denko & Isaac Woungang, Wiley, 2011.
2. Mobile Wireless Communications, Mischa Schwartz, Cambridge University Press, 2005.
3. Fundamentals of Mobile and Pervasive Computing, Frank Adelstein, Sandeep KS Gupta, Golden Richard III & Loren Schwiebert, McGraw-Hill, 2004.

Course Code: CSC 514 **Pre-Requisite:** None

Course Title: Software-Defined Networking and Network Function Virtualization

Credit Hours: 3(3, 0)

Course Objectives:

- To explain OpenFlow, challenges in SDN, and recent development in SDN;
- To explain in detail the operation of the SDN control plane;
- To evaluate a sample SDNs performance and reliability;
- To describe Network Functions Virtualization components and how they work together;
- To configure an example service using SDN and NFV;
- To describe the techniques to enable applications to control the underlying network using SDN.

Course Contents:

The aim of the course is to give the students a deep understanding of two important, emerging network technologies: Software Defined Networking (SDN) and Network Functions Virtualization (NFV). Topics cover include: The history of SDN; SDN API: OpenFlow: Mininet: A simulation environment for SDN;SDN (OpenFlow) controllers and network operating systems; SDN applications (traffic engineering, network virtualization, software defined storage, etc); SDN network updates: SDN scalability; Programming SDN networks; SDN network correctness verification; Network function virtualization (NFV): SDN security.

Recommended Books:

1. SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization, Jim Doherty, Addison-Wesley Professional, 2016.
2. Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, William Stallings, Pearson Education 2015.

Course Code: CSC 515 **Pre-Requisite:** None

Course Title: Communication Networks-Architectures and Protocols

Credit Hours: 3(3, 0)

Course Objectives:

- To transfer comprehensive knowledge of communication networks along with their architectures and protocols;
- To cover in-depth topics on the Internet and the PSTN (wired, wireless, and IoT – Internet of things).

Course Contents:

The topics include: Protocols and Algorithms at all levels including: client/server and peer-to-peer applications, session control, transport protocols, the end-to-end arguments and end-to-end congestion control; network architecture: forwarding, routing, signaling, addressing, and traffic management; programmable and software-defined networks (SDN); quality of service, basic queuing and multimedia applications; LAN architecture, link protocols, access networks and MAC algorithms; physical media characteristics and coding; network security and information assurance; network management.

Recommended Books:

1. Computer Networking: A Top-Down Approach, James F. Kurose and Keith F. Ross, Pearson Addison Wesley, 2017.
2. Communication Networks: Fundamental Concepts and Key Architectures, Alberto Leon-Garcia and Indra Widjaja, McGraw-Hill, 2004.

Course Code: CSC 516 **Pre-Requisite:** None

Course Title: Internet of Things Architecture and Protocols

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the Architectural Overview of IoT;
- To understand the IoT Reference Architecture and Real-World Design Constraints;
- To understand the various IoT Protocols (Datalink, Network, Transport, Session, Service).

Course Contents:

The course aims to help students understand the concepts of the Internet of Things and its architecture. The topics include: The Evolution and Overview of IoT; Organization and primary components of IoT systems; A reference IoT architecture; Data Link and Network Layer Protocols; Transport Layer Protocols, Sensor Networks; Machine to Machine Communication; Interoperability in IoT; Discoverability; Service Layer & Security and Privacy; Applications of IoT.

Recommended Books:

1. Internet of Things: Architectures, Protocols and Standards, Cirani, S., Ferrari, G., Picone, M., & Veltri, L., Wiley, 2018
2. Internet-of-Things (IoT) Systems: Architectures, Algorithms, Methodologies, Serpanos, D. & Wolf, M., Springer, 2017

Course Code: CSC 517 **Pre-Requisite:** None

Course Title: Content Networking

Credit Hours: 3(3, 0)

Course Objectives:

- To transfer knowledge on the fundamentals concepts of moving content on the internet;
- To introduce the concept of web caching and content replication;
- To build complex content delivery network.

Course Contents:

The topics include: The diversity of interest in content networking; Content Transport; Caching techniques for web content and streaming media; Navigating content network; Peer-to-peer content networks; Interactive content delivery; content services; Building content networks; Content network standards.

Recommended Books:

1. Content Networking: Architecture, Protocols, and Practice, Markus Hofmann, The Morgan Kaufmann Series in Networking, 2016.

Course Code: CSC 731 **Pre-Requisite:** None

Course Title: Challenged Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the issues in traditional TCP/IP architecture;
- To introduce the concepts like software defined networks, information centric networking, delay tolerant networks etc. ;
- To demonstrate the working of any challenged network protocol or algorithm.

Course Contents:

This course provides in depth knowledge of different challenged networks. Topics include: Design principles, architecture, applications and open research challenges of Information Centric networking, software defined networking, delay tolerant networking and internet of things.

Recommended Books:

1. Challenged Networks: Protocol and Architectural Challenges in Delay andDisruption Tolerant Networks, Khaled A. Harras, VDM Verlag, 2008.

Course Code: CSC 518 **Pre-Requisite:** None

Course Title: Smart Grid Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To explain various aspects of the smart grid, including, Technologies, Components, Architectures and Applications.
- To explain communication infrastructure of smart grid.
- To explain various integration aspects of conventional and non-conventional energy sources.
- To explain distributed generation coordination including monitoring of smart grid using modern communication infrastructure.
- To analyze Microgrid as a hybrid power system with advantages and challenges in future.

Course Contents:

The topics cover include: Communication Technologies for Power System: Fiber Optical Networks, WAN based on Fiber Optical Networks, IP based Real Time data Transmission, Substation communication network, Zigbee; Information System for Control Centers (ICCS): ICCS Configuration, ICCS communication Network, ICCS Time Synchronization, E-Commerce of Electricity, GIS, GPS; Integration, Control and Operation of Distributed Generation: Distributed Generation Technologies and its benefits, Distributed Generation Utilization Barriers, Distributed Generation integration to power grid.; Monitoring the smart grid: Load dispatch centers, wide-area monitoring system (WAMS), PMU; Smart sensors/telemetry, advanced metering infrastructure (AMI);smart metering; smart grid system monitoring; communication infrastructure and technologies; self-healing; Micro grid: Integration of distributed energy sources; concept, operation, control and protection of Micro grid.; Hybrid Power Systems: Integration of conventional and non-conventional energy sources.

Recommended Books:

1. Smart Grid Infrastructure and Networking, INIEWSKI, McGraw-Hill Education India Pvt Ltd, 2012.
2. Smart Grid: Fundamentals of Design and Analysis, James M., IEEE Computer Society Press, 2012.
3. Smart Grid: Technology and applications, Ekanayake J. Jenkins N., Liyanage K., Wu, J., Yokoyama A., Wiley Publications.
4. Securing the smart grid: Next generation power grid security, Flick T., Morehouse J., paperback.

Course Code: CSC 636 **Pre-Requisite:** None

Course Title: Advanced Wireless Sensor Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To learn the basic principles behind a Wireless Sensor Network;
- To presents the particular challenges of designing network protocols, services and applications for WSNs composed of large numbers of constrained devices;
- To provides an introduction to Network Simulator 3 (ns-3).

Course Contents:

Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors: Network Architecture: Traditional layered stack, Cross-layer designs, Sensor Network Architecture: Hardware Platforms: Motes, Hardware parameters; Medium Access Control Protocol design: Fixed Access, Random Access; Introduction to Markov Chain: Discrete time Markov Chain definition, properties, classification and analysis; MAC Protocol Analysis: Asynchronous duty-cycled, X-MAC Analysis (Markov Chain); MANET protocols; Routing protocols for WSN: Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast; Opportunistic Routing Analysis; clustering in WSNs: QoS management; Overview of different localization techniques; Overview of different time synchronization protocols; Security: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution; Description of the NS-3 core module and simulation example.

Recommended Books:

1. Protocols and Architectures for Wireless Sensor Networks, H. Karl and A. Willig, Wiley Publishers, 2005
2. Wireless Sensor networks- Technology, Protocols and Applications, Kazem Sohraby, Daniel manoli, Wiley Inter Science Publications 2010.
3. Wireless Sensor Network Designs, Anna Ha´c, John Wiley & Sons Ltd, 2009.

Course Code: CSC 631 **Pre-Requisite:** None

Course Title: Advanced Topics in Computer Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the principles and concepts on computer networks.
- To explore general-purpose computer networks.
- To get skills in computer network applications.
- To enhance knowledge on designing and building a complete system.

Course Contents:

Computer Networks and Internet; Application Layer: HTTP, FTP, SMTP, P2P and Socket Programming; Transport Layer: UDP, TCP and principles of congestion control; Transport Layer: UDP, TCP and principles of congestion control; The Network Layer: Router, IP, Routing Algorithms and Routing in the Internet; The Network Layer: Router, IP, Routing Algorithms and Routing in the Internet; Link Layer and Local Area Network: Error-detection and correction, multiple access protocols, link-layer addressing, Ethernet and switches; Midterm exam; Wireless and Mobile Networks: CDMA, cellular Internet Access, Mobile IP and Mobility management; Wireless and Mobile Networks: CDMA, cellular Internet Access, Mobile IP and Mobility management; Multimedia Networking: applications, Streaming stored audio and video, making the best of the best –effort service; Multimedia Networking : applications, Streaming stored audio and video, making the best of the best –effort service; Security in Computer Networks; Presentations

Recommended Books:

1. Computer Networking – A Top-Down Approach Featuring the Internet, by James F. Kurose and Keith W. Ross, ISBN-10: 0132856204 or ISBN-13: 978-0132856201. 6th Edition. Publisher is Addison Wesley.

Course Code: CSC 636 **Pre-Requisite:** None

Course Title: Advanced Topics in Wireless Networks

Credit Hours: 3(3, 0)

Course Objectives:

- Describe advance principles and technologies relating to information transmission over wireless communication channels and different channel models;
- Describe major problems of a wireless communication channel;
- Evaluate the capacity of a wireless channel and derive expressions for error performance for various transmission schemes;
- Formulate advance principles and techniques to design wireless communication systems and/or undertake further research in a related field.

Course Contents:

Topics Include: Wireless Fundamentals; Wireless Advantages and Challenges, Wireless Characteristics; Introduction to Signal Processing; Fourier Transformation Applications, Interferences, Existing Wireless Technologies and Applications; Digital Modulation Techniques; ASK, FSF, PSK, QAM, QPSK, FDM, OFDM; Infrastructure and Ad Hoc Networks: Architecture, Deployment; Wireless LAN, Wireless Sensor Networks; MAC Protocols; Link Scheduling; Convergecast Energy; Management; Example Applications and Deployment; Real-Time Wireless, Wirelesshart; Sensing and Control over Wireless; Whitespace and Cognitive Radio Networking; Mesh and Vehicular Networks, Sensor Networks, DTN, Localization, Sensing etc.

Recommended Books:

1. Wireless Communication Networks and Systems, Cory Beard and William Stallings, Pearson 2015.

Course Code: CSC 609 **Pre-Requisite:** None

Course Title: Advanced Network Programming

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the key protocols that support the internet;
- To teach students to create network applications using different techniques;
- To help students understand advanced programming techniques such as IPv6 Socket Programming, Broadcasting, Multicasting;

Course Contents:

The course includes the following topics: Network Architectures; Network Communications Protocols and Services; Basic Network Programming; Sockets; Socket-Based Client Server Communication; Support for Communication Based Services: Server-Side Network Programming; Client-Side Network Programming; Advanced Client-Server Network Programming.

Recommended Books:

1. Learning Network Programming with Java, Reese, R, M., Packt Publishing - ebooks Account, 2015.
2. Advanced Network Programming – Principles and Techniques: Network Application Programming with Java (Computer Communications and Networks), Ciubotaru, B., & Muntean, G., Springer, 2013.

Course Code: CSC 610 **Pre-Requisite:** None

Course Title: Advanced Topics in Distributed Systems

Credit Hours: 3(3, 0)

Course Objectives:

- To help students understand the advanced issues in Distributed Systems;
- To give students an understanding of the current applications of Distributed Systems;
- To equip students to carry out research in the area of Distributed Systems.

Course Contents:

The course includes the following topics: Definition and Types of Distributed System; Architectures of Distributed Systems; Processes: Threads, Virtualization, Clients, Servers, Code Migration; Communication: Fundamentals, Remote Procedure Call, Message-Oriented Communication, Stream-Oriented Communication, Multicast Communication; Naming: Names, Identifiers and Addresses, Structured Naming, Attribute-Based Naming; Synchronization: Clock Synchronization, Logical Clocks, Mutual Exclusion, Global Positioning of Nodes, Election Algorithms; Consistency and Replication: Introduction, Data-Centric Consistency Models, Client-Centric Consistency Models, Replica Management, Consistency Protocols; Fault Tolerance: Process Resilience, Reliable Client-Server Communication, Distributed Commit, Recovery; Security: Secure Channels, Access Control, Security Management; Distributed Object-Based Systems: Architecture, Processes, Communication, Naming, Synchronization, Consistency and Replication, Fault Tolerance, Security; Distributed File Systems: Architecture, Processes, Communication, Naming, Synchronization, Consistency and Replication, Fault Tolerance: Distributed Web-Based Systems: Architecture, Processes, Communication, Naming, Synchronization, Consistency and Replication, Fault Tolerance; Distributed Coordination-Based Systems: Architecture, Processes, Communication, Naming, Synchronization, Consistency and Replication, Fault Tolerance:

Recommended Books:

1. Distributed Systems, Steen, M, V. & Tanenbaum, A, S., CreateSpace, 2017.
2. Distributed Systems, Principles and Paradigms, Tanenbaum, A., S., Steen, M., V., CreateSpace Independent Publishing Platform, 2016.

Course Code: CSC 523 **Pre-Requisite:** None

Course Title: Cyber Intelligence

Credit Hours: 3(3, 0)

Course Objectives:

- To learn about the Observe-Orient-Decide-Act (OODA) loop and it's applicability to security;
- To understand tactical view of Active defense concepts and their application in today's threat landscape;
- To get acquainted with an operational view of the F3EAD process to drive decision making within an organization;
- To create a Framework and Capability Maturity Model that integrates inputs and outputs from key functions in an information security organization;
- To understand the idea of communicating with the Potential for Exploitability based on cyber intelligence.

Course Contents:

This course provides students with up-to-date research of emerging cyber threats and defensive mechanisms, which are timely and essential. Topics cover include: Overview: Importance, Intelligence Development; Integrating Cyber Intel; Security and Operations; Active Defense; F3EAD for You and for Me; Integrating Threat Intelligence and Operations; Creating the Collaboration Capability; The Security Stack, Driving Cyber Intel; Baselines and Anomalies; Vulnerability Management; Risky Business; Assigning Metrics.

Recommended Books:

1. Practical Cyber Intelligence, Wilson Bautista Jr. Packt Publishing, 2018.
2. Cyber Threat Intelligence, Ali Dehghantanha, Mauro Conti, Tooska Dargahi, Springer, 2018.

Course Code: CSC 524 **Pre-Requisite:** None

Course Title: Cybercrime Investigation

Credit Hours: 3(3, 0)

Course Objectives:

- To explores technical, legal, and social issues related to cybercrime;
- To analyzed micro-level and macro-level theories in depth and applied to cybercrime cases both past and present;
- To present common types of fraudulent schemes, as well as several laws that have been enacted and developed specifically for cybercrime.

Course Contents:

The topics cover include: Overview: Cybercrime, Computer Crime, investigation process; Jurisdiction over Cybercrime; Micros theory vs. Macro theory; Victimization in relation to computer crimes: Individual and public awareness, profiles of victims, nature and extent of victimization, responses of victims; Legal issues in cybercrime, Enforcement issues and cybercrime investigations; Cybercrime prevention strategies.

Recommended Books:

1. Investigating Cybercrime Sara L. Latta, Enslow Publishing, 2017.
2. Cyber Crime Investigations: Bridging the Gaps Between Security Professionals, Law Enforcement, and Prosecutors. Anthony Reyes, Richard Brittson, Kevin O'Shea , James Steele, Syngress 2007.

Course Code: CSC 537 **Pre-Requisite:** None

Course Title: Deep Reinforcement Learning

Credit Hours: 3 (3, 0)

Course Objectives:

- To understand deep learning and reinforcement learning paradigms;
- To understand Architectures and optimization methods for deep neural network training;
- To implement deep learning methods within Tensor Flow and apply them to data;
- To understand the theoretical foundations and algorithms of reinforcement learning;
- To apply reinforcement learning algorithms to environments with complex dynamics.

Course Contents:

The topics cover include: Markov decision processes, planning by dynamic programming, model-free prediction and control, value function approximation, policy gradient methods, integration of learning and planning, and the exploration/exploitation dilemma.

Recommended Books:

1. Reinforcement Learning: An Introduction Richard S. Sutton, Andrew Barto,2017.
2. Reinforcement Learning with TensorFlow: A beginner's guide to designing self-learning systems with TensorFlow and OpenAI Gym Sayon Dutta,2018
3. Algorithms for Reinforcement Learning, Csaba Szepesvari, 2010.

Course Code: CSC 525 **Pre-Requisite:** None

Course Title: Information Security Policy Development

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the lifecycle of policy enactment;
- To develop and modify security policies;
- To create a dissemination plan for the policy;
- To Critique a security policy for its effectiveness and completeness.

Course Contents:

This course examines the steps required in policy development. Topics covered includes: Overview: Policy Lifecycle. Writing Security Policies, information Classification and Privacy Policies; Network Security and Email Policies,; Operating System and Software Security Policy; Encryption and Key Management Policy; Disaster Recovery and Business Continuity; Security Policy: Audit and Compliance, Acceptable use Policies and Training /Awareness, Security Policy: Enforcement and Effectiveness, Internet Censorship (Case Analysis), Intellectual Property Protection (Case Analysis).

Recommended Books:

1. Information Security Policy Development for Compliance, Barry L. Williams, CRC Press, 2013.

Course Code: CSC 526 **Pre-Requisite:** None

Course Title: Information Security Project Management

Credit Hours: 3(3, 0)

Course Objectives:

- To describe the concepts relating to information security management (confidentiality, integrity, availability, vulnerability, threats, risks, countermeasures);
- To understand the current national legislation and regulations which impact upon information security management;
- To provide awareness of current national and international standards, frameworks and organizations which facilitate the management of information security;
- To understand the current business and common technical environments in which information security management has to operate;
- To provide the knowledge of the categorization, operation and effectiveness of controls of different types and characteristics.

Course Contents:

The course covers the range of concepts, approaches and techniques that are applicable in Information Security Management. The topics cover include: Information Security Management Principles, Information Risk, Information Security Framework, Procedural/People Security Controls, Technical Security Controls, Physical and Environmental Security Controls, Disaster Recovery and Business Continuity Management.

Recommended Books:

1. Information Security Management Principles, Andy Taylor, BCS Learning & Development Limited, 2013.

Course Code: CSC 527 **Pre-Requisite:** None

Course Title: Information Technology Forensics and Investigations

Credit Hours: 3(3, 0)

Course Objectives:

- To describe the terminology commonly used in the field of Computer Forensics.
- To demonstrate the ability to perform a basic computer forensic analysis using computer and network-based tools.
- To explain how to recover hidden data for forensic analysis from Windows and Linux/Unix file systems
- To describe the role of computer forensics in a criminal investigation.
- To articulate the laws applying to the appropriation of computers for forensic analysis, citing what laws are relevant and apply under what circumstances.
- To describe the underlying concepts of how data is stored on computers and the general structure of the Internet.

Course Contents:

This course is an introduction designed to familiarize the student with current approaches to computer, digital, and cyber related forensics techniques and to reinforce the appropriate procedures for evidence collection and processing. The topic cover includes: Introduction to Digital Forensics; Investigative Process Methodology; Digital Forensic Readiness; First responder Procedures; incident Handling; Investigative Reports; File Systems and Hard Disks; Digital Media Devices; Boot Processes; Windows and Linux Forensics; Steganography; Data Acquisition; EnCase; Data Recovery; Image File Forensics; Log Investigation; Network Traffic Analysis; DoS Attacks; Internet Crime; Corporate Espionage.

Recommended Books:

1. Digital Forensics and Investigations: People, Process, and Technologies to Defend the Enterprise, Jason Sachowski, CRC Press, 2018.
2. Handbook of Digital Forensics and Investigation, Eoghan Casey, Elsevier Academic Press, 2009.

Course Code: CSC 528 **Pre-Requisite:** None

Course Title: Intrusion detection and firewalls

Credit Hours: 3(3, 0)

Course Objectives:

- To build further on the grounding of principles in the earlier network courses;
- To analyze network traffic to protect a system from network-based threats;
- To learn theory and principles of currently popular technologies such as firewalls and intrusion detection systems;
- To develop and apply firewalls and intrusion detectors and analyses their architectures.

Course Contents:

The topics include: Threats to security from the network; Firewall architecture; Types of different IDS; Intrusion-detection systems (Snort is an open source network intrusion detection system); modeling techniques used by IDS: behavior, signature, anomaly, and heuristic; Use of honeynets and honeypots; Pattern matching and artificial intelligence versus computer immunology; Reading and analyzing log files and audits (Perimeter logs); IP-spoofing and sequence guessing; Malicious ICMP activity and router/switch poisoning; Use of TCPdump for protocol analysis; Denial of Service attacks, structure, detecting and preventing; IPSec filters, Windows filtering, IP filters in Linux and BSD: Anomaly detection; IETF XML standard for exchange of intrusion information; IDS management; Implement an intrusion detection system to detect suspicious activity

Recommended Books:

1. Network Intrusion Detection, Stephen Northcutt, Judy Novak. Publisher. SAMS Publishing, 2012.

Course Code: CSC 529 **Pre-Requisite:** None

Course Title: Reverse Engineering and Malware Analysis

Credit Hours: 3(3, 0)

Course Objectives:

- To give in-depth knowledge to the beginners who want to develop their career in cyber security, penetration testing and as a reverse engineer;
- To introduce various categories of existing malicious software that causes harm to a user and computer, including viruses, Trojan horses, worms, rootkits, scareware, and spyware.

Course Contents:

This course covers fundamental problems, principles, and techniques in reverse engineering and malware analysis. Topics include: Malware methodology; Basic analysis; Advanced static analysis; Advanced Dynamic analysis; Anonymous and stealthy analysis; Malware classification and functionality; Anti Reverse-engineering; malware obfuscation and packing techniques; It also involves research opportunities to analyze new malware samples and firmwares and develop new analysis tools. Return-oriented programming; Web-based malware and social engineering; Behavioral detection signatures

Recommended Books:

1. The IDA PRO Book: The Unofficial Guide to the World's Most Popular Disassembler, No Starch Press, 2011.

Course Code: CSC 530 **Pre-Requisite:** None

Course Title: Security and Privacy for the Smart Grid

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss the fundamentals and theoretical infrastructure of Smart Grids;
- To teach advanced and interdisciplinary approaches to address the security and privacy issues in Smart Grids;
- To teach security and privacy issues in Smart Grids.

Course Contents:

In this course, the focus is on developing simple communication and computing models for the grid with specific emphasis on architecting such a network with strict security and privacy guarantees. The topics include: Overview of security and privacy issues in smart grids: Secure state estimation, Distributed computation in the grid with privacy, privacy issues in smart grids; Distributed data collection in complex networks (the smart grids); Physical network security and reliability issues of smart grids; Large Data Challenges in the Grid: stochastic models for data in the grid, Centralized vs. distributed computation paradigms. Compression/storage/communication challenges; Error and Bad Data Detection. Power flow estimation using Bayesian in smart grids.

Recommended Books:

1. Smart Grids: Security and Privacy Issues. Kianoosh G. Boroojeni, M. Hadi Amini, S. S. Iyengar, Springer, 2017.

Course Code: CSC 531 **Pre-Requisite:** None

Course Title: Privacy and Security in IoT

Credit Hours: 3(3, 0)

Course Objectives:

- To transfer knowledge on the fundamentals of securing connected devices and networks in Internet of Things (IOT);
- To integrate the security aspect into their IOT design taking into consideration all the threats:
- To teach various case studies that use IOT.

Course Contents:

The topics include: Understanding Internet of Things (IOT) Architecture : IOT devices, gateways and applications; Need of Internet of Things (IOT) Security: Confidentiality, Integrity, Availability, Non-Repudiation; Security Classification & Access Control; Use of RASPBERRY PI for developing applications; IOT Protocol Built-In Security Features ; Cryptology ; Case studies: smart Homes, Smart Agriculture, Smart Retail Supply, Smart Healthcare, Smart Grid, Smart Cities

Recommended Books:

2. Security Challenges and Approaches in Internet of Things, Sridipta Misra, Muthucumaru Maheswaran, Salman Hashmi, Springer, 2017.

Course Code: ISC 632 **Pre-Requisite:** None

Course Title: Public Key Cryptography

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce concepts related to public key cryptography;
- To explain the basic number theory;
- To discuss the major public key cryptosystems;
- To discuss the application of digital signatures, hash functions and MAC;
- To introduce the primality testing techniques.

Course Contents:

Topics include: Public key cryptography: background and basic concepts; Algorithmic number theory: integer operation, Euclid,s algorithm, modular arithmetic; Chinese remainder theorem; Pseudorandom generation; Congruence arithmetic; Discrete logarithms and Diffie-Hellman key exchange; Public key cryptosystems: Elgamal and RSA schemes, elliptic curve cryptography; Digital signatures; Hash functions and MAC, Primality testing: Fermat's approach, Miller-Selfridge-Rabin test, true primality tests.

Recommended Books:

1. Public Key Cryptography: Applications and Attacks, Lynn Margaret Batten, Wiley-IEEE Press, 2013.
2. Mathematics of Public Key Cryptography, Steven D. Galbraith , Cambridge University Press, 2012.

Course Code: ISC 634 **Pre-Requisite:** None

Course Title: Elliptic Curve Cryptography

Credit Hours: 3(3. 0)

Course Objectives:

- To introduce concepts, facts and algorithms concerning elliptic curves over the rational numbers and finite fields and their applications in cryptography:
- To explain algorithmic number theory.

Course Contents:

The topics include: The group law; Weierstrass and Edwards curves; Efficient computation: Isogenies and endomorphisms: Elliptic curves over finite fields point counting; The discrete logarithm problem Pollard rho;Elliptic curves over Q torsion subgroups; Integer factorization and primality proving; Endomorphism rings dual isogeny; Elliptic curves over C Lattices; Pairings and divisors the Weil and Tate pairings; the theory of complex multiplication ring class fields; Modular curves; the modular group Riemann surfaces; modular polynomials; isogeny graphs; Modular forms and Fermat's Last Theorem L-series; Galois representations modularity; outline of Wiles' proof.

Recommended Books:

1. Elliptic Curves: Number Theory and Cryptography, Second Edtion, Lawrence C. Washington, CRC Press, 2012

2. The Arithmetic of Elliptic Curves, Joseph H. Silverman, Springer Verlag, 2009

3. Advanced Topics in the Arithmetic of Elliptic Curves, Joseph H. Silverman,Springer Verlag, 2009.

Course Code: ISC 635 **Pre-Requisite:** None

Course Title: Quantum Cryptography

Credit Hours: 3(3, 0)

Course Objectives:

- To understand why quantum computers are important, why they can break certain public key cryptosystems;
- To explain the engineering challenges in building a physical quantum computing device;
- To highlight the level of security assured by quantum cryptographic devices.

Course Contents:

In quantum cryptography we use quantum mechanical effects to construct secure protocols. The topics include: Basics of Quantum Computation; Breaking Crypto with Quantum Computers; Quantum Key Exchange; Quantum Commitments (Possibility/Impossibility); Quantum Zero-Knowledge: Everlasting Security; Quantum Time Vaults

Recommended Books:

1. Quantum Computation and Quantum Information. Nielsen, Chuang, Cambridge University Press, 2000
2. Quantum Cryptography and Secret-Key Distillation by Gilles van Assche, Cambridge University Press, 2006.
3. Quantum Computation and Quantum Information by Chuang Nielsen and Isaac L. Chuang, 2011.
4. Elements of Information Theory by Joy Thomas and Thomas Cover, 2006.

Course Code: ISC 636 **Pre-Requisite:** None

Course Title: Cryptanalysis

Credit Hours: 3(3, 0)

Course Objectives:

- To develop an understanding of the basic concepts of cryptanalysis and the methods used to attack an encryption system;
- To discuss security design principles, the internal structure and important properties of major cryptosystems;
- To teach major computational hard problems in cryptography (symmetric and public key);
- To explain analysis of mathematical/algebraic/statistical attacks, methods and algorithms in cryptanalysis.

Course Contents:

The topics include: Historical cryptanalysis; General mathematical cryptanalysis concepts: Key recovery vs. decryption, Kerckhoff's Principle; Cryptanalysis of symmetric cryptosystems: Symmetric cryptosystems, Brute force attacks; LFSR-based stream ciphers; Modern block ciphers(DES/AES/other); Differential cryptanalysis, linear cryptanalysis, algebraic cryptanalysis in block and stream ciphers. Self-similarity attacks. Groups; finite fields. Number theory; Attacks on public key cryptosystems. RSA; factoring, discrete logarithms; elliptic curves, lattice attacks. Cryptographic explorations with software: Protocol/mode/initialization attacks; Side channel attacks.

Recommended Books:

1. Algorithmic Cryptanalysis, Antoine Joux, CRC Press, 2017
2. Handbook of Applied Cryptography, Menezes, van Oorschot, Vanstone, CRC Press 2016

Course Code: ISC 738 **Pre-Requisite:** None

Course Title: Advanced Topics in Cryptography

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce main theorems and algorithms in number theory used in cryptography;
- To discuss the role of cryptanalysis in the design of secure systems;
- To explain the technical details of private and public key cryptosystems based on logarithm and elliptic curves;
- To discuss interactive and non-interactive proofs for authentication;
- To introduce latest topics in cryptography such as electronic cash, digital watermarking, fingerprinting and steganography and quantum cryptography.

Course Contents:

Topics include: Private and public-key cryptosystems; Digital signature schemes; Number theory; Discrete logarithm based cryptosystems; Elliptic curves cryptosystems; Interactive proofs: zero-knowledge proofs; Non-interactive zero-knowledge proofs; Secure protocols: two-party secure computation, multiparty secure computation; Chosen cipher-text Security; Untraceable electronic cash on the net; Quantum cryptography; Digital watermarking; Fingerprinting and steganography.

Recommended Books:

1. Introduction to Modern Cryptography, Jonathan Katz & Yehuda Lindell, Chapman and Hall, 2014.
2. Applied Cryptography: Protocols, Algorithms and Source Code in C, Bruce Schneier, Wiley, 2015.
3. Cryptography: Theory and Practice, Douglas R. Stinson, CRC Press, 2006.

Course Code: CSC 532 **Pre-Requisite:** None

Course Title: Agent Based Modeling

Credit Hours: 3(3, 0)

Course Objectives:

- To explore how to use agent-based modeling;
- To understand and examine a widely diverse and disparate set of complex problems.
- To build a model from the ground up;
- To analyze and understand the results of a model using the NetLogo programming language.

Course Contents:

Topics cover includes: Overview: History of ABM and Classic Models: Building a Simple Model, Extending Models. Creating Agent-Based Models; The Components of an Agent-Based Model; Analyzing Agent-Based Models; Verification, Validation, and Replication; Advanced ABM

Recommended Books:

1. Agent-Based Models, Nigel Gilbert, SAGE Publications, 2008.
2. Research papers, Additional books and documents, will be used to cover the topics

Course Code: CSC 533 **Pre-Requisite:** None

Course Title: Social Network Modeling and Analysis

Credit Hours: 3(3, 0)

Course Objectives:

- To present the fundamental concepts of Network Analysis;
- To plan and execute network analysis;
- To perform visualizations and empirical investigations of network data.

Course Contents:

The topics include: Overview of Network Analysis; The Network Analysis Process and Methodology; Network Visualization; Networks: Structures, Models, Processes; Models and Simulation of Network Evolution: Subgroups and Cliques; Clustering; Ego networks; Ethics and Privacy; Cognitive Social Structures: Networks and Language; Multi-agent models for representing networks.

Recommended Books:

1. Social network analysis: A handbook, Scott, J. Newbury Park, CA: Sage 2007.
2. Social Network Analysis, Knoke Sage, 2008.

Course Code: CSC 659 **Pre-Requisite:** None

Course Title: Advanced Topics in Simulation and Modeling

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce simulation modeling techniques;
- To discuss the techniques to verify the simulation models;
- To discuss the analysis of simulation results and model optimization algorithms;
- To apply the modeling and simulation techniques to domain specific case studies.

Course Contents:

Topics include: Modeling and simulation basic concepts; System analysis and classification; Abstract and simulation models: Continuous, discrete, and combined models, Heterogeneous models, Parallel process modeling; Input data analysis: Pseudorandom number generation and testing; output data analysis; Queuing systems: Monte Carlo method; Modeling languages: model verification and testing, numerical methods: Continuous simulation; Discrete event simulation; Distributed simulation; Simulation experiment control: Visualization and analysis of simulation results: Model optimization; Case studies of applications of modeling and simulation in specific domains such as: avionics, military, digital logic, computer networks, entertainment and gaming, medical.

Recommended Books:

1. Simulation Modeling and Analysis, Averill M Law, McGraw-Hill, 2014.
2. Simulation, Sheldon M. Ross, Academic Press, 2012.
3. Modeling and Simulation, Hartmut Bossel, CRC press, 1994.

Course Code: CSC 673 **Pre-Requisite:** None

Course Title: Advanced Topics in Distributed Databases

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss the architectural and design issues related to distributed databases;
- To introduce the data management techniques in distributed databases;
- To discuss the distributed query and transaction processing techniques;
- To discuss the security and reliability issues in distributed databases.

Course Contents:

Topics include: Introduction to distributed database systems (DDBMS): architectural models, DDBMS architecture; Distributed database design strategies: design issues, fragmentation, allocation, view management, data security, semantic integrity control; Distributed query processing problems: query decomposition, localization of distributed data, query optimization, join ordering in fragment queries, distributed query optimization algorithms; Transaction processing: concurrency control mechanisms, serializability theory, locked-based and timestamp-based algorithms, optimistic algorithms, deadlock management; Reliability concepts and measures: failures in DDBMS, local reliability protocols, distributed reliability protocols, dealing with site failures.

Recommended Books:

1. Principles of Distributed Database Systems, M.T. Ozsu & P. Valduriez, Springer, 2011.
2. Transactional Information Systems, Gerhard Weikum & Gottfried Vossen, Morgan Kaufmann, 2001.
3. Distributed Database Systems, Chhanda Ray, Pearson, 2012.

Course Code: CSC 534 **Pre-Requisite:** None

Course Title: Soft Computing Techniques

Credit Hours: 3(3, 0)

Course Objectives:

- To familiarize with soft computing concepts;
- To introduce the ideas of Neural networks, fuzzy logic and use of heuristics based on human experience;
- To introduce the concepts of Genetic algorithm and its applications to soft computing using some applications.

Course Contents:

Evolutionary Algorithms: Genetic Algorithms, Genetic Programming, Particle Swarm Optimization; Evolutionary Design of ANN; Fuzzy Systems; Evolutionary Design of Fuzzy System; Neuro- Fuzzy Systems; Fuzzy Evolutionary Algorithms; Parallel Soft Computing.

Recommended Books:

1. Principles of Soft Computing, S.N. Sivanandan and S.N. Deepa, Wiley India, 2007.
2. Neuro-Fuzzy and Soft Computing, J.S.R.Jang, C.T.Sun and E.Mizutani, Pearson Education PHI, 2004.
3. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran and G.A.V.Pai, PHI, 2003.
4. Soft Computing: Integrating Evolutionary, Andrea Tettamanzi, Neural, and Fuzzy Systems, 2001.

Course Code: CSC 677 **Pre-Requisite:** None

Course Title: Advanced Topics in Data Warehousing

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce data warehouse architecture and schema design;
- To explain the dimensional modeling technique for designing a data warehouse;
- To discuss data extraction, transformation, and loading techniques for data warehousing;
- To introduce the query optimization and indexing techniques.

Course Contents:

Topics include: Data warehouse architecture: conceptual, logical and physical models; Online analytical processing (OLAP); Multidimensional OLAP (MOLAP); Relational OLAP (ROLAP); Dimensional modeling (DM): process of dimensional modeling, issues of dimensional modeling, star and snowflake schema; Extract transform load (ETL): issues of ETL, data cleansing; Data duplication elimination & BSN method; Query optimization; Data quality management (DQM): quantifying data quality, total DQM, parallelism, hardware techniques; Indexing: conventional indexing techniques, special indexing techniques, Join techniques; Case studies of Data Warehouse application and design.

Recommended Books:

1. Data Warehousing Fundamentals for IT Professionals, Paulraj Ponniah, Wiley, 2010.
2. Data Warehouse Design: Modern Principles and Methodologies, Matteo Golfarelli & Stefano Rizzi, McGraw-Hill, 2009.
3. Building the Data Warehouse, W. H. Inmon, Wiley, 2005.

Course Code: CSC 666 **Pre-Requisite:** None

Course Title: Advanced Topics in Decision Support Systems

Credit Hours: 3(3, 0)

Course Objectives:

- To develop modeling techniques for supporting semi-structured business decision making;
- To identify decision support systems for generating innovative business solutions;
- To design and implement decision support systems for generating innovative business solutions.

Course Contents:

This course provides an overview of current trends in Decision support systems; This mainly includes DSS methodology and covers Rapid DSS application, Management support systems and other techniques; Understand how management uses computer technologies' Learn basic and advanced concepts of decision-making; Design and implementation of decision support systems; Recognize different types of decision support systems used in the workplace; Decision Theory and Multicriteria Analysis; Situations of uncertainty and risk; Case studies.

Recommended Books:

1. Business Intelligence -- A managerial approach, Turban, Sharda, Delen and King, Pearson.
2. Introduction to Game Theory in Business and Economy, Webster, M.E. Sharpe.
3. Decision Support Systems and Intelligent Systems, Turban, E. and Aronson, Jay E., Prentice Hall, 2001

Course Code: CSC 613 **Pre-Requisite:** None

Course Title: Advanced Topics in Artificial Neural Networks

Credit Hours: 3(3. 0)

Course Objectives:

- To explain the fundamentals of artificial neural networks (ANN);
- To give examples of design and implementation for small problems in ANN;
- To understand motivation and functioning of the most common types of deep neural networks;
- To understand the choices and limitations of a model for a given setting;
- To apply deep learning techniques to practical problems.

Course Contents:

This course offers you an introduction to Deep Artificial Neural Networks; The topics include: Intro to machine learning and neural networks: supervised learning, linear models for regression, basic neural network structure, simple examples and motivation for deep networks; Use of tensorflow; Neural networks: forward propagation, cost functions, error backpropagation, training by gradient descent, bias/variance and under/overfitting, regularization; Convolutional Neural Networks; Recurrent Neural Networks (Implementing both CNN and RNN in Tensorflow); Limitations of Deep learning (e.g. data-hungry, results are at most as good as the data, ethical issues, advanced topics.

Recommended Books:

1. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer 2016.
2. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press 2016

Course Code: CSC 651 **Pre-Requisite:** None

Course Title: Pattern Recognition

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce concepts and applications of pattern recognition;
- To explain the probability theory used in pattern recognition;
- To discuss the classification and feature selection techniques;
- To introduce the dimensionality reduction techniques;
- To discuss the clustering techniques for pattern recognition.

Course Contents:

Topics include: Pattern recognition: basic concepts; Probability theory: conditional probability theory, bayes decision theory; Linear classifiers: the perceptron algorithm, least-squares methods; Nonlinear classifiers: multilayer perceptron's, back propagation algorithm, decision trees, combinations of classifiers, boosting; Feature selection: data preprocessing, ROC curves, class separtability measures, feature subset selection, bayesian information criterion; Dimensionality reduction: basis vectors, singular value decomposition, independent component analysis, kernel PCA, wavelets; Additional features and template matching: texture, shape and size characterization, fractals, features for audio, Context dependent classification; Clustering: sequential algorithms, hierarchical algorithms, functional optimization-based clustering, graph clustering, learning clustering, clustering high dimensional Data, Cluster validity measures.

Recommended Books:

1. Pattern Recognition, Theodoridis, S. & K. Koutroumbas, CA: Academic Press, 2009.
2. Pattern Recognition and Machine Learning, Bishop, C. M., Springer, 2007.
3. Pattern Classification, Duda, R.O., Hart, P.E., &Stork, D.G., Wiley-Interscience, 2001.

Course Code: CSC 668 **Pre-Requisite:** None

Course Title: Machine Learning

Credit Hours: 3 (3, 0)

Course Objectives:

- To enlighten the methods and learning algorithms related to data sciences field;
- To establish the foundation for big data applications ranging from social networks to medical and business informatics.

Course Contents:

This is an introductory course in machine learning, the major topics are: Dimensionality Reduction: Principal Component Analysis (PCA) and Singular Value Decomposition (SVD); Canonical Correlation Analysis (CCA); Independent Component Analysis (ICA); Compressed Sensing; Random Projection; The information bottleneck (We expect to cover some, but probably not all, of these topics); Clustering: K-Means, Gaussian Mixture Models, The Expectation-Maximization (EM) Algorithm; Link-based Clustering; Probabilistic-Modeling: Graphical Models, Latent-Variable Models; Inference (e.g., belief propagation); Parameter Learning and Regression.

Recommended Books:

1. The Elements of Statistical Learning: Data mining, inference and prediction, Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2017.
2. Pattern Classification, Richard O. Duda, Peter E. Hart, David G. Stork, A Wiley-inter science publication, 2016.
3. Foundations of data science, Blum, A., Hopcroft, J., & Kannan, R., Vorabversion eines Lehrbuchs, (2016).
4. Machine Learning: A Probabilistic Perspective, Murphy Kevin P., MIT Press, 2012.

Course Code: CSC 540 **Pre-Requisite:** None

Course Title: Robotics

Credit Hours: 3(3, 0)

Course Objectives:

- To present the fundamentals of robotic systems;
- 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:

Topics include: Overview: Robotics, types, uses, brief history, key components, applications, state-of-the-art robot systems; Robot control architectures: deliberative and reactive, inherent uncertainty in sensing & control: Interpreting sensor data; basic imaging for robotics; coordinate transformations; Sensing; sensors: Effectors and actuators; Localizing and mapping; Navigation and control: Path planning; Motion planning; Kinematics: direct and inverse, jacobians and robot dynamics; trajectory generation; Modeling: control; feed forward and feedback control, introduction to probabilistic robotics. MATLAB programming is an important part of the course to ensure that the student acquires skills in kinematics, motion planning and robot vision.

Recommended Books:

1. Introduction to Robotics, John. J. Craig, Pearson, 2013.
2. Probabilistic Robotics, Sebastian Thrun, MIT Press, 2005.
3. Principles of Robot Motion: Theory, Algorithms, and Implementations, Howie Choset, MIT Press, 2004.

Course Code: CSC 614 **Pre-Requisite:** None

Course Title: Advanced Topics in Image Processing

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss advanced topics in image processing and analysis;
- To help the students acquire the mathematical and algorithmic tools necessary to address the majority of image processing and vision applications;
- To help students understand the latest advancements in Image Processing Techniques;
- To enable students to implement solutions for complex image processing problem.

Course Contents:

The following topics will be included in this course: Image Formation Process; Preprocessing in the Spatial Domain; 2-D Fourier Transform; Edge Enhancement; Segmentation; Calibration techniques; Mathematical Morphology; Feature detection; Motion estimation and analysis; Object recognition; Image Correction; Image Inpainting; Image Fusion; Image Stitching; Image Watermarking.

Recommended Books:

1. Algorithms for Image Processing and Computer Vision, Parker, J. R., Wiley, 2010
2. Advanced Image and Video Processing Using MATLAB, Gong, S., Liu, C., Ji, Y.& Zhong, B., Springer, 2018

Course Code: CSC 764 **Pre-Requisite:** None

Course Title: Advanced Topics in Artificial Intelligence

Credit Hours: 3(3, 0)

Course Objectives:

- To acquaintance the learning with basic theoretical bases of AI;
- To explore problem solving paradigm and theorem solving;
- To understand search control and learning methods.

Course Contents:

Topic includes: AI methodology and Fundamentals; Intelligent Agents; Search Algorithms; Game Playing; Uncertainty& Probability Theory; Probabilistic Reasoning in AI; Logic & Theorem Proving; Knowledge-Based System and Logical Problem; First Order Logic; Knowledge Engineering; Application of AI in Different Domains such as Semantic Web.

Recommended Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2010.

Course Code: CSC 652 **Pre-Requisite:** None

Course Title: Advanced Topics in Computer Vision

Credit Hours: 3(3, 0)

Course Objectives:

- To demonstrate fundamental computer vision techniques;
- To implement ideas on publicly available or self-generated datasets for particular CV tasks.

Course Contents:

This course covers different aspects of computer vision and is focused on providing enough grounding in both theoretical and practical aspects of what computer vision is. The theoretical foundations required for a professional in CV include mathematical, statistical, image processing, and machine learning aspects of it, and then building on them to build a complete computer vision system. Students will be required to implement their ideas on publicly available or self-generated datasets for particular CV tasks. The topics include: Linear Algebra; Pixels and Filters; Edge Detection; RANSAC; Feature Detectors: Harris; Difference of Gaussian; SIFT; Panorama Stitching; Segmentation; Clustering; Feature Tracking; Linear Classifiers and Classification; PCA and Eigen faces; Deep Learning.

Recommended Books:

1. Deep Learning, Goodfellow, I., Bengio, Y., Courville, A., The MIT Press, 2016
2. Computer Vision: Models, Learning, and Inference. Prince, S. J. D., Cambridge University Press, 2012.
3. Computer Vision: A Modern Approach. Forsyth and Ponce, Pearson, 2012.
4. Computer Vision: Algorithms and Applications. Richard Szeliski, Springer, 2011.

Course Code: CSC 640 **Pre-Requisite:** None

Course Title: Advanced Topics in Multimedia Design and Technologies

Credit Hours: 3(3, 0)

Course Objectives:

- To help the students understand the technical details of common multimedia data format protocols, and compression techniques of digital images, video and audio content;
- To teach the significance of "Quality of Service" in multimedia networking;
- To teach the development of simple but demonstrative multimedia applications;

Course Contents:

Multimedia is an essential part of today's world. The topics included in this course include: Software Installation and Preparation; Introduction to Multimedia Studies; Data Representation; Basic Compression Techniques; Video and Audio Data Compression Techniques; Multimedia Networks and QoS Support: Multimedia Wireless Networks, Heterogeneous Networks, and advanced QoS Support; Multimedia Applications; Topics in Multimedia Technologies.

Recommended Books:

1. Multimedia Foundations: Core Concepts for Digital Design, Costello, V., Routledge, 2016
2. Multimedia: Making It Work, Vaughanm T., McGraw-Hill Education, 2014

Course Code: CSC 641 **Pre-Requisite:** None

Course Title: Advanced Topics in Game Design and Development

Credit Hours: 3(3, 0)

Course Objectives:

- Discuss and define the terms and principles of game design and development;
- Practice animation production and creation tools;
- Apply the mathematics, physics and artificial intelligence used in game design;
- Explain the networking issues involved in games development.

Course Contents:

This includes the following topics: History of Computer and Video Games; Types of Game Platforms; Game Design Principles; Platforms for Game Development (e.g., C++, Java, Lua, Python); Game Platform Constraints; Pygame; Storytelling; Sprites; Animation; Game Architecture; Game Development Methodologies; Physics; Loose Ends; Audio; Sound; Music; 2D Game Group Project Check-In; Debugging Games; Game Testing; Ethics; MMORPGs; Securing Online Games; Game Engines; iOS Development; Cocos2D; Leading Trends in Games Development. Networks and Multiplayer Mode. AI for game development; Machine Learning in Game Development;

Recommended Books:

1. Game Engine Architecture, Gregory, J., A K Peters, 2018.
2. Practical Game Design: Learn the art of game design through applicable skills and cutting-edge insights, Kramarzewski, A., Nucci, E. D., Packt Publishing, 2018.
3. Introduction to Game Design, Prototyping and Development: From Concept to Playable Game with Unity and C#, Bond, G., Addison-Wesley Professional, 2016.

Course Code: CSC 701 **Pre-Requisite:** None

Course Title: Advanced Topics in Augmented and Virtual Reality

Credit Hours: 3(3, 0)

Course Objectives:

- Ability to develop 3D virtual environments;
- Ability to develop 3D interaction techniques;
- Ability to develop immersive virtual reality applications;
- Understand the human factors needed in navigating in Virtual world;
- Help students create Augmented Reality applications.

Course Contents:

The course includes the following topics: Introduction to Virtual Reality; Output/Input Devices; Virtual Reality APIs; 3D Interaction Techniques; Modeling and Simulation; Experimental Design and User Studies; Effects of System Fidelity; Augmented Reality; Basics of AR functionality; AR Core; Bringing AR Core to Life: Real-world Applications of Virtual Reality and Augmented Reality.

Recommended Books:

1. Virtual Reality Blueprints: Create compelling VR experiences for mobile and desktop, Palmer, C., John Williamson, J., Packt Publishing - ebooks Account, 2018.
2. Learn ARCore - Fundamentals of Google ARCore: Learn to build augmented reality apps for Android, Unity, and the web with Google ARCore, Lanham, M., Packt Publishing, 2018.
3. Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia, Linowes, J., Krystian Babilinski, K., Packt Publishing, 2017.
4. Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Aukstakalnis, S., Addison-Wesley Professional, 2016.

Course Code: CSC 519 **Pre-Requisite:** None

Course Title: Cloud and Fog Computing

Credit Hours: 3(3, 0)

Course Objectives:

- To investigates cloud and Fog computing models, techniques, and architectures;
- To cover in-depth topics and expose to the current practices in cloud and Fog computing;
- To understand the Cisco Fog Computing Architecture and Portfolio.

Course Contents:

This course covers cloud and Fog computing models, techniques, and architectures. Topics may include distributed computing models and technologies: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS); virtualization; security and privacy issues; performance and systems issues: Scalability; QoS; Public cloud, private cloud and hybrid clouds; capacity planning; disaster recovery; Cloud OS; federated clouds; challenges in implementing clouds; data centers, hypervisor CPU and memory management; cloud hosted applications; Fog Computing Technology architecture and Scope; The Cisco Fog Computing Solution: Infrastructure, IOx Architecture, Platform, portfolio, services, D3 Models, Security, Data Acquisition and Transformation.

Recommended Books:

1. Distributed and Cloud Computing, 1st edition, Morgan Kaufmann, 2011.

Course Code: CSC 520 **Pre-Requisite:** None

Course Title: Cluster and Grid Computing

Credit Hours: 3(3, 0)

Course Objectives:

- To investigates advanced topics relating to grid computing, and high-performance applications;
- To cover in-depth topics and expose to the current practices in cluster and grid computing.

Course Contents:

This course covers cluster and Grid computing architectures. Topics may include distributed computing models and technologies; Cluster Computing models: System-independent Parallel Programming on Distributed Systems, Anonymous Remote Computing Model, Integrating Task Parallelism with Data Parallelism, Location Independent Inter-Task Communication, Parallel Programming on CORBA, Moset: An Anonymous Remote Mobile Cluster Computing Paradigm; From Cluster to Grid Computing: Classification of Grids, Introduction to Service Oriented Computing, Peer-to-Peer (P2P) Concepts in Grids, Overlays Unstructured P2P systems (Gnutella, Freenet), Structured P2P systems (Distributed Hash Tables - Chord, Pastry), Integrating unstructured and structured P2P systems Introduction to P2P security - Sybil attacks; Grid Computing Middleware; Data/Object Management in Large Scale Grids; Programming Models for Grid and Cluster Computing.

Recommended Books:

1. Distributed Systems, Coulouris et. al., Pearson 2016
2. Grid Computing, Janakiram, D., Tata Mcgrahill, 2005.

Course Code: CSC 546 **Pre-Requisite:** None

Course Title: Probability and Stochastic Processes

Credit Hours: 3(3, 0)

Course Objectives:

- To define basic concepts from the theory of Markov chains and present proofs for the most important theorems;
- To compute probabilities of transition between states and return to the initial state after long time intervals in Markov chains;
- To derive differential equations for time continuous Markov processes with a discrete state space;
- To solve differential equations for distributions and expectations in time continuous processes and determine corresponding limit distributions.

Course Contents:

Discrete Markov Chains; Classification of States; First Passage and Recurrence Times; Absorption Problems; Stationary and Limiting Distributions; Chapman-Kolmogorov Equations; Long Run Behavior of Markov Chains; Absorption Probabilities and Expected Times to Absorption; Statistical Aspects of Markov Chains; The Mover-Stayer Model; Application of a Markov Chain and Mover-Stayer Model to Modeling Repayment Behavior of Bank Loans' Grantees. Markov Processes in Continuous Time: Poisson Processes, Birth-Death Processes; Poisson Process the Kolmogorov Differential Equations; Limiting Behavior of Continuous Time Markov Chains the Q Matrix; Forward and Backward Differential Equations: Imbedded Markov Chain; Stationary Distribution. Renewal Theory; Brownian Motion and its Generalizations; Discrete Time Martingales; Conditional Expectation; Definition of a Martingale and Examples: Optional Stopping Theorem; Stochastic Calculus.

Recommended Books:

1. Introduction to Probability Models, 11th Ed, Sheldon M. Ross, Academic Press 2014.
2. Essentials of stochastic processes, Durrett, Richard. Springer Science & Business Media, 2nd Ed. 2012.
3. Introduction to Stochastic Processes, 2nd Ed, G.F. Lawler, Chapman and Hall, Probability Series, 2006.

Course Code: CSC 538 **Pre-Requisite:** None

Course Title: Data Exploration and Visualization

Credit Hours: 3(3, 0)

Course Objectives:

- Understand how fundamental principles of design and human cognition inform effective visualizations;
- Compare methods for visualizing data and understand how these different methods might guide users towards different conclusions;
- Develop a toolkit for exploring and communicating complex data using visualizations;
- Construct interactive visualizations for the web using D3 and other popular platforms
- Utilize popular visualization applications;
- Expose the students to different data domains.

Course Contents:

In this course students will learn the fundamental principles of exploring and presenting complex data, both algorithmically and visually. We will cover systems infrastructure for collating large data, basic visualization of summary statistics, algorithms for exploring patterns in the data (such as rule-mining, graph analysis, clustering, topic models and dimensionality reduction), and artistic and cognition aspects of data presentation (including interactive visualization, human perception, decision-making). Domains will include numeric data, relational data, geographic data, graphs and text. Tools and technologies available for data visualization. Principles of the visual presentation of data. Survey of Information Visualization, Scientific Visualization, and Visual Analytics. Design and evaluation of visualizations and interactive exploration tools. Introduction to relevant foundations in visual design, human perception, and data analysis. Encodings, layout and interaction. Approaches to large data sets. Visualization of complex data types such as scalar fields, graphs, sets, texts, and multi-variate data. Use of 2D, 3D and motion in data presentations. Implementation issues

Recommended Books:

1. Visualization Analysis and Design (AK Peters Visualization Series), Munzner, T., CRC Press, 2014.

Course Code: CSC 541 **Pre-Requisite:** None

Course Title: Big Data Analytics

Credit Hours: 3 (3, 0)

Course Objectives:

- Introduce the concepts and the main algorithms used for Big Data analytics;
- Introduce the principles of the Hadoop;
- Enable the students to write and deploy efficient parallel algorithms to analyze Big Data sources for various applications.

Course Contents:

Topic includes: Alpha, Beta, Gamma and Delta Models for Collecting and Ingesting Data from various sources into the Big Data Analytics Infrastructure; Incorporating Distributed File Systems and Non-Relational (NoSQL) Databases for Data Storage; Processing Frameworks for Batch and Real-Time Analytics; Publish-Subscribe Messaging Frameworks (Kafka & Kinesis); Source-Sink Connectors (Flume); Database Connectors (Sqoop); Messaging Queues (RabbitMQ, ZeroMQ, RestMQ, Amazon SQS) and Custom REST; WebSocket and MQTT-Based Connectors; Batch and Real-Time Analysis; Interactive Querying Frameworks including HDFS, Hadoop, MapReduce, YARN, Pig, Oozie, Spark, Solr, HBase, Storm, Spark Streaming; Spark SQL; Hive; Amazon Redshift and Google BigQuery; Various machine learning algorithms with examples: The Spark MLlib and H2O Frameworks; Visualizations using frameworks such as Lightning, Pygal and Seaborn.

Recommended Books:

1. Big Data Analytics: Methods and Applications, Saumyadipta Pyne, B.L.S. Prakasa Rao, S.B. Rao, Springer, 2016.
2. Big Data Science & Analytics: A Hands-On Approach, Arshdeep Bahga, Vijay Madisetti, VPT, 2016.
3. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2015.
4. Big Data Analytics with Spark: A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Mohammed Guller, Apress, 2015
5. Big Data Analytics with R and Hadoop, Vignesh Prajapati, Packt Publishing Ltd, 2013.

Course Code: CSC 542 **Pre-Requisite:** None

Course Title: Deep Leaning

Credit Hours: 3 (3, 0)

Course Objectives:

- To discuss major deep learning algorithms, the problem settings, and their applications to solve real world problems;
- To familiarize graduate students with the current state-of-the-art in machine perception of images and sound using Deep Learning architectures;
- To Analyze and contrast broad classes of deep learning models (multilayer perceptrons vs ConvNets vs RNNs);
- To derive and implement Backprogation-based parameter learning and modern optimization techniques in deep learning models;
- Summarize and review state-of-art approaches in deep learning.

Course Contents:

Topics include: Theoretical Advantages of Deep Architectures: Architectures for Deep Neural Networks; Convolutional Neural Networks; Properties of CNN representations: Invertibility, Stability, Invariance; Deep Unsupervised Learning: Auto-Encoders (Standard, Denoising, Contractive), Variational Auto-Encoders, Adversarial Generative Networks, Maximum Entropy Distributions, Optimization Methods for Deep Neural Networks, Non-convex optimization for deep networks, Deep Reinforcement Learning; Deep Belief Networks. Recent Applications of Deep Learning (case studies).

Recommended Books:

1. Deep Learning: A practitioner Approach, Adam Gibson, Josh Patterson, O'Reilly Media, 2017.
2. Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016.
3. Learning Deep Architectures for AI: Foundations and Trends(r) in Machine Learning, Yoshua Bengio, Now Publishers Inc, 2009.

Course Code: CSC 630 **Pre-Requisite:** None

Course Title: Advanced Data Mining

Credit Hours: 3(3, 0)

Course Objectives:

- To teach the basic concepts of Data Mining;
- To teach Clustering, Association and Classification techniques;
- To enable the students to apply the different data mining techniques.

Course Contents:

This course provides both theoretical and practical coverage of all data mining topics. The topics include: Data; Classification: Basic Concepts and Techniques; Classification: Alternative Techniques; Association Analysis: Basic Concepts and Algorithms; Association Analysis: Advanced Concepts; Cluster Analysis: Basic Concepts and Algorithms; Cluster Analysis: Additional Issues and Algorithms; Anomaly Detection; Avoiding False Discoveries.

Recommended Books:

1. Introduction to Data Mining, Tan, P., Steinbach, M., Karpatne, A., & Kumar, V., Pearson, 2018
2. Data Mining: Practical Machine Learning Tools and Techniques, Witten, I. H. et al., Morgan Kaufmann, 2016.

Course Code: CSC 535 **Pre-Requisite:** None

Course Title: Natural Language Processing

Credit Hours: 3 (3, 0)

Course Objectives:

- To present the main models, formalisms and algorithms necessary for the development of applications in the field of natural language information processing.

Course Contents:

Course Orientation and Overview; 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.

Reference Books:

1. D. Jurafsky & J. Martin, Speech and Language Processig, Prentice Hall, 2nd ed., 2008.
2. Natural Language Processing and Information Retrieval. Tanveer Siddiqui, U. S. Tiwary. Oxford University Press. 2008.
3. Steven Bird.Natural Language Processing with Python. 2009, O'Reilly.

Course Code: CSC 635 **Pre-Requisite:** None

Course Title: Advanced Software Engineering

Credit Hours: 3(3, 0)

Course Objectives:

- To derive models of software systems and express them in a language such as UML;
- To understand the differences between different types of software architecture;
- To derive cost estimation tables delineating the tasks to be performed, and the cost, effort, and time involved for each task.

Course Contents:

The course aims to develop the broad understanding of the discipline of software engineering (gained in the earlier Software Engineering course) by considering the wider systems engineering context in which software plays a role. In this context the main topics covered in this course are: Software Process and its various Models and Standards (CMMI, ISO 9001); Software Architecture; Model Driven Engineering; Software Project Scheduling; Software Cost Estimation; Software Metrics; Software Performance.

Recommended Books:

1. Software Engineering, Ian Somerville, Pearson, 2015.
2. Refactoring: Improving the Design of Existing Code, Martin F., Kent B., John B., William O., D. Roberts, Addison-Wesley Professional, 1999.

Course Code: CSC 543 **Pre-Requisite:** None

Course Title: Formal Methods and Semantics

Credit Hours: 3(3, 0)

Course Objectives:

- To understand how formal methods help produce high-quality software;
- To discuss temporal specifications and model checking;
- To solve simple problems in semantic analysis;
- To explain different reduction methods such as Spin and Promela;
- To undertake guided research in topics in semantics.

Course Contents:

Introduction to Formal Methods and Specification; State-Based Formal Methods; Transformational Systems: Traditional Approaches: Z specification; Formal Development Cycle; Temporal Specification: Reactive Systems. Syntax and Semantics of Temporal Logic, Temporal Specification of Reactive Systems (safety, aliveness, fairness). Model Checking: Generating Finite Models, Analysis of a Simple Model Checking Algorithm; Symbolic Model Checking; Overview of Reduction Methods; Spin and Promela; Case study and practical verification of properties; Current research topics based on Formal Methods.

Recommended Books:

1. Z: An Introduction to Formal Methods by Antoni Diller, 2nd Edition, John Wiley & Sons, Inc..
2. Research papers, Additional books and documents, will be used to cover the topics.

Course Code: CSC 544 **Pre-Requisite:** None

Course Title: Agile Software Development

Credit Hours: 3(3, 0)

Course Objectives:

- To demonstrate the ability to participate effectively in agile practices/process for software development;
- To explain the purpose behind common agile practices;
- To be able to apply agile principles, methods and values;
- To identify developments in current research topics in Agile Software Development.

Course Contents:

Agile values and principles. Agile Practices. Pair programming Refactoring. Test-driven development. Continuous integration and delivery. Automated build. Coding standards simplicity. SMART user stories and release and deployment. Applying Agile methods: Integration, XP+SCRUM, SCRUM +Kanban, Agile methods +User-Centered Design. Distributed Agile teams. Current research topics in Agile Software Development.

Recommended Books:

1. Learning Agile: Understanding Scrum, XP, Lean, and Kanban, Andrew Stallman and Jennifer Greene, O'Reilly Media, 2014.
2. Research papers, Additional books and documents, will be used to cover the topics.

Course Code: CSC 636 **Pre-Requisite:** None

Course Title: Advanced Software Architectures

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the role and applicability of methods for evaluating architectures;
- To describe inter-dependencies among quality-attributes and understand how they affect architecting;
- To assess an architecture quantitatively and qualitatively;
- To develop architectural models using ADLs, and understand the intentionality of models throughout the system life-cycle;
- To conduct incremental and multi-fidelity architecture-centric verification and validation;
- To understand the characteristics and challenges of architecting system-of-systems and ultra-large-scale systems;
- To understand difference between software architecture, system architecture, and run-time architectures.

Course Contents:

This course focuses on principles and methods that aid the designer/developer/architect to gain increased confidence in the architectural design. This includes Architectural Patterns; Qualitative and Quantitative Assessment of Architectures; Quantitative Modeling using Architecture Description Languages such as AADL and MARTE; Qualitative Architecture Evaluation Methods, e.g., ATAM. The course will also address the specific challenges related to Scale, Dynamics, and Heterogeneity as found in system of systems, and Ultra-large Scale Systems.

Recommended Books:

1. Software Architecture in Practice, Len Bass, Paul Clements, Rick Kazman, Addison-Wesley Professional, 2012.
2. Patterns of Enterprise Application Architecture, Martin Fowler, Addison-Wesley Professional, 2002.

Course Code: CSC 547 **Pre-Requisite:** None

Course Title: Game Theory

Credit Hours: 3(3, 0)

Course Objectives:

- To introduce the key models and solution concepts of non-cooperative and cooperative game theory;
- To introduce the issues that arise when computing with game theoretic solution concepts, and the main approaches to overcoming these issues, and to illustrate the role that computation plays in game theory;
- To introduce a research-level topic in computational game theory.

Course Contents:

This course aims to introduce the key concepts of game theory for a computer science audience, emphasizing both the applicability of game theoretic concepts in a computational setting, and the role of computation in game theoretic problems. The Topics includes: Preferences, Utility, and Goals; Strategic Form Non-Cooperative Games; Iterated Games; Extensive Form Non-Cooperative Games; Cooperative Games; Social Choice.

Recommended Books:

1. Game Theory, Michael Maschler, Eilon Solan, Shmuel Zamir, Cambridge UP, 2013.
2. Computational Aspects of Cooperative Game Theory, G. Chalkiadakis, E. Elkind, and M. Wooldridge, Morgan & Claypool, 2011.

Course Code: CSC 545 **Pre-Requisite:** None

Course Title: Usability and Interaction Design

Credit Hours: 3(3, 0)

Course Objectives:

- To provide knowledge of the technical, cognitive, and social factors that can make interactive software effective;
- To understand the methods, benefits, and limitations of a range of user-centered design approaches;
- To identify user needs and specify requirements for new interactive systems;
- To establish techniques to plan, construct and evaluate paper and digital prototypes.

Course Contents:

This course explores the current theory and practice of interface design and usability and examines ways in which to identify and focus upon the needs of the user. The following aspects of topics will be covered: Theoretical Foundations: Theories of Human-Computer Interaction, User Characteristics, and User Experience: User Interfaces (e.g., mobile, web, and wearable interfaces); Usability and User Experience: User-Centered Design, User Needs Analysis, Participatory Design, and Usability Evaluation.

Recommended Books:

1. Microinteractions: Designing with Details, Dan Saffer, O'Reilly Media, 2013.
2. About Face 3: The Essentials of Interaction Design, Alan Cooper, Robert Reimann, David Cronin, John Wiley & Sons, 2007.
3. Designing Interfaces: Patterns for Effective Interaction Design, Jenifer Tidwell, O'Reilly Media, 2005.

Course Code: CSC 548 **Pre-Requisite:** None

Course Title: Optimization Techniques

Credit Hours: 3(3, 0)

Course Objectives:

- To formulate problems in science and engineering as optimization problems;
- To describe and explain the principles behind algorithms covered in the course;
- To apply basic concepts in optimization, such as convexity, basic solutions, extreme values, duality, convergence rate, Lagrangian, KKT conditions;
- To choose appropriate numerical method for different classes of optimization problems using the methods advantages and limitations as a starting-point.

Course Contents:

This course provides basic concepts, theory, models and solution methods for optimization. The major topics include: Examples of Applications and Modeling Training; Basic Concepts and Theory for Optimization; Convexity and Optimality; Optimality Condition for Unlimited Optimization; Numerical Methods for Unlimited Optimization: Newton's Method, Steepest Descent Method, and Quasi-Newton Methods; Methods to Guarantee Descent Directions; Line Search; Non-Linear Least Squares Methods (Gauss-Newton); Optimality Condition for Optimization with Constraint (KKT condition); Introduction to Methods for Optimization with Constraints: Penalty and Barrier Methods, Simplex Method; Duality and Complementarity.

Recommended Books:

1. Optimization in Operations Research, Ronald L. Rardin, Pearson, 2016.
2. Linear and nonlinear optimization, Griva, Igor. Nash, Stephen, Sofer, Ariela, Philadelphia: Society for Industrial and Applied Mathematics, 2009.

Course Code: CSC 702 **Pre-Requisite:** None

Course Title: Advanced Computer Graphics

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the basics of geometry processing;
- To understand and work with advanced rendering methods such as radiosity;
- To design programs for advanced animation methods.

Course Contents:

The major topics in this course includes: Basic and Advanced Modeling; Scan Conversion for Photorealistic Rendering; Ray Tracing, Radiosity and related methods; Particle-based Methods; Physical Modeling: Water and Fire; Discrete Differential Geometry; Curves, splines, NURBS; Quaternions for Computer Graphics; Computational Geometry; Non-Photorealistic Methods; Volume Rendering and Constructive Solid Geometry; Gaming and Simulation.

Recommended Books:

1. Programming 3D Applications with HTML5 and WebGL, Tony Parisi, O'Reilly Media, 2014.
2. OpenGL Programming Guide, Dave Shreine, Adisson Wesley, 2013.
3. Fundamentals of Computer Graphics, Erik Reinhard, Kelvin Sung, and others, O'Reilly Media, 2002.

Course Code: CSC 549 **Pre-Requisite:** None

Course Title: High Performance Computing

Credit Hours: 3(**3, 0**)

Course Objectives:

- To introduce the use of high-performance computing systems in science and engineering;
- To design and implement efficient parallel programs high-performance computers;
- To understand the current state-of-the art in parallel programming environments, portable software libraries and program development.

Course Contents:

The purpose of this course is to introduce computing systems, software, algorithms, and methods used to solve large-scale problems in science and engineering. Topics mainly covered in this course are: Parallel Programming Models: Shared Memory (Work/Depth, PRAM); Sorting, Searching, Selecting, Merging; Dense and Sparse Linear Algebra; Discrete Algorithms; Trees, Graphs (coloring, partitioning, traversal); Numerical Algorithms; Butterfly Algorithms (FFT); Domain Decomposition; Multigrid; N-body Algorithms and Programming APIs: Shared-memory (OpenMP and PThreads); Distributed memory (message passing, MPI); GPUs (CUDA/OpenCL).

Recommended Books:

1. Introduction to High Performance Scientific Computing, V. Eijkhout et al, Creative Commons, 2015.
2. Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press, 2011.
3. Applied Parallel Computing, Y. Deng, World Scientific, 2011.

Course Code: CSC 550 **Pre-Requisite:** None

Course Title: Professionalism in Computer Science

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:

The course is titled Professionalism in Computer Science which focuses on social and professional issues. This course mainly includes: Professional Ethics; Privacy; Freedom of Speech; Intellectual Property; Crime; Safety; Human Needs; Innovation; Entrepreneurship; Communications; Career Planning; IEEE CS/ACM Code of Ethics and Professional Practice.

Recommended Books:

1. Ethics in Information Technology, Reynolds, G., Cengage, 2014.
2. Ethical and Social Issues in Information Age, Kizza, J. M., Springer, 2013.

Course Code: CSC 551 **Pre-Requisite:** None

Course Title: Data Compression

Credit Hours: 3(3, 0)

Course Objectives:

- To define and understand compression as an example of representation;
- To understand the idea of lossless and lossy compression;
- To understand the most common file formats for image, sound and video;
- To distinguish the basic techniques of lossless compression.

Course Contents:

The course provides an overview of classical and modern techniques and algorithms of various types of data compression. The major topics includes: Introduction to Information theory: Entropy, Information Value, Data Redundancy; Statistical Methods: Shannon-Fano Algorithm, Huffman Algorithm, Adaptive Huffman Coding; Statistical Methods: Arithmetic Coding (Encoding, Decoding, Adaptive Coding); Dictionary Methods: LZ77, LZ78, LZW Algorithms; Image Compression: Discrete Cosine Transform, JPEG; Wavelet Methods: Discrete Wavelet Transform, JPEG 2000; Video Compression: Motion Compensation, Temporal and Spatial Prediction, MPEG and H.264; Audio Compression: Digital Audio, WAVE, FLAC, MPEG-1/2 Audio Layers.

.Recommended Books:

1. Introduction to data compression, Khalid Sayood, Morgan Kaufmann, 2013
2. Handbook of Data Compression, Salomon, David, Motta, Giovanni, Springer, 2010.
3. JPEG2000 Standard for Image Compression: Concepts, Algorithms and VLSI Architectures, Tinku Acharya Ping-Sing Tsai, John Wiley & Sons, 2005.

Course Code: CSC 552 **Pre-Requisite:** None

Course Title: Multicore and GPU Programming

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the multicore and GPU architectures;
- To write or rewrite the code for multicore and GPU architectures;
- To understand parallel algorithms and data structures;
- To know general principles for parallel computing and techniques for parallelization.

Course Contents:

The major topics in course are: Introduction to Multi-core; Many-core and GPU Architecture Concepts; Theory of Parallel Computing; Theory of Parallelization; Design and Analysis of Parallel Algorithms; Survey of Parallel Programming Language Concepts; Thread Programming for Multicore Computing; SIMD-Programming and Data-Parallel Programming; GPU-Programming with OpenCL and/or CUDA; Non-Blocking Synchronization and Transactional Memory; Scheduling for Multicore and Operating System Issues; Introduction to Heterogeneous Multicore and Parallel DSP Architecture Concepts and Programming.

Recommended Books:

1. CUDA by example, J. Sanders, E. Kandrot, Addison-Wesley, 2011.
2. OpenCL Programming Guide, A. Munshi, B. Gaster, T. Mattsson, J. Fung, D. Ginsburg, Addison-Wesley, 2011.
3. Principles of Parallel Programming, Alan Cooper, C. Lin, L. Snyder, Addison Wesley, 2008.
4. The Art of Multiprocessor Programming, M. Herlihy and N. Shavi, Morgan Kaufmann Publishers, 2008.
5. Computer Architecture: A Quantitative Approach, J. Hennessy, D. Patterson, Morgan Kaufmann, 2007

Course Code: CSC 546 **Pre-Requisite:** None

Course Title: Information security

Credit Hours: 3(3, 0)

Course Objectives:

- To describe major information security issues and trends;
- To explain information security concepts and algorithms;
- To describe the basic process of risk assessment in the context of overall IT security management.

Course Contents:

The topics include: Fundamentals of information security; Computer security technology and principles; Access control mechanisms; Cryptography algorithms; Software security; Physical security; Security management and risk assessment; Regulations, Compliance, and Investigations.

Recommended Books:

1. Managing Information Security, John R. Vacca, Syngress, 2013.
2. All In One CISSP, Shon Harris, 2011

Course Code: CSC 634 **Pre-Requisite:** None

Course Title: Advanced Topics in Business Process Design & Intelligence

Credit Hours: 3(3.0)

Pre-requisites: None

Course Objectives:

- To provide complete understanding of process based execution of information systems.
- To learn how processes are re-engineered through business process management systems.
- To learn how organizational structure can be modeled using different process modeling technologies.
- To learn how a process model can be deployed.

Course Contents:

Business process reengineering, Business process management, Process identification, Essential of process modeling using business process modeling notations, Advanced process modeling, Process model discovery, Business process model repositories, Process matching, Business process abstractions Qualitative process analysis, Quantitative process analysis, Process redesign and improvements, Process automation and automation tools, Process Intelligence, Process Mining, Process Warehouse

Recommended books:

1. Marlon Dumas, Fundamentals of Business Process Management, Springer, 2018
2. Jan vom Brocke, Theresa Schmiedel, BPM - Driving Innovation in a Digital World, Springer, 2015
3. Wil M.P. van der Aalst, Process Mining Discovery , Conformance and Enhancement of business Processesby, Springer , 2011

Course Code: CSC 639 **Pre-Requisite:** None

Course Title: Advanced Topics in Software Requirement Engineering

Credit Hours: 3(3,0)

Pre-requisites: None

Course Objectives:

- To learn and apply practices of requirement elicitation, analysis, specification and validation for development of software products.
- To apply software requirement management techniques and tools on real projects
- To learn requirement management for agile and web based systems

Course Contents:

Good Practices for Requirement Engineering, Requirements Engineering Processes, Requirements Elicitation and Analysis, Role of stakeholders, Requirements Negotiation, Requirements Prioritization, Requirement Analysis and Modeling Approaches, Use Case Modeling, Natural Language Processing in Requirement Engineering, Requirement Specification Techniques and Tools, Goal Oriented Requirement Engineering, Requirements Verification and Validation, Requirements Management, Requirements Management Techniques and Tools, Requirements Traceability, Tools for Requirement Traceability, Requirement engineering for Agile methods, Requirement engineering for Web based Systems.

Recommended books:

1. Beatty, J. and Wiegers, Software Requirements, K. Microsoft Press, 2013
2. Laplante, P., Requirements Engineering for Software and Systems, Auerbach Publications, 2013.

Course Code: CSC 703 **Pre-Requisite:** None

Course Title: Advanced Topics in Geometric Modeling

Credit Hours: 3(3,0)

Pre-requisites: None

Course Objectives:

- To investigate methods for automatic analysis of 2D/3D data and its approximation as per required standards and applications.
- To apply geometric modeling concepts to generate challenging realistic scenes and tasks.
- To explore advanced geometric modeling techniques for the solution of industrial problems and research issues.

Course Contents:

The course covers geometry representations, algorithms, and the underlying theoretical framework, essential to solving geometric problems encountered in these application areas. The topics include: (1) geometric representation and transformation of objects, (2) curve and surface representation, (3) geometric algorithms and operations on curves and surfaces, and (4) project on research issues or real-world problems in geometric modeling.

Recommended books:

1. Farin Gerald, Curves and Surfaces for CAGD, A Practical Guide, Morgan-Kaufmann, 2002.
2. Mortenson M. E., Geometric Modeling, Industrial Press, Inc., 2006.
3. Farin Gerald, Hansford Dianne, The Essentials of CAGD, A K Peters, 2000.
4. Hoschek Josef, Lasser Dieter, Fundamentals of Computer Aided Geometric Design (Translation by L.L. Schumaker), A. K. Peters, Wellesley, 1993.

Course Code: CSC 539 **Pre-Requisite:** None

Course Title: Text Processing

Credit Hours: 3(3, 0)

Pre-requisites: None

Course Objectives:

- To explain Linguistic and mathematical techniques well-suited for text processing.
- To implement text processing tasks and systems
- To analyze large volumes of textual data

Course Contents:

Topics include: Programming for text processing, Linguistic and mathematical background, Text processing, topics, such as: Author Profiling, Semantic Analysis, Information Retrieval, Automatic Summarization. Single document and multi-document summarization, Extractive and abstractive summaries, Summarization techniques (TextRansk, LEAD, RANDOM etc.), Evaluating quality of system generated summaries using ROUGE, Text Processing, Machine Translation, Machine Translation using different techniques.

Recommended Books:

1. Daniel Jurafsky and James Martin "Speech and Language Processing", 3rd Edition, Prentice Hall, 2018.
2. David Mertz, Text Processing in Python, Addison-Wesley Professional; 1 edition, 2003.