MS (Computer Science) - 2020

Program Learning Outcomes (PLOs)

Computing programs prepare students to attain educational objectives by ensuring that students demonstrate achievement of the following outcomes (derived from NCEAC-HEC curriculum).

No.	Program Learning Outcomes (PLOs)	Computing Professional Graduate
1.	Knowledge for Solving Computing Problems	Students will be able to possess advanced knowledge of Computer Science field
2.	Creative thinking	Students will be able to think creatively and critically; to solve non-trivial problems
3.	Design/Development of Solutions	Students will be able to use computing knowledge to develop efficient solutions
4.	Research Activities	Students will be able to design solutions and can conduct research related activities

MS (Computer Science) Core Courses

CS-701	ADVANCED ANALYSIS OF ALGORITHM		3(3-0)
Learning Objectives			
• To analyze the asymptotic performance of algorithms. • To describe rigorous correctness proofs for algorithms. • To demonstrate a familiarity with major algorithms and data structures.			
Learning Outcomes			
At the end of the course the students will be able to:	**Domain**	**BT Level***	**PLO**
• Analyze simple algorithms and determine their complexities	C	4,5	2
• Explain the major graph algorithms and their analyses. Employ graphs to model engineering problems	C	3	2
• Explain what competitive analysis is and to which situations it applies. Perform competitive analysis.	C	3	4
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain			
SDGS addressed in the course:	9 (Industry, Innovation, and Infrastructure)		
Teaching Mode: the course will be taught in hybrid learning mode offering a substantial portion of contents and course activities online through learning management system			
Course Contents			
Theory			
Advanced algorithm analysis including the introduction of formal techniques and the underlying mathematical theory. NP-completeness; Search Techniques; Randomized Algorithms; Heuristic and approximation algorithms; Asymptotic analysis of upper and average complexity bounds using big-o, little-o, theta notation; Fundamental algorithmic strategies (brute -force, greedy, divide-and conquer, backtracking, branch-and-bound, pattern matching, numerical approximations, standard graph and tree algorithms); Standard complexity classes, time and space tradeoffs in algorithm using recurrence relations to analyze recursive algorithms; Non-computable functions, halting problem, implications of non-computability; Algorithmic animation is used to reinforce theoretical results.			
Teaching Methodology:			
Lectures, Written Assignments, Practical labs, Semester Project, Presentations			
Course Assessment:			
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam			
Textbook 1. Atallah, M. J. 2000. Algorithms and Theory of Computation Handbook, 2nd Ed. CRC Press, USA.k:			
Suggested Readings:			

1. Cormen, T. H, C. E. Leiserson, R. L. Rivest and C. Stein. 2001. Introduction to Algorithms. 2nd Ed. MIT Press, London, UK.
2. Goodrich, M. T. and R. Tamassia. 2008. Data Structures and Algorithms in Java. 5th Ed. Addison -Wesley, NY, USA.
3. Levitin, A. 2012. Introduction to the Design & Analysis of Algorithms. 3rd Ed. Pearson, Boston Mass, London, UK.
4. Vazirani, V. V. 2004. Approximation Algorithms. 2nd Ed. Springer, NY, USA.

CS-702	ADVANCE THEORY OF AUTOMATA	3(3-0)

Learning Objectives

The course introduces concepts in automata theory and theory of computation. Identify different formal language classes and their relationships

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Analyze simple computing problems	C		2
• Devise suitable algorithmic solutions and code these algorithmic solutions in a computer programming language.	C		2
• Develop maintainable and reusable solutions using the object-oriented paradigm	C		4

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

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

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

Course Contents

Theory

Automata theory; Language definitions preliminaries; Regular expressions/Regular languages; Finite automata (FAs); Transition graphs (TGs); Kleene's theorem; Turing machines; Post machine; Variations on TM, TM encoding; Universal Turing Machine; Context sensitive grammars; Computability theory and reducibility; Computational complexity; Determinism; Non-deterministic, time hierarchy, space hierarchy; NP completeness.

Teaching Methodology:

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

Course Assessment:

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

Textbook

1. Cohen, D.I.A. 1991. Introduction to Computer Theory. 2nd Ed. John Wiley and Sons, NY, USA

Suggested Readings:

1. Hopcroft, J.E. and D. U. Jeffrey. 2008. Introduction to Automata Theory, Languages, and Computation. 3rd Ed. Pearson Education, India.
2. Peter, L .2016. An Introduction to Formal Languages and Automata. 6th Ed. Jones & Bartlett Learning, Burlington, MA, USA.
3. Rich, E.A.2008. Automata, Computability and Complexity: Theory and Applications. Prentice Hall, Upper Saddle River, NJ, USA.

4. Sipser, M. 2012. Introduction to the Theory of Computation. 2nd Ed. Cengage Learning, Delhi, India

CS-703	THEORY OF PROGRAMMING LANGUAGES	3(3-0)

Learning Objectives

- To study **programming language** constructs and features.
- To experience a diverse range of **programming languages**, constructs, and implementation issues
- To introduce students to **programming language theory**

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
understating the underlying theory of programming languages	C	1	2
• Enable a student to choose the appropriate Language for a Project	C	2	2
• Learning of formal semantics design for a programming Languages	C	2	4

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

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

Course Contents

Theory

Introduction; Models of computation, syntax and semantics, pragmatics, language design Principles; Syntax and Semantics; Context-free grammars; Regular expressions, attribute grammars and static semantics; Algebraic semantics, axiomatic semantics and denotational semantics; BNF grammars and syntax; Operational equivalence; Abstraction and generalization; Expressions, assignment statement, and control structures; Functional programming; The lambda calculus; Operational semantics; Reduction order; Recursive functions, logic Programming, inference engine and Concurrency.

Teaching Methodology:

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

Course Assessment:

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

Textbook

1. Robert W. Sebesta. 2012. Concepts of Programming Languages 10th edition. Pearson. Upper Saddle River, USA.

Suggested Readings:

1. Bradley, J. C. and A.C. Millspaugh. 2014. Programming in C# .NET. McGraw Hill, New York City, NY, USA.

2. Deitel, H. and P. Deitel. 2010. Visual C# How to Program. Prentice Hall Press. Upper Saddle River, NJ, USA.
3. Foxall, J. 2015. Visual basic in 24 hours. Sams Publishers, Carmel, IN, USA.
4. Hanly & Koffman. 2009. Problem Solving and Program Design in C, 6th edition. Addison- Wesley. Boston, MA, USA

CS-704	ADVANCED OPERATING SYSTEMS	3(3-0)

Learning Objectives

The students will learn about advanced OS concepts, design and internal processes

Learning Outcomes

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

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

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

Course Contents

Theory

Characterization of Modern Operating Systems; File systems; Memory management techniques; Process scheduling and resource management; System Models Architectural models; Inter-process Communication; Issues of Security in Distributed Systems (Partial coverage); Distributed file system; Concurrency control in distributed systems; Problems of coordination and agreement in distributed systems; Replication advantages and requirements, fault-tolerant services; Mobile and ubiquitous computing

Teaching Methodology:

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

Course Assessment:

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

Textbook

1. Achyut, S.G and A. Kahate. 2011. Operating Systems. 3rd Ed. Tata McGraw-Hill, New Delhi, India

Suggested Readings:

1. Mehmood, T. and I. Saeed. 2005. A Comprehensive study of Operating systems & Networks, IT Series, Publication, Pakistan.
2. Wang, K. C. 2017. Embedded and Real-Time Operating Systems, Springer, WA, USA.
3. Ulrich, W. 2012. Quantum Dissipative Systems. 4th Ed. World Scientific Publisher, Singapore.
4. Raggo, M.T and C. Hosmer. 2013. Data Hiding Exposing Concealed Data in Multimedia, Operating Systems, Mobile Devices and Network Protocols. Syngress, Waltham, MA, USA.

CS-705	ADVANCED COMPUTER ARCHITECTURE	3(3-0)

Learning Objectives

This course is concerned with

- the structure and behaviour of the various functional modules of the computer.
- how they interact to provide the processing needs of the user.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Understand functionality of major components of a computer system like CPU, control unit, memory, I/O and storage.	C	2	2
• Understand principles of instruction set design including RISC architectures and basic assembly programming	C	4	2
• Understand pipelining and parallelism features applied in single processor, multiple processors, and multicore architectures	C	4	2

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

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

Course Contents

Theory

Hardware aspects of parallel computer architectures, design and protocols evaluation for memory coherence; Inter-connection networks and system scalability; Multiprocessors on a chip, reconfigurable, computing and power aware designs; Various coarse-grained and fine grained architectures with reference to SIMD and MIMD designs.

Teaching Methodology:

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

Course Assessment:

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

Textbook

1. Behrooz. P. 2005.Computer Architecture: From Microprocessors to Supercomputers, Oxford University Press, NY, USA

Suggested Readings:

1. Govindarajalu, B.2010. Architecture and Organization, Design Principles and Application. 2nd Ed. Mcgraw hill, New Delhi, India.
2. Hwang, K. and X. Zhiwei. 2005. Scalable Parallel Computing Technology, Architecture Programming, McGraw Hill, USA.
3. Hennessy, J. L. and D.A, Patterson. 2011. Computer Architecture: A Quantitative Approach. Elsevier, MA, USA.
4. William, B. and A. Wilson. 2001. Advanced PC Architecture. Prentice Hall, USA.

MS (Computer Science) Elective Courses

CS-706	RESEARCH METHODOLOGY	3(3-0)

Learning Objectives

This course is designed to enable students to:

- Identify and discuss the role and importance of research.
- Identify and discuss the issues and concepts salient to the research process.
- Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project.
- Identify and discuss the concepts and procedures of sampling, data collection, analysis, and reporting.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Understand** some basic concepts of research and its methodologies	C	2	1
• **Select** and define appropriate research problem and parameters	C	3	3
• **Identify** appropriate research topics.	C	3	4

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

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

Course Contents

Introduction to research; Objectives of research; Importance of research methodology in research study; Types of research; Steps in conducting research; What is literature review; Why need for literature review; Types of literature review; Systematic literature review protocol; Problem statement and problem formulation; Criteria for selecting a problem; Identifying types of variables in research; Types of hypothesis; Identifying target population; Types of sampling; Sampling techniques; Quantitative research methods; Scientific methods; Design of quantitative surveys; Techniques to conduct quantitative methods; Introduction to qualitative research; Qualitative research methods; Data analysis and theory in qualitative research articles; Introduction to mixed methods research; Design of mixed methods research; Evaluation of mixed methods research; Case study: How to conduct a case study, case study protocol; Importance and benefits of case study; types of statistical tests to conduct data analysis; Data analysis tools; Introduction to SPSS; Hands on practice of SPSS; How to define variables in SPSS; How to record collected data in SPSS; Types o Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam f tests via SPSS including regression; Correlation;

Cross tabulation and others; How to write good research proposal; Contents of thesis; Important elements of research thesis.
Teaching Methodology:
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Textbook: 1. Bazeley, P. and K. Jackson. 2014. Qualitative Data Analysis with NVivo. 2nd Ed. SAGE, Lose Angeles CA. USA.
Suggested Readings
1. Creswell, J. W. 2018. Qualitative Inquiry and Research design: Choosing among Five Approaches. 5th Ed. SAGE, Publications Inc, CA, USA. 2. Rajendra, K. 2012. Research methodology, APH Publishing Corporation. New Delhi, India. 3. Rugg, G. 2006. A Gentle Guide to Research Methods. 2nd Ed. McGraw-Hill, London, UK 4. Creswell, J. W. and J. D. Creswell. 2017. Research design: Qualitative, Quantitative and Mixed Methods Approach. 4th Ed. Thousand Oaks, CA, USA.

CS-707	ADVANCED NETWORKING	3(3-0)

Learning Objectives

This course is designed to enable students to:

- Enumerate the layers of the OSI model and TCP/IP. Explain the function(s) of each layer
- Familiarity with the basic protocols of computer networks, and how they can be used to assist in network design and implementation
- Understand and building the skills of subnetting and routing mechanisms
- Differentiate between different LAN-based forwarding devices so that they can make thoughtful suggestions on how to build a network.

Learning Outcomes

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Describe** the key terminologies and technologies of computer networks	C	2	1
• **Explain** the services and functions provided by each layer in the Internet protocol stack	C	2	1
• **Identify** various internetworking devices and protocols, and their functions in a network	C	4	2
• **Analyze** working and performance of key technologies, algorithms and protocols	C	4	2

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

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

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

Course Contents:

Review of basic concepts; The OSI Model, packet and circuit switching; Network topology; ISDN; The TCP/IP protocol stack, IP, ARP, TCP, UDP,DNS, ICMP; Internet Addressing, routing, IP multicast, RSVP; Next generation IP ping; Wireless: radio basics; Satellite systems, WAP; Current trends; Issues with wireless over TCP; Congestion control; Control vs. avoidance; Algorithms; Congestion in the internet; Mobile IP; Voice over IP (VoIP); VPNs; Network Security; Management; Quality of service (QoS) ; Network vs. distributed systems management Protocols; Web-based management.

Teaching Methodology:

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

Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam

Textbook:

1. Coulouris, D. and G. Kindberg. 2004. Distributed Systems – Concepts and Design, Pearson education. Boston, MA, USA

Suggested Readings

1. George, C., J. Dollimore, T. Kindberg and G. Blair. 2006. Distributed Systems Concepts and Design. 5th Ed. Academic Internet Publishers, UK.
2. James F.K. and K. W. Ross. 2017. Computer Networking a Top-Down Approach Featuring the Internet. 7th Ed. Pearson Education, Harlow, UK
3. Terry S. and B. Burton and W. Burton. 2000. Advanced IP Routing in Cisco Networks. Prentice Hall, USA.
4. William Stallings.2014. Data and Computer Communications, 6th Ed. Pearson Education, Harlow, UK.

CS-708	MACHINE LEARNING	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- To introduce students to the basic concepts and techniques of Machine Learning.
- To become familiar with regression methods, classification methods, clustering methods.
- To become familiar with Dimensionality reduction Techniques

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Describe** the key terminologies and technologies of computer networks	C	2	2
• **Explain** the services and functions provided by each layer in the Internet protocol stack	C	2	2
• **Identify** various internetworking devices and protocols, and their functions in a network	C	4	3

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

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

Course Contents:

Basic concepts of Machine Learning; Supervised learning; Supervised learning setup; Logistic regression; Perception; Generative learning algorithms; Gaussian discriminate analysis; Support vector machines; Model selection and feature selection; Evaluating and debugging learning algorithms; Learning theory; Bias/variance tradeoff; Union and Chernoff / Hoeffding bounds; Unsupervised learning; K-means Clustering; EM algorithm; Factor analysis; PCA (principal components analysis); ICA (independent components analysis); Reinforcement learning and control; Bellman equations; Value iteration and policy iteration; Linear quadratic regulation; Q-learning; Value function approximation

Teaching Methodology

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

Course Assessment:

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

Text Book:

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

Suggested Readings:

1. Bishop, C.2006. Pattern Recognition and Machine Learning, Springer-Verlag, NY, USA.

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

CS-709	CRYPTOGRAPHY	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Classify the symmetric encryption techniques
- Evaluate the authentication and hash algorithms
- Summarize the intrusion detection and its solutions to overcome the attacks.
- Basic concepts of system level security

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• System and hence be able to design a security solution.	C	1	1
• Identify the security issues in the network and resolve it.	C	2	2
• Evaluate security mechanisms using rigorous approaches, including theoretical	C	3	2

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

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

Course Contents:

Overview of cryptography, what is a cipher, one-time pad and stream ciphers, perfect secrecy and the one-time pad; Semantic security and stream ciphers; Block ciphers; Feistel networks, DES, 3DES, AES; Basic modes of operation; CBC and counter mode. Block cipher abstractions: PRPs and PRFs; Pseudo random permutations (PRP); Pseudo random functions (PRF); Security against chosen plaintext attacks (CPA); Nonce-based CBC encryption and nonce-based counter mode; Attacks on block ciphers, exhaustive search, time-space tradeoffs, differential & Linear cryptanalysis, meet in the middle, side channels; Message integrity: definition and applications; Collision resistant hashing; Authenticated encryption security against active attacks; Public key

encryption; RSA and Rabin functions; Digital signatures, definitions and applications hash based signatures; Certificates, certificate transparency, certificate revocation; Identification protocols; Authenticated key exchange and SSL/TLS

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Mollin, R. A. 2007. An Introduction to Cryptography. 3rd Ed. Chapman & Hall/CRC, Boca Raton, FL, USA.

Suggested Readings:

1. Douglas, R. Stinson. 2017. Cryptography. 2nd Ed. CRC Press, Boca Raton, FL, USA.
2. Schroeder, M. 2009. Number Theory in Science and Communication with Applications in Cryptography, Physics, Digital Information, Computing, and Self-Similarity.5th Ed. Springer, Berlin, Germany.
3. William, S. 2017. Cryptography and Network Security: Principles and Practice. 7th Ed. Pearson Prentice Hall, Boston, FL, USA.
4. William, B. 2017. Cryptography. 2nd Ed. River Publishers, Aalborg, Denmark.

CS-710	ADVANCED DATABASE SYSTEMS	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Understand the role of a database management system in an organization.
- Design and implement a small database project using Microsoft Access
- Be able to develop new methods in databases based on knowledge of existing techniques.
- Ability to apply acquired knowledge for developing holistic solutions based on database systems/database techniques.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Design and implement advanced queries using Structured Query Language	C	2	1
• To study the usage and applications of Object-Oriented database	C	2	2
• To acquire knowledge on variety of No SQL databases	C	2	2

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

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

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

Course Contents:

Advance normal forms; Multivalued dependency, 4th and 5th normal forms; Domain key normal form; Hierarchical structure of DBMS; Storage and file organization; Storage indexing and hashing; Relational calculus; Query processing transaction processing; ACID properties, Serializability, recoverability; Concurrency control and recovery; Protocols (Lock-based, Graph-based, timestamp-based, validation-based); Deadlock handling techniques and prevention; Log-based Recovery; Failure with loss of nonvolatile storage

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Connolly, R. and P. Begg. 2015. Database Systems: A Practical Approach to Design, Implementation and Management. 6th Ed. Addison-Wesley, N J, USA

Suggested Readings:

1. Elmasri, R and S. Navathe, 2011. Fundamentals of Database Systems, 6th Ed. Willey, Hoboken, NJ, USA.
2. Mustafa, T. and A.R. Sattar, 2010. Database Management System, IT Series Publications, Pakistan
3. Ramakrishnan R, and J. Gehrke. 2003. Databse Management System Concepts. 6th E. Willey, Hoboken, NJ, USA.
4. Silberschatz, A, HF. Korth and S. Sudarshan. 2010. Database System Concepts. 6th Ed. McGraw Hill, NY. USA

CS-711	BIG DATA ANALYTICS	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Big data analytics and machine learning approaches, which include the study of modern computing big data technologies and scaling up machine learning techniques focusing on industry applications.
- Conceptualization and summarization of big data and machine learning, trivial data versus big data, big data computing technologies, machine learning techniques, and scaling up machine learning approaches

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Provide fundamental information to get insight into the challenges with big data	C	1	1
• **Understand techniques for storing and processing large amounts of structured and unstructured data**	C	2	2
• **Apply** Application of big data concepts to get valuable information on market trends	C	3	2
• **Implement** and deploy a sample project for extracting useful information from a mid-sized dataset	C	4	2

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

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

Course Contents:

Introduction Hadoop and Map Reduce; Association Rules, frequent item sets and association rule mining, similar item sets and LSH; Near neighbor search in high dimensional data; Recommender systems, link analysis; Personalized PageRank, hubs and authorities; Web spam and trust Rank; clustering, descriptive analytics –clustering; Dimensionality reduction: SVD, Machine learning with massive datasets, Mining streaming data, Analysis of very large graphs, Time series data and streaming, Other application areas, Proximity search on Graphs: Random Walks with Restarts, Web Advertising

Teaching Methodology

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

Course Assessment:

Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book: **1.** Leskovec, J., A. Rajaraman and U. Jeff, 2011. Mining of Massive Datasets, 2nd Ed. Cambridge University Press
Suggested Readings:
1. Tom W.2003. Hadoop: The Definitive Guide, 4th Ed. O Reily Media, Sebastopol, CA, USA 2. Jimmy Lin and Chris, 2010. Data-Intensive Text Processing with Map Reduce, 3rd Ed. Morgan & Claypool, UK 3. Ramakrishnan,R. and J. Gehrke. 2003. Database Management Systems, 3rd Ed. Pearson Education, Boston, MA, USA. 4. Silberschatz, A., H.F. Korth and S. Sudarshan. 2010. Database System Concepts. 6th Ed. McGraw Hill, NY, USA

CS-712	COMPUTER VISION	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- To introduce students the major ideas, methods, and techniques of computer vision and pattern recognition
- To provide the student with programming experience from implementing computer vision and object recognition applications
- To develop an appreciation for various issues in the design of computer vision and object recognition systems

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• **Identify** basic concepts, terminology, theories, models and methods in the field of computer vision	C	1	3
• **Describe** basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition	C	2	3
• **Assess** which methods to use for solving a given problem, and analyse the accuracy of the methods •	C	3	3

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

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

Course Contents:

Concepts behind computer-based recognition and extraction of features from raster images; Applications of vision systems and their limitations; Overview of early, intermediate and high level vision; Segmentation; Region splitting and merging; Quad tree structures for segmentation; mean and variance pyramids; Computing the first and second derivatives of images using the isotropic, Sobel and Laplacian operators; Grouping edge points into straight lines by means of the hough transform; Limitations of the hough transform; Parameterization of conic sections; Perceptual grouping; Failure of the hough transform; Perceptual criteria; Improved hough transform with perceptual features; Grouping line segments into curves; Overview of mammalian vision; Experimental results of hubel and weisel; Analogy to edge point detection and hough transform; Relaxation labeling of images; Detection of image features; Grouping of

contours and straight lines into higher order features such as vertices and facets; Depth measurement in images.
Teaching Methodology
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book: 1. Forsyth, D. A. and P. Jean 2002. Computer Vision: A Modern Approach. 2nd Ed. Pearson Education, Harlow, UK
Suggested Readings:
1. Linda, G., S. George and C. Stockman. 2001. Computer Vision. Prentice Hall, Upper Saddle River, NJ, USA. 2. Nikos, P. C.Yunmei, O. F. Birkhäuser. 2006. Handbook of Mathematical Models in Computer Vision. Springer, Boston, MA, USA. 3. Parker. R., 2000. Algorithms for Image Processing and Computer Vision. Prentice Hall, NY USA. 4. Richard. S. 2010. Computer Vision, Algorithms and Applications. Springer, NY, USA.

CS-713	DEEP LEARNING	3(3-0)

Learning Objectives:

This course is designed to enable students to:

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

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Gain Knowledge about basic concepts of Deep Learning	C	2	2
• Identify Deep Learning techniques suitable for given problem.	C	3	2
• Solve the problems using various deep learning techniques.	C	3	4
• Apply Dataset analysis techniques.	C	3	2
• Design application using Deep Learning techniques.	C	3	2

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

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

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

Course Contents:

Introduction to Deep learning, Review of Linear classification (Multi-class Support Vector Machines, Soft max) and Regularization, Gradient Descent & Stochastic Gradient Descent (SGD), Back propagation (Intuitions, back propogation as flow graph), Introduction to Neural Networks (model of a biological neuron, activation functions, neural net architecture, representational power, etc.), Building Neural Networks (data preprocessing, loss functions, weight initialization, regularization, dropout, batch normalization), Learning Neural Networks (Learning and Evaluation gradient checks, sanity checks), Variants of SGD (momentum, Adagrad/RMSprop, ADAM), Introduction to Convolutional Neural Networks (CNN) and its components (Convolution and Pooling Layers), Convolutional Neural Network case studies (AlexNet/ZFNet/VGGNet), Understanding and Visualizing Convolutional Neural Networks, Convolutional networks for other visual Recognition Tasks (Localization, Detection, Segmentation, etc.), Transfer Learning and Fine-tuning Convolutional Neural Networks, Introduction to Natural Language Processing (NLP), Learning word and sentences embedding (wordvec, glove, sentvec), Introduction to recurrent networks (RNNs, LSTMS, etc.), Applications of Recurrent neural networks to different NLP tasks (e.g. sentiment analysis, parsing, NER tagging, etc.), Introduction to Reinforcement Learning and Q-Learning, Deep Q-Networks (DQN) and Game playing using DQN, Introduction to Policy gradients and their applications.

Teaching Methodology

Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book: 1. Deep Learning 1st Edition, Yoshua Bengio, lan Goodfellow, Aaron Courville, Neural Networks and Deep Learning 1st Edition, Michael A. Nielsen.
Suggested Readings:
1. Hands on Machine Learning with Scikit-Learn and Tensor Flow, 1st Edition, Aurelien Geron.

CS-714	NETWORK SECURITY	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Identify some of the factors driving the need for network security
- Define the terms vulnerability, threat and attack
- Compare and contrast symmetric and asymmetric encryption systems and their vulnerability to attack and explain the characteristics of hybrid systems.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Understand operation of wireless networks	C	2	2
• Emerging topics in computer networks	C	2	2
• A range of network architectures and protocols	C	2	2

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

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

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

Course Contents:

Introduction: Cryptology and simple cryptosystems; Conventional encryption techniques; Stream and block ciphers; DES; More on block ciphers; Advanced encryption standard; Confidentiality & message authentication; Hash functions; Number theory and algorithm complexity; Public key encryption; RSA and discrete logarithms; Elliptic curves; Digital signatures; Key management schemes; Identification schemes; Dial-up security; E-mail security; PGP; S-MIME; Kerberos and directory authentication; Emerging internet security standards; SET; SSL and IPSec; VPNs; Firewalls; Viruses.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Bishop, M. 2003. Computer Security: Art and Science. 2nd Ed. Addison-Wesley, Davis, USA

Suggested Readings:

1. .Charlie, K., R. Perlman and M. Speciner. 2002. Network Security: Private Communication in a Public World. 2nd Ed. Prentice Hall PTR, Upper Saddle River, NJ, USA.
2. Douglas, R. S. 2006. Cryptography: Theory and Practice. CRC Press, Boca Raton, FL, USA
3. Stallings, W. 2003. Cryptography and Network Security. 7th Ed. Prentice Hall PTR, Upper Saddle River, NJ, USA.
4. James, F. and W. K. Ross. 2002. Computer Networking – A Top-Down Approach Featuring the Internet, Addison Wesley, USA..

CS-715	ADVANCED REQUIREMENTS ENGINEERING	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- To understand requirements engineering process and apply it for elicitation, specification, modelling and analysis of software and system requirements.
- Understand the stakeholders involved in requirements engineering.
- Understand requirements engineering processes.
- Understand object-oriented and goal-oriented requirements engineering.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Understand of the importance of following a systematic requirement engineering process	C	2	2
• Effectively gather and analyze software requirements for the development of cost-effective and efficient technical solutions.	C	3	2
• Use system modeling techniques for requirements analysis and requirements presentation.	C	3	4

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

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

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

Course Contents:

Software Requirements Fundamentals: Product and process requirements, Functional and non-functional requirements, Emergent properties, Quantifiable requirements, System and software requirements. Requirements Process: Process models, Process actors, Process support and management, Process quality and improvement. Requirements Analysis: Requirements sources, Elicitation techniques. Requirements Analysis: Requirements classification, Conceptual modeling, Architectural design and requirements allocation, Requirements negotiation, Formal analysis. Requirements Specification: System definition document, System requirements document, Software requirements specification. Requirements Validation*:* Requirements reviews.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Software Engineering: A Practitioner's Approach, Roger S. Pressman, Bruce R. Maxim, 8th Ed, McGraw-Hill Education, 2015.

Suggested Readings:

1. Object-Oriented Analysis, Design and Implementation, Brahma Dathan, Sarnath Ramnath, 2nd Ed, Universities Press, India, 2014.
2. Software Modeling and Design: UML, Use Cases, Patterns, and Software Architectures, Hassan Gomaa, Cambridge University Press, 2011.
3. Applying UML & Patterns: An Introduction to Object-Oriented Analysis & Design and Iterative Development, Craig Larmen, 3rd Edition.
4. Head First Design Patterns, Eric Freeman, Elisabeth Freeman, Kathy Sierra and Bert Bates, O'Reilly Media, Inc., 2004.

CS-716	ADVANCED HUMAN COMPUTER INTERACTION	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Describe and apply user-centered design methods to conduct formative and summative evaluations.
- Explain and apply core theories and models from the field of HCI.
- Design and implement useful, usable, and engaging graphical computer interfaces.
- Discuss and critique research in the field of HCI.
- Describe special considerations in designing user interfaces for wellness.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Gain Knowledge about basic concepts of HCI Learning	C	2	2
• Identify HCI techniques suitable for given problem. w.r.t users & system.	C	3	2
• Solve the problems using various HCI techniques.	C	3	4

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

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

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

Course Contents:

Introduction to HCI. Importance of usable and useful software products. The theories of HCI. How to evaluate/develop software products. How to apply theoretical results from HCI research to software products. How to conduct their own research about aspects of usability and user experience. Concepts of Human Computer Interaction. The psychology of usable things. Usability Engineering. Prototypes. Usability inspection methods. Usability testing methods. Usability in practice. User Experience (UX). Web Usability. Mobile Usability. Mobile User Experience. Site objectives and user needs. Information architecture. Information and navigation design. Implementation and optimization. Experiments and HCI guidelines. Current research topics in Human-Computer Interaction.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. About Face: The Essentials of Interaction Design, Alan Cooper, Robert Reimann, David Cronin, Christopher Noessel, Wiley, 4th Edition, 2014.

Suggested Readings:

1. Dix,A., J. E. Finlay, G.D. Abowd and R. Beale. 2003. Human-Computer Interaction. 3rd Ed. Prentice Hall, Upper Saddle River, NJ, USA.
2. J. Preece, Y. Rogers, S. Holland, and T. Carey.1994. Human-Computer Interaction: Concepts and Design, 1st Ed. Addison Wesley, Boston, MA, USA.
3. Julie, A. J. 2012. Human-Computer Interaction Handbook Fundamentals. Evolving Technologies, and Emerging Applications. 3rd Ed. CRC Press, Boca Raton, FL, USA.
4. Yvonne, R., H. Sharp, and J.Preece. 2011. Interaction Design: Beyond Human - Computer Interaction, 3rd Ed. Addison Wesley, Boston, MA, USA.
5. Johnson, J. 2013. Designing With the Mind in Mind: Simple Guide to Understanding User Interface Design Guideline, Elsevier, Amsterdam, Netherlands.

CS-717	STATISTICAL METHODS IN COMPUTATIONAL SCIENCES	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- A solid foundation of computational statistics, which they will use in other courses and their research at SMU.
- Introduces some computational methods in statistics with emphasis on the usage of statistical software packages, statistical simulation, numerical methods, and related topics.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Use R and other statistical software to perform statistical analysis	C	2	2
• Use different methods to solve an optimization problem	C	3	2
• Use system modeling techniques for requirements analysis and requirements presentation.	C	3	4
• Apply some efficient computer algorithms in linear models	C	3	4

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

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

Course Contents:

Sampling and sampling designs for IT; Selection of best sample design; Procedure for planning and conduct of census and surveys in IT; Determination of sample size under different conditions using R; Test of significance for population proportion; Markov chain methods; perfect sampling, applications to Bayesian inference, Resampling Methods; bootstrapping, jackknife resampling; percentile confidence intervals, Non-parametric multiple comparisons; Multi-way contingency tables; Log-linear models logistic regression; Introduction to mixed methods research for in computational sciences.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Rizzo, M. L. 2008. Statistical Computing with R. Boca Raton, FL: Chapman & Hall/CRC Press. Boca Raton, FL, USA.

Suggested Readings:

1. Creswell, J.W. and V. L.P. Clark. 2011. Designing and Conducting Mixed Methods Research. Sage Publishers, CA, USA.
2. David,S. 2006. Practical Non-Parametric Statistics. CRC Press, Boca Raton, FL, USA.

3. Moser, C.A. and G. Kalton. 2001. Survey Methods in Social Investigation. Aldershot, Hants Burlington, VT Ashgate, UK.
4. Muhammad, F. 2015. Statistical Methods and Data Analysis. Kitab Markaz, Bhawana Bazar, Faisalabad, Pakistan.

CS-718	SEMANTIC WEB	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- To teach the students the concepts, technologies and techniques underlying and making up the Semantic Web.
- Understand the rationale behind Semantic web.
- Students should be able to model and query domain knowledge as ontologies defined using standards such as RDF and OWL.

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Understand the concept structure of the semantic web technology and how this technology revolutionizes the World Wide Web and its uses.	C	2	2
• Understand the concepts of metadata, semantics of knowledge and resource, ontology, and their descriptions in XML-based syntax and web ontology language (OWL).	C	3	2
• Describe logic semantics and inference with OWL.	C	3	4

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

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

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

Course Contents:

Introduction to the semantic web, introduction to ontologies, ontology languages for the semantic web, Resource Description Framework (RDF), lightweight ontologies: RDF Schema, Web Ontology Language (OWL), query language for RDF: SPARQL, Ontology Engineering, Semantic web and Web 2.0 and applications of Semantic Web.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Foundations of Semantic Web Technologies, Pascal Hitzler, Markus Krotzsch, Sebastian Rudolph,

Suggested Readings:

1. Anderson, R. and B. Francis. Beginning ASP. Wrox series Publications, Hoboken, NJ, USA.
2. Kappel, G., B. Proll, S. Reich and W. Retschitzegger. 2006. Web Engineering, 1st Ed, John Wiley & Sons, Hoboken, NJ, USA.
3. Build Flexible Applications with Graph Data, Toby Segaran, Colin Evans, Jamie Taylor,302 pages O'Reilly Media, 2009

4. Foundations of Semantic Web Technologies, Pascal Hitzler, Markus Krotzsch, Sebastian Rudolph
5. Introduction to the Semantic Web and Semantic Web Services, Liyang Yu, Chapman and Hall/CRC, 2007.

CS-721	COMPUTATIONAL ECONOMICS	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Introduce computational approaches for solving mathematical problems and economic models.
- Applying techniques to solve economic problems like growth models, optimal savings problem, and optimal taxation problems.
- Methods for solving dynamic optimization problems

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Learn the theory and practice of public finance.	C	1	
• Develop analytical skills and understanding from earlier economics courses by studying public finance topic.	C	2	
• Develop analytical and research experience and scholarly writing and presentation skills.	C	3	

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

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

Course Contents:

Introduction; Computational skills for economic analysis; Numerical analysis including root finding optimization, function approximation; Numerical dynamic programming; Representative agent models, infinite Horizon Ramsey Model, value function iteration and refinements, time iteration, projection methods; Stochastic recursive methods for economic growth models; Heterogeneous agent models without aggregate risk; Calibration; Sensitivity Analysis; Manipulate and represent data using tools (scatterplots and histograms).

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Kiusalaas, J. 2013. Numerical Methods in Engineering with Python3. Cambridge University press, NY, USA

Suggested Readings:

1. Miao, J. 2014. Economic Dynamics in Discrete Time. MIT Press, London, UK.
2. Miranda, M. J. and P. L. Fackler. 2004. Applied Computational Economics and Finance. MIT Press, London, UK.
3. Velupillai, K. V. 2012. Computable Foundations for Economics. 4th Ed. Relupillai, NY, USA.
4. Chen, S. H., M. Kaboudan, M. and Y. R. Du. 2018. The Oxford Handbook of Computational Economics and Finance, Oxford University Press, NY, USA.
5. Introduction to the Semantic Web and Semantic Web Services, Liyang Yu, Chapman and Hall/CRC, 2007.

CS-722	PROJECT EVALUATION AND ANALYTICS	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- Knowledge: Aquire a basic understanding of common terminology, principles and methods for planning and implementation of project evaluations.Develop indicators and targets for each result level
- Develop a comprehensive monitoring and evaluation plan
- Collect data using mobile data collection tools

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• To provide the student with fundamental knowledge about project evaluation and investment decisions within the institutional environments of health enterprises	C	2	2
• Design an evaluation study witk emphasize on methodology, focus and analytic standard.	C	2	2
• Scientific approach in overall analyses of projects	C	3	

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

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

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

Course Contents:

Introduction to project management; The project management and information technology context; The project management process groups; Project integration management; Project scope management; Project time management; Project cost management; Project quality management; Project human resource management; Project communications management; Project risk management; Project procurement management; Project management tools.

Teaching Methodology

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

Course Assessment:

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

Text Book:

1. Jack T. M. 2009. Information Technology Project Management, 3rd Ed. John Wiley & Sons. USA

Suggested Readings:

1. Joseph, P.2010. IT Project Management: On Track from Start to Finish by Phillips. 3rd Ed. McGraw-Hill Osborne Media, NY, USA.

2. Kathy.S.2010. Information Technology Project Management 4th Ed. Cambridge, Mass, London, UK.
3. Vanhoucke, M. 2012. Project Management with Dynamic Scheduling: Baseline Scheduling, Risk Analysis and Project Control, Springer, NY, USA.
4. Wysocki, R.K. 2011. Effective Project Management: Traditional, Agile, Extreme. 7th Ed. John Wiley & Sons, IN, USA.

CS-723	BUSINESS INTELIGENCE AND ANALYTICS	3(3-0)

Learning Objectives:

This course is designed to enable students to:

- To introduce students to the concepts, processes and practice of decision making at both individual and group levels in relation to the appropriate utilization of the ICT in today's organizations To provide an understanding of the senior management perspective regarding the use of business intelligence (BI) systems,
- To encourage students to consider the strategic use of BI technology for strategic advantage, and to provide practical understanding of the BI concepts and technologies in business organizations
- To encourage students to consider the strategic use of BI technology for strategic advantage, and to provide practical understanding of the BI concepts and technologies in business organizations

Learning Outcomes:

At the end of the course the students will be able to:	Domain	BT Level*	PLO
• Apply theoretical concepts of the course materials (e.g., textbook, journal articles, etc) to the decision-making and BI processes and technologies in order to prepare students for making appropriate managerial decisions in future real-life situations	C	2	2
• Undertake systematic investigation/research related to the decision support and BI systems and technologies for today's dynamic business environment	C	2	2
• Develop professional attitudes in students in relation to the teamwork, interpersonal communication, and business ethics	C	2	2

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

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

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

Course Contents:

Business intelligence introduction; BI environment; Business process and information flow; Data requirements analysis; Data warehouses and technical BI architecture; Data profiling; Business rules; Data quality; Data integration; Deriving insight from data; Knowledge discovery & delivery; BI user types and reports; Installations; Configuring and maintaining the BI server;

Creating repositories from relational sources; Creating repositories from OLAP data sources; Creating reports using answers and dashboards.
Teaching Methodology
Lectures, Written Assignments, Practical labs, Semester Project, Presentations
Course Assessment:
Sessional Exam Home Assignments, Quizzes, Project, Presentations, Final Exam
Text Book: 1. Brian, L.2016. Delivering Business Intelligence with Microsoft SQL Server 2016. 4th Ed. McGraw- Hill Education, London, UK
Suggested Readings:
1. Jeremy, K.M. 2012. Business Intelligence in Plain Language: A Practical Guide to Data Mining and Business Analytics. Applied Data Labs Inc, USA. 2. Robert, L. 2012. The Data Warehouse Mentor: Practical Data Warehouse and Business Intelligence Insights. 1st Ed. McGraw-Hill Companies, NY, USA. 3. Müller, R. M. and H.J.Lenz. 2013. Business Intelligence. 2nd Ed. Springer, Berlin, Germany. 4. Turban, E., R. Sharda and D. Delen.2011.Decision Support and Business Intelligence Systems. 9th Ed. Pearson Education, India.

CS-719 Seminar 1(1-0)

CS-720 Special Problem 1(1-0)

Open seminar to be delivered on some selected topics on latest technology challenges, issues and problems.

A detailed write-up/ report on some assigned topic in literature

CS-730 Research and Thesis 6(0-6)