Department of Computer Science

Curriculum of BS (Computer Science) Program

Approved by the Curriculum Review Committee

On: 11-05-2018

University of Engineering & Technology, Mardan

A: BS Computer Science Program Overview

BS in Computer Science is a four (4) years undergraduate program which will prepare the students to meet future challenges in computing and instil in them the ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings. To achieve this goal, the curriculum has been designed to provide a balanced mixture of theory and laboratory at foundation as well as advanced levels to make the graduate capable of sound professional decisions. The following is an overview of the proposed BS (Computer Science) program at University of Engineering & Technology, Mardan:

Duration:	4 Years
Number of Semesters:	8 semesters
Number of Weeks per Semester:	18 (16 for teaching and 2 for mid and final exams)
Total Number of Credit Hours:	130
Number of Credit Hours per Semester:	15(min) to 18(max)
Medium of Instruction:	English

B: Distribution of Courses

Major Area	Core (Credit Hours)	Electives (Credit Hours)	Credit Hours in each domain (Core+ Electives)	Percentage of Credit Hours
Computing	42	--	42	32.3%
Computer Science	24	15	39	30%
Computer Science Supporting	--	9	9	7%
Maths /Science Foundation	12	--	12	9.2%
General Education	16	12	28	21.5%
Total Credit Hours			**130**	**100%**

C: Detail of Courses Distribution in Each Domain

		Computing Core	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	CS-101	Introduction to Computing	2
2	CS-101L	Introduction to Computing Lab	1
3	CS-102	Programming Fundamentals	3
4	CS-102L	Programming Fundamentals Lab	1
5	CS-201	Discrete Structures	3
6	CS-104	Object Oriented Programming	3
7	CS-104L	Object Oriented Programming Lab	1
8	CS-202	Data Structures & Algorithms	3
9	CS-202L	Data Structures & Algorithms Lab	1
10	CS-303	Introduction to Software Engineering	3
11	CS-206	Database Systems	3
12	CS-206L	Database Systems Lab	1
13	CS-302	Operating Systems	3

14	CS-302L	Operating Systems Lab	1
15	CS-305	Computer Networks	3
16	CS-305L	Computer Networks Lab	1
17	CS-402	Information Security	3
19	CS-403	Final Year Project	6
Total Credit Hours in Computing Core:			**42**

		Computer Science Core	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	CS-301	Compiler Construction	3
2	CS-203	Computer Organization & Assembly Language	3
3	CS-203L	Computer Organization & Assembly Language Lab	1
4	CS-103	Digital Logic Design	3
5	CS-103L	Digital Logic Design Lab	1
6	CS-204	Design & Analysis of Algorithms	3
7	CS-401	Parallel & Distributed Computing	3
8	CS-304	Artificial Intelligence	3
9	CS-304L	Artificial Intelligence Lab	1
10	CS-205	Theory of Automata	3
Total Credit Hours in Computer Science Core:			**24**

		Computer Science Electives	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	CS-***	CS Elective-I	3
2	CS-***	CS Elective-II	3
3	CS-***	CS Elective-III	3
4	CS-***	CS Elective-IV	3
5	CS-***	CS Elective-V	3
Total Credit Hours in Computer Science Electives:			**15**

		Computer Science Supporting	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	BSI-231	Differential Equations	3
2	BSI-242	Numerical Analysis	3
3	CS-315	Graph Theory	3
Total Credit Hours in Computer Science Supporting Electives:			**9**

		Natural Sciences	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	BSI-122	Calculus	3
2	BSI-181	Applied Physics	3
3	BSI-111	Linear Algebra	3
4	BSI-351	Probability and Statistics	3
Total Credit Hours in Natural Sciences:			**12**

		General Education Core	
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	BSI-101	Islamic Studies	2
2	BSI-142	English Composition & Comprehension	3
3	BSI-143	Communication & Presentation Skills	3
4	BSI-110	Pakistan Studies	2
5	BSI-321	Professional Practices	3
6	CS-316	Technical Report Writing	3
Total Credit Hours in General Education:			**16**

General Education Electives			
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	BSI-***	General Education Elective-I	3
2	BSI-***	General Education Elective-II	3
3	BSI-***	General Education Elective-III	3
4	BSI-***	General Education Elective-IV	3
Total Credit Hours in General Education Electives:			**12**

D: List of Elective Courses in Each Domains

Computer Science Electives			
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	CS-306	Computer Vision	3
2	CS-307	Digital Image Processing	3
3	CS-308	Web Design & Development	3
4	CS-309	Computer Graphics	3
5	CS-310	Expert Systems	3
6	CS-311	Data Warehousing	3
7	CS-312	Artificial Neural Networks	3
8	CS-313	Fuzzy Logic Systems	3
9	CS-404	Web Engineering	3
10	CS-405	Fundamentals of Data Mining	3
11	CS-406	Mobile Application Development	3
12	CS-407	Computational Intelligence	3
13	CS-408	Multi Agent Systems	3
14	CS-409	Natural Language Processing	3
15	CS-410	Game Development	3
16	CS-411	Logical Paradigms of Computing	3
17	CS-412	Formal Methods	3
19	CS-413	Systems Programming	3
20	CS-414	Network Security	3
21	CS-415	Advanced Database Systems	3
General Education Electives			
S. No	**Course Code**	**Course Title**	**Credit Hours**
1	BSI-135	Psychology	3
2	BSI-304	Principles of Management	3
3	BSI-401	Human Resource Management	3
4	BSI-***	Economics	3
5	BSI-***	Sociology	3
6	BSI-***	English Literature	3
7	BSI-***	Organizational Behaviour	3
8	BSI-***	Accounting and Finance	3
9	BSI-***	Intellectual Property Rights	3

Note:
i. One credit hour is equal to 3 contact hours for Lab course and 1 contact hour for theory course.
ii. Elective courses in CS, CS Supporting and General Education domains will be selected in a semester from the list of elective in each domain based on the availability of instructor, market trend and fulfilling the required number of students' registrations.
iii. Codes to BSI-*** and CS-*** will be assigned by the Department according to the elective course selected.
iv. Theory and Lab are treated as separate courses.
v. Lab courses have "L" at the end of Course Code.

Scheme of Studies
BS (Computer Science)

1st Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-101	Introduction to Computing	2	2	Computing Core	None
CS-101L	Introduction to Computing Lab	1	3	Computing Core	None
CS-102	Programming Fundamentals	3	3	Computing Core	None
CS-102L	Programming Fundamentals Lab	1	3	Computing Core	None
BSI-142	English Composition & Comprehension	3	3	General Education	None
BSI-122	Calculus	3	3	Natural Sciences	None
BSI-181	Applied Physics	3	3	Natural Sciences	None
BSI-101	Islamic Studies	2	2	General Education	None
	Total Contact Hours	--	**22**		
	Total Credit Hours	**18**	--		

2nd Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-103	Digital Logic Design	3	3	CS Core(Breadth)	BSI-181
CS-103L	Digital Logic Design Lab	1	3	CS Core(Breadth)	BSI-181
CS-104	Object Oriented Programming	3	3	Computing Core	CS-102
CS-104L	Object Oriented Programming Lab	1	3	Computing Core	CS-102L
BSI-43	Communication & Presentation Skills	3	3	General Education	BSI-142
BSI-111	Linear Algebra	3	3	Natural Sciences	None
BSI-110	Pakistan Studies	2	2	General Education	None
	Total Contact Hours	--	**21**		
	Total Credit Hours	**16**	--		

3rd Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-201	Discrete Structures	3	3	Computing Core	None
CS-202	Data Structure & Algorithms	3	3	Computing Core	CS-104
CS-202L	Data Structure & Algorithms Lab	1	3	Computing Core	CS-104L
CS-203	Computer Organization & Assembly Language	3	3	CS Core(Breadth)	CS-102
CS-203L	Computer Organization & Assembly Language Lab	1	3	CS Core(Breadth)	CS-102L
BSI-321	Professional Practices	3	3	General Education	None
BSI-231	Differential Equations	3	3	CS Supporting/Natural Sciences	None
	Total Contact Hours	--	**21**		
	Total Credit Hours	**17**	--		

4th Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-204	Design & Analysis of Algorithms	3	3	CS Core(Breadth)	CS-202
CS-205	Automata Theory	3	3	CS Core(Breadth)	None
CS-206	Database Systems	3	3	Computing Core	CS-202
CS-206L	Database Systems Lab	1	3	Computing Core	CS-202L

BSI-351	Probability & Statistics	3	3	Natural Sciences	None
BSI-***	General Education Elective-I	3	3	General Education	None
	Total Contact Hours	--	**18**		
	Total Credit Hours	**16**	--		

5th Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-301	Compiler Construction	3	3	CS Core(Breadth)	CS-205
CS-302	Operating Systems	3	3	Computing Core	CS-202
CS-302L	Operating Systems Lab	3	3	Computing Core	CS-202L
CS-303	Introduction to Software Engineering	1	3	Computing Core	None
BSI-242	Numerical Analysis	3	3	CS Supporting/Natural Sciences	None
CS-315	Graph Theory	3	3	CS Supporting	None
	Total Contact Hours	--	**18**		
	Total Credit Hours	**16**	--		

6th Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-304	Artificial Intelligence	3	3	CS Core(Breadth)	CS-201
CS-304L	Artificial Intelligence Lab	1	3	CS Core(Breadth)	CS-201
CS-305	Computer Networks	3	3	Computing Core	None
CS-305L	Computer Networks Lab	1	3	Computing Core	None
CS-***	CS Elective-I	3	3	CS Elective (Depth)	++
CS-***	CS Elective-II	3	3	CS Elective (Depth)	++
CS-316	Technical Report Writing	3	3	General Education	None
	Total Contact Hours	--	**20**		
	Total Credit Hours	**17**	--		

7th Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-401	Parallel & Distributed Computing	3	3	CS Core(Breadth)	CS-302
CS-403a	Final Year Project-I	3	9	Design Project	None
CS-***	CS Elective-III	3	3	CS Elective (Depth)	++
CS-***	CS Elective-IV	3	3	CS Elective (Depth)	++
BSI-***	General Education Elective-II	3	3	General Education	None
	Total Contact Hours	--	**21**		
	Total Credit Hours	**15**	--		

8th Semester

Course Code	Course Title	Credit Hours	Contact Hours	Knowledge Area	Pre-Requisite
CS-402	Information Security	3	3	Computing Core	None
CS-403b	Final Year Project-II	3	3	Design Project	None
CS-***	CS Elective-V	3	9	CS Elective (Depth)	++
BSI-***	General Education Elective-III	3	3	General Education	None
BSI-***	General Education Elective-IV	3	3	General Education	None
	Total Contact Hours	--	**21**		
	Total Credit Hours	**15**			

Total Credit Hours: 130
Note: Codes to CS-*** and BSI-*** will be assigned to these courses according to the electives list.
++: Appropriate Pre-requisite will be defined by the department at the time of offering these courses.

1st Semester

CS-101 Introduction to Computing (2-3-3)
Prerequisite: None.

Course Objective:

After completing this course, the students will be able to:
- Understand the basic concepts of Computer and Number System.
- Understand the fundamentals of organization of the computer system and its hardware.
- Understand the fundamentals of Computer Software Architecture.
- Understand concepts of Basics of data communication.
- Understand the use of Internet as information publishing and retrieving tool.
- Understand the concepts of IT and communication technologies.

Course outline:

Introduction to IT, Computing & Communication, Understanding Computer, Peripheral Devices, Connectivity, Interactivity & Multimedia, Internet Access Devices and connecting medias, World Wide Web, Browsers & Search Engines, Application Software, Microsoft Office, Operating Systems History and Basics, Hardware Technology, System Unit, Storage Devices, Data Entry Devices, Output Devices, Digital Communication, Orientation with computers and Internet, DSL Connection and using email, Word Processing, Spread Sheet, Power Point, Communication Devices and Protocols used for Networking.

Text & Reference Books:

1. Computers by Larry Long and Nancy Long (11th Edition), ISBN-10:0131405810, Publisher Prentice Hall Publication , Year of Publication: 2003.
2. Introduction to Computers by Peter Norton (4th edition), ISBN-10: 0078210585, Publisher: Mcgraw-hill Professional, Publication Year: 2000.

CS-102 Programming Fundamentals (3-3-4)
Prerequisite: None.

Course Objective:

After completing this course, the students will be able to:
- Understand basic problem solving steps and logic constructs.
- Apply basic programing concepts.
- Design and implement algorithms to solve real world problems.

Course outline:

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

Text & Reference Books:
1. Starting out with Python, 4th Edition, Tony Gaddis. Publisher: Pearson; 4th edition (March 16, 2017), ISBN-13: 978-0134444321.
2. Starting out with Programming Logic & Design, 4th Edition, Tony Gaddis. Publisher: Pearson; 4 edition (February 26, 2015), ISBN-13: 978-0133985078.
3. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie. Publisher: Prentice Hall; 2 edition (April 1, 1988), ISBN-13: 978-0131103627.

4. The Waite Group's Turbo C Programming for the PC, by: Robert Lafore, SAMS series, ISBN13: 9780672226601 year of publication: 1988.
5. Introduction to Computation and Programming Using Python: With Application to Understanding Data, 2nd Edition by Guttag, John.
6. Practice of Computing Using Python, 3rd Edition by William Punch & Richard Enbody. Verlag: Pearson; Auflage: 3 (31. März 2016), ISBN-13: 978-0134520513
7. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel. Publisher: Pearson; 7 edition (Feb. 23 2012), ISBN-13: 978-0132990448
8. Problem Solving and Program Design in C++, 7th ,Edition by Jeri R. Hanly & Elliot B. Koffman. Publisher: Pearson; 7 edition (March 4, 2012), ISBN-13: 978-0132936491

BSI-142 English Composition & Comprehension (3-0-3)
Prerequisite: None

Course Objective:
After completing this course, the students will be able to:
- Practice English correctly in speaking and writing.
- Comply with complex English language texts.
- Exhibit sound vocabulary and skills to use English in professional life.
- Avoid common errors usually made by the learners of English as second language.

Course outline:
Composition: Vocabulary Building skills, Words & expressions commonly misused, Articles; their use, Prepositions; Prepositional phrases, Punctuations, Common Grammatical mistakes, Elementary Principles of Composition, Relative Pronouns & Clauses, Conditional Sentences & types, Adverbs & Adjectives; their forms & use.
Comprehension: Getting the essential information, Finding the main idea**,** Defining vocabulary in context, Practice.
Order of importance: Using order in the writing to determine what is most important to the author Similarities & Differences; using comparisons to determine the author's attitude Sentence structure, degree of detail, description & tone, Practice.
Critical reading & thinking: Evaluating evidence and author credibility, rejecting faulty reasoning Reading across the curriculum; asking the right questions to get the most out of reading in the natural sciences, social sciences & Humanities
Drawing Conclusions: putting it all together.

Text & Reference books:
1. College Writing Skills with Readings, by John Langan, McGraw-Hill, 5th Edition. Publisher: McGraw-Hill; 5th edition (January 2, 2005), ISBN-13: 978-0072381214
2. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute, 2000.

BSI-122 Calculus (3-0-3)
Prerequisite: None

Course Objective:
After completing this course, the students will be able to:
- Understand the ideas of rate of change and derivatives using the concept of limits and continuity.
- Use the techniques of integration for solving and analyzing problems in integral calculus.
- Apply the derivatives for solving different problems arising in engineering sciences.
- Use the vector calculus and analytical geometry in multiple dimensions to solve different problems.

Course outline:
Type of Functions (continuous, periodic, odd, even), graphs of functions, Limits and continuity, Derivatives, total differential, Higher odder derivative, Tangents and normal, approximation by Taylor and McLaurin's, Maxima & Minima and Point of inflection, Indeterminate form Integral Calculus (basic concepts, Integral formula, some rules of integral), Integration by parts, area bounded by curve, volume of revolution. Multivariate Calculus (Basic Concept, level curves and surfaces, limits and continuity), Partial Derivative, Higher order partial derivative, tangent plan, total differential.

Text & Reference Books:
1. Calculus by Thomas Finney, Addison-Wesley Publishing Company.
2. Mathematics for Engineer 2nd Edition by Robert Davison.
3. Multivariate Calculus 2nd Edition by Robert T. Smith.

BSI-101 Islamic Studies (2-0-2)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Value basic concepts of Islam (faith, pillars, dawat, preaching and seerat).
- Understand the Basic Concepts of the Holy Quran and Hadith.
- Present Islam as a complete code of life.

Course outline:
History of Islam: Compilation of the Holy Quran and Hadith, Fundamental doctrine of Islam i.e Tawheed, oneness of Allah, Prophet hood, the day of Judgment, Revealed books, Ibadaat (worship) Philosophy of Ibadaat, Namaz, Zakat, Hajj & Sawm, Importance of preaching of Islam, its needs and effects, Difficulties in the ways of preaching of Islam, Sectarianism, its causes and effects in Muslim society, Definition of Right, classification of right, importance of Rights, Khutba Hajjatul Wida (last Address of the Holy Prophet Peace be upon him), Seeratun-Nabi (Peace Be upon him).
Life of Holy Prophet (Peace Be upon him): The life of the Holy prophet before and after prophet hood. The Hijra (Migration to Madina), Treaty of Al madina, Makki and Madani Life of Holy Prophet Muhammad (Peace be upon him), Importance of peace and causes of Terrorism.
Islam and civilization: Definition of civilization, Impacts of Islamic civilization on the Sub-continents, International impacts of Islamic civilization, Impacts of Human thoughts, social and humanistic effects, Importance of Ethics, Human rights (Hoqooq Ul Ibad) with detail.
Knowledge and Islam: Definition of Knowledge, Classification of knowledge, Importance of technology in the light of Holy Quraan and Sunnah, Relevent verses of the Holy Quran about Technology (Baqara 28,30,33,201, Nahal:76, Jasia: 13, Araf: 32, Noor: 55 etc), Islamic and scientific knowledge.

Text & Reference Books:
1. A guide book for Muslims by Syed. Abul Hasan Ali Nadvi.
2. An Introduction to Islam by Dr. Muhammad hameedullah.
3. What is Islam by Maulana Manzoor Nomani.
4. Islamiat (A standard book for CSS), Prof. Dr. Arif Naseem.
5. Islamiat for Students O levels, Farkhanda Noor Muhammad.

BSI-181 Applied Physics (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Refresh students' previous knowledge of the basic physical laws and introduce them with the techniques of calculations at the higher levels.
- Train/guide students in the analytical studies of different physical phenomenon pertaining to wave creation/propagation.
- Divert the information achieved on wave production/propagation/properties towards its practical applications.

Course outline:
Scalar and Vector quantities, Vector Algebra, Rectangular and non-rectangular components, Product of vectors, Laws of motion, Law of gravitation, Projectile motion, Simple harmonic motion (SHM), Simple pendulum, torsion pendulum, compound pendulum, Damped Harmonic Oscillation, Forced Harmonic Oscillation, Types of Waves, Expression describing travelling waves, Differential wave equation, Wave speed in stretched string, Wave speed in fluids, Superposition principle, Interference, Young's double slit experiment, Standing waves (analytical treatment), Standing waves in stretched string, air columns. Beats (analytical proof), Doppler's Effect , Doppler's Effect in EM

waves, Hydrogen spectrum, Bohr's atomic model, determining radii/energies of stable orbits in H-atom, Finite mass correction, EM spectrum, X-rays, X-rays production, properties, uses, Mosley Law, X-rays diffraction, X-rays spectrum, Mosley law, X-rays diffraction, Wave-particle duality, Photoelectric effect, De-Broglie wavelength, Electric current, Ohm's law (microscopic), resistance/resistivity, temperature co-efficient of resistivity, resistor combinations, Capacitor & capacitance, energy stored in a charged capacitor, combinations of capacitors, Capacitor with dielectric.

<u>Text & Reference Books:</u>

1. Sears and Zemansky's University Physics with modern Physics, 13th Edition, Authors; Young/Freedman Ford. Publisher: Addison-Wesley; 13th edition (January 8, 2011), ISBN-13: 978-0321696861
2. Fundamentals of Physics by Halliday, Resnic, Walker (6th Edition). Publisher: Wiley; 10th Edition (August 5, 2013), ISBN-13: 978-1118886328
3. Physics by David Holliday & Resnick, College Physics, Pacific Physics for A Levels.

CS-103 Digital Logic Design (3-3-4)
Prerequisite: BSI-181 Applied Physics

Course Objectives:
After completing this course, the students will be able to:
- Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits
- Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques
- Apply the acquired knowledge to simulate and implement small-scale digital circuits
- Understand the relationship between abstract logic characterizations and practical electrical implementations.

Course Contents:
Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey method), Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA); Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.

Text & Reference Books:
1. Digital Fundamentals by Floyd, 11/e. Publisher: Pearson; 1ˢᵗ edition (October 3, 2013), Publication Date: October 3, 2013.
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e. Publisher: SEM; 3ʳᵈ edition (February 12, 2013), Publication Date: February 1, 2013.

CS-104 Object-Oriented Programming (3-3-4)
Prerequisite: CS-102 Programming Fundamentals

Course Objectives:
After completing this course, the students will be able to:
- Understand principles of object oriented paradigm.
- Identify the objects & their relationships to build object oriented solution
- Model a solution for a given problem using object oriented principles
- Examine an object oriented solution.

Course outline:
Introduction to object oriented design, history and advantages of object oriented design, introduction to object oriented programming concepts, classes, objects, data encapsulation, constructors, destructors, access modifiers, const vs non-const functions, static data members & functions, function overloading, operator overloading, identification of classes and their relationships, composition, aggregation, inheritance, multiple inheritance, polymorphism, abstract classes and interfaces, generic programming concepts, function & class templates, standard template library, object streams, data and object serialization using object streams, exception handling.

Text & Reference Books:
1. C++ How to Program, By: Harvey Deitel & Paul Deitel, Edition: 8th, Publisher: Prentice Hall, ISBN: 0136152503, Year of Publication: 2011.
2. Object Oriented Programming in C++ By: Robert Lafore, Edition: 4th , Publisher: SAMS Publishing, ISBN: 0672323087, Year of Publication: 2001.
3. Java How to Program, By: Harvey Deitel & Paul Deitel, Edition: 9th, Publisher: Prentice Hall, ISBN: 0132575663, Year of Publication: 2011.

BSI-143 Communication & Presentation Skills (3-0-3)
Prerequisite: BSI-142 English Composition and Comprehension

Course Objectives:
After completing this course, the students will be able to:
- Know how to make their day to day communication effective by incorporating and analyzing all the important components of the process of communication.
- Be proficient in designing persuasive, vivid, coherent, and concise documents.
- Know how to have convincing discussions with their superiors, coordinates, and subordinates- their overall speaking strategies would improve.
- Understand effective communication which would eventually lead to: Improved writing, listening and presentation skills.
- Plan and produce effective documents such as essays, letters and reports.

Course outline:
Principles of writing good English, understanding the composition process: writing clearly; words, sentence and paragraphs; Comprehension and expression; Use of grammar and punctuation. Process of writing, observing, audience collecting, composing, drafting and revising, persuasive writing, reading skills, listening skills and comprehension, skills for taking notes in class, skills for exams; Business communications; planning messages, writing concise but with impact. Letter formats, mechanics of business, letter writing, letters, memo and applications, summaries, proposals, writing resumes, styles and formats, oral communications, verbal and non-verbal communication, conducting meetings, small group communication, taking minutes. Presentation skills; presentation strategies, defining the objective, scope and audience of the presentation, material gathering material organization strategies, time management, opening and concluding, use of audio-visual aids, delivery and presentation.

Text book:
1. Effective Business Communication by Herta A. Murphy, Herbert W. Hilderandt, 7th Edition
2. Practical English Grammar-Exercise 2, by A. J. Thomson and A.V. Martinet, 3rd Edition. Publisher: Oxford University Press; 3 edition (July 31, 1986), ISBN-13: 978-0194313445.
3. Writing Upper-Intermediate – Oxford Supplementary Skills by Rob Nolasco, 4th Edition, Publisher: Oxford University Press (19 Nov. 1987), ISBN-13: 978-0194534062.

BSI-111 Linear Algebra (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Demonstrate their competence with the ideas in linear algebra to work with linear systems and vector spaces.
- Apply the knowledge of linear algebra to model and solve linear systems that appear in engineering sciences.
- Apply the techniques of Gauss Elimination and Gauss Jordon for solving Homogeneous and Non-Homogeneous equations.
- Use the vector space to describe the bases and dimension of different type problems and to solve different problems.

Course outline:
Groups and Fields, Vector Spaces, Sub-Spaces, Matrices, Upper & Lower Triangular form, Echelon Form, Determinants, Co-factor and Inverse, Rank, Linear Independence, Solution of system of Linear systems, Gaussess Elimination Method, Gauses Gorden Method, Positive Definite matrix, Linear Transformations, Operations on matrices, Inner products, orthgonality and least squares, Eigenvalue & Eigenvectors. Applications to Systems of Equations and to Geometry, Singular Value Decomposition.

Text & Reference books:
1. Elementary Linear Algebra with Applications, By: Bernard Kolman, David Hill, Edition: 9th, Publisher: Prentice Hall PTR, ISBN: 0132296543, Year of Publication: 2007.
2. Linear Algebra And Its Applications, By: David C. Lay, Edition: 4th, Publisher: Pearson, ISBN: 0321385179, Year of Publication: 2011.
3. Elementary Linear Algebra, By: Howard Anton, Chris Rorres, Edition: 11th, Publisher: John Wiley & Sons, ISBN: 1118473507, Year of Publication: 2013.

BSI-110 Pakistan Studies(2-0-2)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Be aware about difference between ideological and non-ideological state.
- Be aware about Pakistan Movement, political and constitutional history of Pakistan.
- Be aware about current issues of Pakistan, their causes and solution.

Course Outline:
Historical background of Pakistan: Muslim society in Indo-Pakistan, the movement led by the societies, the downfall of Islamic society, the establishment of British Raj- Causes and consequences. Political evolution of Muslims in the twentieth century: Sir Syed Ahmed Khan; Muslim League; Nehru; Allama Iqbal: Independence Movement; Lahore Resolution; Pakistan culture and society, Constitutional and Administrative issues, Pakistan and its geo-political dimension, Pakistan and International Affairs, Pakistan and the challenges ahead.

Text & Reference books:
1. The Emergence of Pakistan, Chaudary M., 1967
2. The making of Pakistan, Aziz. 1976
3. A Short History of Pakistan, I. H. Qureshi, ed., Karachi, 1988

CS-201 Discrete Structures (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs, and Trees etc.
- Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.
- Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.
- Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular.

Course outline:
Introduction to logic and proofs: Direct proofs; proof by contradiction, Sets, Sequences and series, Formal logic, Prepositional and predicate calculus, Mathematical Induction and Recursion, loop invariants, Relations and functions, Trees and Graphs, Elementary number theory, Combinatorics: K-Permutation and K-Combination, K-Selection and K-Sampling, Inclusion Exclusion Principle, Optimization and matching. Fundamental structures: Functions; relations (more specifically recursions); pigeonhole principle; cardinality and count ability, probabilistic methods.

Text & Reference books:
1. Discrete Mathematics with Applications, By: Susanna S. Epp, Edition: 4th, Publisher: Cengage Learning, ISBN: 0495391328, Year of Publication: 2010.
2. Discrete Mathematics and Its Applications, By: Kenneth H. Rosen, Edition: 7th, Publisher: McGraw-Hill Science/Engineering/Math, ISBN: 0073383090, Year of Publication: 2011.
3. Discrete Mathematics, By: Richard Johnsonbaugh, Edition: 7th, Publisher: Pearson, ISBN: 0131593188, Year of Publication: 2007.
4. Discrete Mathematical Structures, By: Kolman, Busby & Ross, Edition: 6th, Publisher: Pearson, ISBN: 0132297515, Year of Publication: 2008.

CS-202 Data Structures & Algorithms (3-3-4)
Prerequisite: CS-104 Object Oriented Programming

Course Objectives:
After completing this course, the students will be able to:
- Implement various data structures and their algorithms, and apply them in implementing simple applications.
- Analyze simple algorithms and determine their complexities.
- Apply the knowledge of data structures to other application domains.
- Design new data structures and algorithms to solve problems.

Course outline:
Abstract data types, complexity analysis, Big Oh notation, Stacks (linked lists and array implementations), Recursion and analyzing recursive algorithms, divide and conquer algorithms, Sorting algorithms (selection, insertion, merge, quick, bubble, heap, shell, radix, bucket), queue, dequeuer, priority queues (linked and array implementations of queues), linked list & its various types, sorted linked list, searching an unsorted array, binary search for sorted arrays, hashing and indexing, open addressing and chaining, trees and tree traversals, binary search trees, heaps, M-way tress, balanced trees, graphs, breadth-first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection.

Text & Reference books:
1. Data Structures and Algorithm Analysis, Mark Allen Weiss, Florida International University, Addison-Wesley (latest Edition), Publisher: Benjamin-Cummings Pub Co (September 1991), ISBN-13: 978-0805390520.

2. Algorithms, Robert Sedgewick, Princeton University Publisher: Addison- Wesley Professional (latest Edition). Publisher: Addison-Wesley Professional; 4 edition (February 21, 2011), Publication Date: February 21, 2011
3. Data Structures: Abstraction and Design Using Java, Koffman and Wolfgang, Wiley; 2nd Edition (or latest Edition), 2010 22. Publisher: John Wiley & Sons; 2nd ed. edition (12 Feb. 2010), ISBN-13: 978-0470128701
4. Data Structures and Algorithms in C++, Adam Drozdek, Course Technology; 4th Edition, 2012. Published by Cengage Learning, ISBN 13: 9781133608424

CS-203 Computer Organization & Assembly Language (3-3-4)
Prerequisite: CS-102 Programming Fundamentals

Course Objectives:
After completing this course, the students will be able to:
- Acquire the basic knowledge of computer organization, computer architecture and assembly language
- Understand the concepts of basic computer organization, architecture, and assembly language techniques
- Solve the problems related to computer organization and assembly language

Course Outline:
Introduction to SAP-1, SAP-II, SAP-III, Microprocessor Bus Structure: Addressing, Data and Control, Memory Organization and Structure (Segmented and Linear Models), Introduction to Registers and Flags, Data Movement, Arithmetic and Logic, Programme Control, Subroutines, Stack and its operation, Peripheral Control Interrupts, Interfacing with high level languages, Real-time application.

Objectives and Perspectives of Assembly Language, Addressing Modes, Introduction to the Assembler and Debugger, Manipulate and translate machine and assembly code, describe actions inside the processing chip, Discuss operations performed by an instruction set, Write a fully documented program, Using an assembler of choice.

Text & Reference books:
1. Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e), Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University. Publisher: Pearson; 3 edition (March 12, 2015), ISBN-13: 978-0134092669.
2. Robert Britton, MIPS Assembly Language Programming, Latest Edition, 3. Computer System Architecture, M. Morris Mano, Latest Edition. Publisher: Pearson (June 7, 2003), ISBN-13: 978-0131420441.
3. Assembly Language Programming for Intel- Computer, Latest Edition. Publisher: Macmillan Coll Div; 3rd edition (September 8, 1998), ISBN-13: 978-0136603900.

BSI-321 Professional Practices (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Define the Engineering dimensions and problem solving approach towards moral engineering complexities
- Judgmental and critic towards technological products and to give meaning to engineering endeavor
- Define and Produce a frame work for making reasonable moral choices and resolving moral dilemmas.
- Recognize that the foremost obligation of the engineers is to keep their professional integrity even more high.

Course outline:
Computing Profession, Computing Ethics, Philosophy of Ethics. The Structure of Organizations, Finance and Accounting, Anatomy of a Software House, Computer Contracts, Intellectual Property Rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse and the Criminal Law, Regulation and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct, ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.

Text & Reference books:
1. Professional Issues in Software Engineering by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, CRC Press; 3rd Edition (2000). ISBN-10: 0748409513.
2. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition (January 3, 2009). ISBN-10: 0131112414.
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (3rd Edition) by Sara Baase, Prentice Hall; 3rd Edition (2008). ISBN-10: 0136008488
4. Applied Professional Ethics by Gregory R. Beabout, University Press of America (1993). ISBN-10: 0819193747.

BSI-231 Differential Equations (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
*   Identify, analyze and subsequently solve physical situations whose behavior can be described by ordinary differential equations.
*   Determine solutions to first order separable differential equations.
*   Determine solutions to first order linear differential equations.
*   Determine solutions to first order exact differential equations.
*   Determine solutions to second order linear homogeneous and non-homogeneous differential equations with constant coefficients.

Course outline:
Ordinary Differential Equations of the First Order: Geometrical Considerations, Isoclines, Separable Equations, Equations Reducible to Separable Form, Exact Differential Equations, Integrating Factors, Linear First-Order Differential Equations, variation of Parameters. Ordinary Linear Differential Equations; Homogeneous Linear Equations of the Second Order, Homogeneous Second-Order Equations with Constant Coefficients, General Solution, Real Roots, Complex Roots, Double Root of the Characteristic Equation, Differential Operators, Cauchy Equation, Homogeneous Linear Equations of Arbitrary Order, Homogeneous Linear Equations of Arbitrary Order with Constant Coefficients, Non- homogeneous Linear Equations. Modelling of Electrical Circuits. Systems of Differential Equations. Series Solutions of Differential Equations. Partial Differential Equations: Method of Separation of variables, wave, Heat & Laplace equations and their solutions by Fourier series method.

Text & Reference books:
1. Advanced Engineering Mathematics Michael, G.1996, Prentice Hall Publishers Publisher: Pearson; 2 edition (January 18, 1998), ISBN-13: 978-0133214314
2. Advanced Engineering Mathematics, 7th edition, Erwin, K. 1993, John Wiley & Sons Inc. Published by John Wiley & Sons Inc, 1992, ISBN 13: 9780471553809
3. A First Course in Differential Equation Zill. Prindle. Weber. Schmidt.1996. Brooks/Cole Publishing. Published by Pws Pub Co (1993), ISBN 13: 9780534931544
4. Differential Equations with Boundary-Value Problems, Dennis. G. Zill, Michael, R. Cullen. 1996, Brooks/Cole Publishing, Published by Pws Pub Co (1996), ISBN 13: 9780534955809
5. Elementary Differential Equations with Applications C. H. Edwards. David, E. 1993. Penney, Prentice Hall.

CS-204 Design & Analysis of Algorithms (3-0-3)

Prerequisite: CS-202 Data Structure & Algorithms

Course Objectives:

After completing this course, the students will be able to:

- Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm.
- Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.
- Determine informally the time and space complexity of simple algorithms.
- List and contrast standard complexity classes.
- Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms.
- Use of the strategies (brute-force, greedy, divide-and-conquer, and dynamic programming) to solve an appropriate problem.
- Solve problems using graph algorithms, including single-source and all-pairs shortest paths, and at least one minimum spanning tree algorithm.
- Trace and/or implement a string-matching algorithm.

Course outline:

Introduction; role of algorithms in computing, Analysis on nature of input and size of input Asymptotic notations; Big-O, Big Ω, Big Θ, little-o, little-ω, Sorting Algorithm analysis, loop invariants, Recursion and recurrence relations; Algorithm Design Techniques, Brute Force Approach, Divide-and-conquer approach; Merge, Quick Sort, Greedy approach; Dynamic programming; Elements of Dynamic Programming, Search trees; Heaps; Hashing; Graph algorithms, shortest paths, sparse graphs, String matching; Introduction to complexity classes;

Text & Reference books:

1. Introduction to Algorithms (3ʳᵈ edition) by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein. Publisher: The MIT Press; 3rd edition (July 31, 2009), ISBN-13: 978-0262033848.

2. Algorithm Design, (1ˢᵗ edition, 2013/2014), Jon Kleinberg, Eva Tardos, Published by Pearson, ISBN 13: 9780321295354.

3. Algorithms, (4ᵗʰ edition, 2011), Robert Sedgewick, Kevin Wayne. Publisher: Addison-Wesley Professional; 4th edition (March 19, 2011), ISBN-13: 978-0321573513.

CS-205 Automata Theory (3-0-3)

Prerequisite: None

Course Objectives:

After completing this course, the students will be able to:

- Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc;
- Prove properties of languages, grammars and automata with rigorously formal mathematical methods
- Design of automata, RE and CFG
- Transform between equivalent NFAs, DFAs and REs
- Define Turing machines performing simple tasks.
- Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.

Course outline:

Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: CFGs, Derivations, derivation trees and ambiguity,

Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Text & Reference books:

1. Introduction to computer theory, Daniel I. A. Cohen, 2nd Edition. Publisher: Wiley; 2 edition (October 25, 1996), ISBN-13: 978-0471137726
2. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich, 2011. Publisher: Pearson; 1 edition (September 28, 2007), ISBN-13: 978-0132288064
3. An Introduction to Formal Languages and Automata, by Peter Linz, 4th edition, Jones & Bartlett Publishers, 2006. Publisher: Jones & Bartlett Learning; 5 edition (February 28, 2011), ISBN-13: 978-1449615529
4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Kavier, 2005, New Age Publishers.

CS-206 Database Systems (3-3-4)
Prerequisite: SE-202 Data Structure & Algorithms

Course Objectives:
After completing this course, the students will be able to:
- Explain fundamental database concepts.
- Design conceptual, logical and physical database schemas using different data models.
- Identify functional dependencies and resolve database anomalies by normalizing database tables.
- Use Structured Query Language (SQL) for database definition and manipulation in any DBMS

Course outline:
Basic database concepts, Database approach vs file based system, database architecture, three level schema architecture, data independence, relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints, relational algebra, selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Structured Query Language (SQL), Joins and sub-queries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, NoSQL systems.

Text book:
1. Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition by Thomas Connolly and Carolyn Begg. Publisher: Pearson; 6 edition (January 18, 2014), ISBN-13: 978-0132943260.
2. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom. Publisher: Pearson; 2 edition (June 15, 2008), ISBN-13: 978-0131873254.
3. Database System Concepts, 6th Edition by Avi Silberschatz, Henry F. Korth and S. Sudarshan.publisher: McGraw-Hill, Inc. New York, NY, USA ©1986, ISBN:0-07-044752-7.
4. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke. Publisher: McGraw-Hill; 3rd edition (August 14, 2002), ISBN-13: 978-0072465631.

BSI-351 Probability and Statistics (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Understand the basic concepts of probability, random variables, probability distribution, and joint probability distribution.
- Use statistical methodology and tools in the engineering problem-solving process. Compute and interpret descriptive statistics using numerical and graphical techniques.
- Compute point estimation of parameters, explain sampling distributions, and understand the central limit theorem.
- Use software i.e Microsoft excel, Matlab for complex problems having huge data.

Course outline:

Introduction to Statistics, Descriptive Statistics, Statistics in decision making, Graphical representation of Data Stem-and Lead plot, Box-Cox plots, measures of central tendencies and dispersion, moments of frequency distribution; Counting techniques, introduction to probability, sample space, events, laws of probability, Conditional probability and Baye's theorem with application to random variable (Discrete and continuous) Binomial, Poisson, Geometric, Negative Binomial Distributions; Exponential Gamma and Normal distributions, Expectation and variance of a random variable, PDF, PMF, Chebyshev's Theorem, Regression and Correlation, Estimation and testing of hypotheses, use of elementary statistical packages for explanatory Data analysis.

Text & Reference books:

1. Probability & Statistics for Engineers & Scientists , By: Ronald Walpole, Myers, Myers, Ye, Edition: 9th, Publisher: Prentice Hall, ISBN: 0321629116, Year of Publication: 2011.
2. Probability and Statistics for Engineering and the Sciences, By: Lay L. Devore, Edition: 8th, Publisher: Cengage Learning, ISBN: 0538733527, Year of Publication: 2011.
3. An Introduction to Statistical Methods and Data Analysis, By: R Layman Ott & Micheal T., Edition: 6th, Publisher: Cengage Learning, ISBN: 0495017582, Year of Publication: 2008.

CS-301 Compiler Construction (3-0-3)
Prerequisite: CS-205 Automata Theory

Course Objectives:
After completing this course, the students will be able to:
- Understand the basic techniques used in compiler construction such as lexical analysis, top-down, bottom-up parsing, context-sensitive analysis, and intermediate code generation
- Understand the basic data structures used in compiler construction such as abstract syntax trees, symbol tables, three-address code, and stack machines
- Design and implement a compiler using a software engineering approach
- Use generators (e.g. Lex and Yacc)

Course outline:
Introduction to interpreter and compiler. Compiler techniques and methodology; Organization of compilers; Lexical and syntax analysis; Parsing techniques. Types of parsers, top-down parsing, bottom-up parsing, Type checking, Semantic analyser, Object code generation and optimization, detection and recovery from errors.

Text & Reference books:
1. Compilers: Principles, Techniques, and Tools, A. V. Aho, R. Sethi and J. D. Ullman, Addison-Wesley, 2ⁿᵈ ed., 2006. Publisher: Addison Wesley; 2nd edition (September 10, 2006), ISBN-13: 978-0321486813.
2. Modern Compiler Design, D. Grune, H. E. Bal, C. J. H. Jacobs, K. G. Langendoen, John Wiley, 2003. Publisher: Wiley; 1st edition (October 11, 2000), ISBN-13: 978-0471976974.
3. Modern Compiler Implementation in C, A. W. Appel, M. Ginsburg, Cambridge University Press, 2004. Publisher: Cambridge University Press (July 8, 2004), ISBN-13: 978-0521607650.

CS-302 Operating Systems (3-3-4)
Prerequisite: CS-202 Data Structure & Algorithms

Course Objectives:
After completing this course, the students will be able to:
- Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems.
- 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.
- Demonstrate the knowledge in applying system software and tools available in modern operating systems.

Course outline:
Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading models, threading issues, process scheduling algorithms, thread scheduling, multiple-processor scheduling, synchronization, critical section, synchronization hardware, synchronization problems, deadlocks, detecting and recovering from deadlocks, memory management, swapping, contiguous memory allocation, segmentation & paging, virtual memory management, demand paging, thrashing, memory-mapped files, file systems, file concept, directory and disk structure, directory implementation, free space management, disk structure and scheduling, swap space management, system protection, virtual machines, operating system security.

Text & Reference books:
1. Operating Systems: Internal and Design Principles, By: William Stallings, Edition: 9ᵗʰ, Publisher: Pearson, ISBN: 0134670957, Year of Publication: 2017.
2. Operating Systems Concepts, By: Silberschatz A., Peterson, J.L., & Galvin P.C., Edition: 9ᵗʰ or later, Publisher: Wiley & Sons, ISBN: 1118063333, Year of Publication: 2012.

3. Modern Operating Systems, By: Andrew S. Tanenmaum & Herbert Bos, Edition: 4th or later, Publisher: Prentice Hall, ISBN: 013359162X, Year of Publication: 2014.

CS-303 Introduction to Software Engineering (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Describe and apply the basic concepts of software engineering and workflow of software development process.
- Analyze and solve small-scale engineering problems.
- Design small software systems.
- Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis

Course outline:
Nature of Software, Overview of Software Engineering, Professional software development, Software engineering practice, Software process structure, Software process models, Agile software Development, Agile process models, Agile development techniques, Requirements engineering process, Functional and non-functional requirements, Context models, Interaction models, Structural models, behavioral models, model driven engineering, Architectural design, Design and implementation, UML diagrams, Design patterns, Software testing and quality assurance, Software evolution, Project management and project planning, configuration management, Software Process improvement. Validation Testing, System Testing; Internal and External View of Testing. Project Management. Risk Management; Maintenance and Reengineering.

Text book:
1. Software Engineering, Sommerville I., 10th Edition, Pearson Inc., 2014. Publisher: Pearson; 10 edition (April 3, 2015), ISBN-13: 978-0133943030
2. Software Engineering, A Practitioner's Approach, Pressman R. S.& Maxim B. R., 8th Edition, McGraw-Hill, 2015.

BSI-242 Numerical Analysis (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Explain factual knowledge including the mathematical notation and terminology used in this course.
- Describe the fundamental principles including the laws and theorems arising from the concepts covered in this course.
- Apply course material along with techniques and procedures covered in this course to solve problems.
- Develop specific skills, competencies, and thought processes sufficient to support further study or work in this field or related fields.

Course outline:
General Introduction of the subject regarding the practical applications of Numerical Analysis in computer Sciences, Major sources of errors in numerical methods, Linear systems, Matrix factorization, Symmetric and Tri-diagonal matrices, Matrix inversion, Taylor's method, Taylor's series and its applications, Eigen Value computation, Power method, Jacobi iterative, Gauss-Seidel iterative method, Introduction to non-linear systems, Bisection method, Fixed point method, Convergence criterion of iterative processes, Newton's method, Newton's method for two and multi dimensions, Introduction to Interpolations, Linear interpolation, Interpolation with equal/unequal intervals, LaGrange interpolations, Inverse interpolation, Error terms. Curve fitting by various methods (Application, Examples), Introduction to numerical integration and solution methods. Trapezoidal rule to evaluate numerical integration, Simpson 1/3 and 3/8 rule to evaluate numerical integration. Forward, Backward and Modified Eular's method. Introduction to Finite Difference approximations.

Text & Reference books:

1. Numerical Analysis (9th Edition) by Richard L. Burden, J. Douglas Faires by Brooks/Cole Boston USA, 2011. Publisher: Cengage, 2011, ISBN 13: 9780538735643
2. Numerical Methods for Scientific Computing by J.H. Heinbockel Trafford Publishing USA, 2006. ISBN 13: 9781412031530
3. Applied Numerical Analysis, By: Cutis F Gerald, Edition: 7th, Publisher: Pearson, ISBN: 0321133048, Year of Publication: 2003.
4. Applied Numerical Methods W/MATLAB: for Engineers & Scientists, By: Steven Chapra, Edition: 3rd, Publisher: McGraw Hill, ISBN: 0073401102, Year of Publication: 2011.

CS-315 Graph Theory (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Introduce the fundamental concepts of Graph Theory
- Provide knowledge for application of Graph Theory in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.

Course outline:
Introduction to Graph Theory, Basic definitions, computer representations and properties of Graph, Data structure for representing Graphs, Fundamental theorem of Graph Theory, Isomorphic and Special Graphs, Properties of Trees and Forests, Binary tree, Balanced binary tree, Directed and Undirected rooted tree, Minimum Spanning Tree algorithms and implementation, Path and Distance in graphs, Shortest path algorithms and implementation, Cycle and distance in weighted graph and digraphs, Distance algorithms and implementation, Eulerian graphs and Hamiltonians graphs with applications, Flow networks, Max-flow Min-cut Theorem, Graph coloring, Edge coloring, Planar graphs, Four color theorem, Deadlock of computer system, Matching Algorithms, Dominance & Ramsey theory.

Text & Reference books:

1. Graph Theory & Applications (1st Edition) by Fournier. Published by Wiley-ISTE, 2011. Publisher: Wiley-ISTE (March 23, 2009), ISBN-13: 978-1848210707

2. Applied Algorithmic Graph Theory (1st Edition) by Chartrand. Published by McGraw-Hill College, 1995.

3. Handbook of Graph Theory (Series Edition) by Jonathan Published . December 17, 2013 by Chapman and Hall/CRC, ISBN 9781439880180

4. Graph Theory with Applications (8th Edition) by J. A. Bondy, Published Elsevier USA, 1982.

CS-304 Artificial Intelligence (3-3-4)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Understand key components in the field of artificial intelligence.
- Implement classical artificial intelligence techniques.
- Analyze artificial intelligence techniques for practical problem solving.

Course outline:
Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, First order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint Satisfaction Problems; Adversarial Search (Min-max algorithm, Alpha beta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning) ;Uncertainty handling (Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems).

Text & Reference books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2010. Publisher: Pearson; 3 edition (December 11, 2009), ISBN-13: 978-0136042594.
2. Hart, P.E., Stork, D.G. and Duda, R.O., 2001. Pattern classification. John Willey & Sons. Verlag: Wiley-Interscience; Auflage: 2 (21. November 2000), ISBN-13: 978-0471056690.
3. Luger, G.F. and Stubblefield, W.A., 2009. AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley. Publisher: Pearson; 6 edition (September 4, 2008), ISBN-13: 978-0136070474.

CS-205 Computer Networks (3-3-4)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Describe the key terminologies and technologies of computer networks.
- Explain the services and functions provided by each layer in the Internet protocol stack.
- Identify various internetworking devices and protocols, and their functions in a network.
- Analyze working and performance of key technologies, algorithms and protocols.
- Build Computer Network on various Topologies.

Course outline:
Introduction to layers and protocols architecture, basic concepts of networking, network topologies, layered architecture, physical layer functionality, transmission media, modulation, encoding, data link layer functionality, multiple access techniques, circuit switching and packet switching, LAN technologies, wireless networks, MAC addressing, networking devices, network layer protocols, IPv4 and IPv6, IP addressing, sub netting, CIDR, routing protocols, transport layer protocols, ports and sockets, connection establishment, flow and congestion control, application layer protocols, latest trends in computer networks.

Text & Reference books:

1. Computer Networking: A Top-Down Approach Featuring the Internet, 6th edition by James F. Kurose and Keith W. Ross. Publisher: Pearson; 6th edition (March 5, 2012), ISBN-13: 978-0132856201.

2. Computer Networks, 5th Edition by Andrew S. Tanenbaum. Publisher: Prentice Hall, Indian International Ed.; 5th edition (January 9, 2010), ISBN-13: 978-9332518742

3. Data and Computer Communications, 10th Edition by William Stallings. Publisher: Pearson; 10 edition (September 23, 2013), ISBN-13: 978-0133506488

4. Data Communication and Computer Networks, 5th Edition by Behrouz A. Forouzan. Publisher: Science Engineering & Math; 5 edition (July 1, 2012), ASIN: B008K9U0K8.

CS-316 Technical Report Writing (3-0-3)
Prerequisite: None

<u>Course Objectives:</u>
After completing this course, the students will be able to:
- Gain the ability to use modern presentation skills.
- Gain the ability to know basics of technical report writing.
- Have a skill to write correct technical English in proposal preparation, research papers and reports preparations.

<u>Course outline:</u>
Words and Phrases: A brief history of words, Dictionary of Thesaurus, Elements of Style.
Sentence Construction: Introduction, Guidelines for Effectiveness.
Paragraph Development: Introduction, Central Components of a Paragraph, Length, Techniques for Paragraph Development.
The Art of Condensation: Introduction, Steps to Effective Précis Writing, Samples, Guidelines.
Reading Comprehension: Introduction, Purpose of Reading, Reading Rates, Reasons for Poor Comprehension, Improving Comprehension Skills, Techniques for Good, Comprehension, Worked Out Sample Passages.
Business Letters: Business letters, Memos, E-mails.
Reports: Introduction, Objectives, Characteristics of a Report, Types of Reports, The Importance of Reports, Formats, Prewriting, Structure of Reports, Writing the Report, Revising, Editing, and Proofreading, Samples Exercises.
Technical Proposals: Definition Purposes, Types, Characteristics, Elements of Structure, Style and Appearance, Evaluation.
Research Paper, Dissertation, and Thesis: Introduction to Research Paper, Dissertation, Thesis.

<u>Text & Reference books:</u>
1. Technical Communication: Principles and Communication, Author: Meenakshi Raman and Sangeeta Sharma. Publisher: Oxford University Press (January 13, 2005), ISBN-13: 978-0195668049
2. Basic communication skills for Technology by Andrea J. Rutherford, ISBN 978-8177584073.

CS-401 Parallel & Distributed Computing (3-0-3)
Prerequisite: CS-302 Operating Systems

Course Objectives:
After completing this course, the students will be able to:
- Learn about parallel and distributed computers.
- Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library.
- Analytical modelling and performance of parallel programs.
- Analyze complex problems with shared memory programming with open MP.

Course outline:
Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD, multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE).

Text & Reference books:

1. Distributed Systems: Principles and Paradigms, A. S. Tanenbaum and M. V. Steen, Prentice Hall, 2ⁿᵈ Edition, 2007. Publisher: CreateSpace Independent Publishing Platform; 2 edition (February 26, 2016), ISBN-13: 978-1530281756.
2. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K Hwang, J Dongarra and GC. C. Fox, Elsevier, 1ˢᵗ Ed. Imprint: Morgan Kaufmann Published Date: 17th October 2011 , ISBN: 9780128002049.

CS-402 Information Security (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Explain key concepts of information security such as design principles, cryptography, risk management, and ethics
- Discuss legal, ethical, and professional issues in information security.
- Apply various security and risk management tools for achieving information security and privacy.
- Identify appropriate techniques to tackle and solve problems in the discipline of information security.

Course outline:
Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, key management, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.

Text & Reference books:
1. Computer Security: Principles and Practice, 3rd edition by William Stallings. Publisher: Pearson; 3 edition (July 18, 2014, ISBN-13: 978-0133773927.
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord. Publisher: Course Technology; 6 edition (March 13, 2017), ISBN-13: 978-1337102063.
3. Computer Security, 3rd edition by Dieter Gollmann. Publisher: Wiley; 3 edition (February 28, 2011), ISBN-13: 978-0470741153.
4. Computer Security Fundamentals, 3rd edition by William Easttom. Publisher: Pearson IT Certification; 3 edition (June 23, 2016), ISBN-13: 978-0789757463.
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition. Publisher: Auerbach Publications; 3 edition (December 21, 2012), ISBN-13: 978-1466569768.

CS-306 Computer Vision (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Understand and explain the field of computer vision in general for different applications.
- Understand and implement camera calibration.
- Work under OpenCV or Matlab computer vision toolbox.
- Implement an algorithm to assemble the extracted features to develop a higher-level perception.
- Implement different algorithms for spatial and frequency domain filtering, feature detection, structure from motion, motion estimation.
- Detect, recognize and track different types of the objects in the scene.
- Develop an algorithm for context awareness or scene understanding.

Course outline:
Introduction, Image formation, Spatial and frequency domain processing, Feature detection and extraction, Image registration, Segmentation, Camera calibration, Structure from motion, Motion estimation, Stereo vision, Object detection and recognition, Object tracking, 3D scene reconstruction, Context and scene understanding, Image stitching, Image-based and video-based rendering, High-performance computing paradigms for vision and image processing.

Text & Reference books:
1. Computer Vision - A Modern Approach, by D. Forsyth and J. Ponce, Prentice Hall, 2003. Publisher: Pearson; 2nd edition (November 5, 2011), ISBN-13: 978-0136085928.
2. Szeliski R., Computer Vision - Algorithms and Applications, Springer, 2011. Publisher: Springer; 2011 edition (November 24, 2010), ISBN-13: 978-1848829343.
3. J. R. Parker, Algorithms for Image Processing and Computer Vision, Willey Publishing Inc. 2011. Publisher: Wiley; 2nd edition (December 21, 2010), ISBN-13: 978-0470643853.
4. Gonzalez R. C., Woods R. E., Digital Image Processing, Pearson Education, 3rd edition, 2008. Publisher: Pearson; 3 edition (August 31, 2007), ISBN-13: 978-0131687288.

CS-307 Digital Image Processing (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Understand the basics, applications in general, working inside the digital camera, sampling and quantization, image representation, etc.
- Implement image enhancement, image segmentation, image transformations, spatial and frequency domain processing, filtering, convolution, image registration, feature detection, pattern recognition, etc
- Evaluate the performance of different image processing algorithms.

Course outline:
The human visual system, electromagnetic system, working and components inside digital camera, pixels, image representation, sampling, quantization, mathematics of image formation, convolution, camera projection, point-based image processing, Fourier theory, image filtering in spatial and frequency domain, wavelets, image registration, morphological operations, color models, multispectral images, feature detection, image segmentation, Pattern recognition, etc.

Text & Reference books:
1. Gonzalez R. C., Woods R. E., Eddins S. L., Digital Image Processing Using Matlab, Pearson Education, 2nd edition, 2009. Publisher: Gatesmark Publishing; 2nd edition (2009), ISBN-13: 978-0982085400

2. Gonzalez R. C., Woods R. E., Digital Image Processing, Pearson Education, 3rd edition, 2008. Publisher: Pearson; 3 edition (August 31, 2007), ISBN-13: 978-0131687288

3. Understanding Digital Signal Processing by Richard G. Lyons, Prentice Hall; 3rd edition, 2010. Publisher: Prentice Hall; 3 edition (November 11, 2010), ISBN-13: 978-0137027415

CS-308 Web Design & Development (3-0-3)
Prerequisite: CS-102 Programming Fundamentals

Course Objectives:
After completing this course, the students will be able to:

Course Outline:
HTML, DHTML, CSS, clients side scripting, server side scripting, dynamic website development. Introduction to current technology e.g. MySQL, php, ASP, ASP.net. Introduction to related methods and tools e.g., website hosting, database connectivity, Macromedia. Overview of XML

Text & Reference books:
1. Web enabled Commercial application development using HTML, DHTML, **Publisher:** BPB (30 September 2009), **ISBN-13:** 978-8183330084
2. JAVASCRIPT by Ivon Bayross. BPS Publications.
3. Beginning ASP by Richard Anderson, Brain Francis. Wrox series Publications. **Publisher:** Peer Information; Special edition (February 2002), **ISBN-13:** 978-8173664335

CS-309 Computer Graphics (3-0-3)
Prerequisite: None

Course Objectives:
After completing this course, the students will be able to:
- Comprehend the structure of modern computer graphics systems.
- Explain the basic principles of implementing computer graphics fundamentals.
- Compare key algorithms for modelling and rendering graphical data.
- Develop design and problem solving skills with applications to computer graphics.
- Construct interactive computer graphics programs using OpenGL.

Course outline:
Fundamental Concepts: forward and backward rendering (i.e., ray-casting and rasterization), applications of computer graphics: including game engines, cad, visualization, virtual reality, polygonal representation, basic radiometry, similar triangles, and projection model, use of standard graphics APIs (see HCI GUI construction); basic rendering: rendering in nature, i.e., the emission and scattering of light and its relation to numerical integration, affine and coordinate system transformations, ray tracing, visibility and occlusion, including solutions to this problem such as depth buffering, painter's algorithm, and ray tracing, the forward and backward rendering equation, simple triangle rasterization, rendering with a shader-based API, texture mapping, including minification and magnification (e.g., trilinear MIP-mapping), application of spatial data structures to rendering, sampling and anti-aliasing, scene graphs and the graphics pipeline; geometric modeling: basic geometric operations such as intersection calculation, proximity tests, polynomial curves and surfaces, approximation techniques such as polynomial curves, bezier curves, spline curves and surfaces, animation as a sequence of still images.

Text & Reference books:
1. Computer Graphics with Open GL (4th Edition) by Donald D. Hearn, Prentice Hall, 2010, ISBN-10: 0136053580. Publisher: Pearson; 4 edition (November 19, 2010), ISBN-13: 978-0136053583.
2. Foundations of 3D Computer Graphics by S. J. Gortler, The MIT press, 2012. Publisher: The MIT Press (July 13, 2012), ISBN-13: 978-0262017350.
3. Fundamentals of Computer Graphics, 3rd Edition, A K Peters, 2009. Publisher: A K Peters/CRC Press; 3 edition (July 21, 2009), ISBN-13: 978-1568814698.

4. Computer Graphics: Principles and Practice, 3rd Edition, Addison Wesley, 2013. 5.   Real-Time Rendering, 3rd Edition, A K Peters, 2008.Publisher: A K Peters/CRC Press; 3 edition (July 25, 2008), ASIN: B007COYODQ.

CS-310 Expert Systems (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Understand important problems, challenges, concepts and techniques from the field of Expert Systems.
- Learn how to analyze, design, and build systems with ability to deal with knowledge in various forms.
- Know importance of an explanation of many systems' suggestions in a format accessible to humans.

Course outline:
Introduction of expert systems, Review of knowledge representation, Review of inference techniques, Study of logic, rule-based expert systems, Review of course expert system development software, Demonstration of a rule based expert system, Workshop: Building a small rule-based expert system, Advance expert system programming techniques, Review of typical programming errors, Review of MYCIN, Overview of inexact reasoning, Study of inexact classification, intelligent database management, intelligent distributed problem solving.

Text & Reference books:
1. Expert Systems: Principles and Programming, Joseph C. Giarratano, Gary D. Riley, 4th Edition, Course Technology, 2004,. ISBN-13: 978-0534384470 Publisher: Course Technology; 4 edition (October 15, 2004).
2. Jess in Action: Java Rule-Based Systems, Ernest Friedman-Hill, Manning Publications, July 2003 ISBN-13: 978-1930110892,. Publisher: Manning Publications (July 2003).

CS-311 Data Warehousing (3-0-3)
Prerequisite: CS-206 Database Systems

Course Objectives:
After completing this course, the students will be able to:
- Manage large database systems.
- Monitor the processing of database system.

Course outline:
Need for DW, Evolution of Business intelligence, DW building blocks, Intro to data marts, architectural types, Trends, Web enabled DW, Planning and Project management, Defining Requirements, Metadata, Storage Specifications, Info delivery strategy, Architectural components and frameworks, Tools, Types of functional areas for metadata, Schemas, Star Schema, Dimensional Modelling, Data Extraction, Transformation and loading, OLAP Models, Data Quality.

Text book:
1. Data warehousing fundamentals for IT Professionals by Paulraj ponniah, (2011). John Wiley and Sons. (Latest Edition). **Publisher:** Wiley; 2 edition (May 24, 2010), **ISBN-13:** 978-0470462072

CS-312 Artificial Neural Networks (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Understand key components in the field of artificial intelligence.
- Implement classical artificial intelligence techniques.
- Analyze artificial intelligence techniques for practical problem solving.

Course Outline:
Introduction to cybernetics, Brain and Neural System as Cybernetics, Type of Neural Networks, Static and Dynamic Neural Networks, Neuron Models. Network Architecture and Toplogy, Training and Validation Procedure, Perceptron, Hamming Network, Feed forward Layer, Recurrent Layer, Perceptron Learning Rule, Proof of

Convergence, Signals and Weight Vector Space, Linear Transformation, Performance Surface and Optimization, Hebbian and Widrow-Hoff Learning, Back-propagation and Variations. Associative Learning, Competitive Networks using SOM, Biological Motivation for Vision using Grossberg Network, Adaptive Resonance Theory, Hopfield Network, Cellular Neural Network. Evolutionary Neural Network, Spike Neural Networks, Application of Neural Networks in Signal and Image Processing, Bioinformatics, Telecommunication and High Energy Physics. Quantum Neural Networks.

Text book:
1. Neural Network Design, Martin T. Hagan, Howard B. Demuth, Mark H. Beale,. ISBN-13: 978-0971732117 Publisher: Martin Hagan; 2 edition (September 1, 2014).

CS-313 Fuzzy Logic Systems (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Outline:
Mathematical introduction of fuzzy sets and fuzzy logic, A study of the fundamentals of fuzzy sets, operations on these sets, and their geometrical interpretations. Methodologies to design fuzzy models and feedback controllers for dynamical systems, fundamental concepts of dynamical systems, multi-input multi-output dynamical systems, stability, feedback control design, and MATLAB® Control System Toolbox. Fuzzy systems and properties Fuzzifier and Defuzzifier design, Design of fuzzy systems Fuzzy controllers, Hardware and Software based design of fuzzy logic control system.

Text & Reference books:
1. A Course in Fuzzy Systems and Control, Li-Xin Wang (Prentice-Hall). **Publisher:** Prentice Hall; 1 edition (August 30, 1996, **ISBN-13:** 978-0135408827
2. Hand out and research papers related with the subject.

CS-404 Web Engineering (3-0-3)
Prerequisite: CS-102 Programming Fundamentals

Course Objectives:
After completing this course, the students will be able to:
- Discuss how web standards impact software development.
- Describe the constraints that the web puts on developers.
- Design and Implement a simple web application.
- Review an existing web application against a current web standard.

Course outline:
Web programming languages (e.g., HTML5, CSS 3, Java Script, PHP/JSP/ASP.Net), Design principles of Web based applications, Web platform constraints, Software as a Service (SaaS), Web standards, Responsive Web Design, Web Applications, Browser/Server Communication, Storage Tier, Cookies and Sessions, Input Validation, Full stack state management, Web App Security - Browser Isolation, Network Attacks, Session Attacks, Large scale applications, Performance of Web Applications, Data Centers, Web Testing and Web Maintenance.

Text & Reference books:
1. Web Engineering, Rajiv Chopra, Prentice-Hall of India, 2016. Publisher: Prentice-Hall of India Pvt.Ltd; 1st edition (September 30, 2016), ISBN-13: 978-8120352544.
2. Web Engineering, Emilia Mendes and Nile Mosley, Springer Verlag, 2010. Publisher: Springer; 2006 edition (December 22, 2005), ISBN-13: 978-3540281962.
3. Web Engineering: A Practitioners' Approach, Roger S. Pressman, McGraw Hill, 2008.
4. Dynamic HTML: The Definitive Reference: A Comprehensive Resource for XHTML, CSS, DOM, JavaScript 3rd Edition, O'Reilly Media 2007. Publisher: O'Reilly Media; Third edition (January 6, 2007, ISBN-13: 978-0596527402.
5. JavaScript: The Definitive Guide, 8th Edition, David Flanagan. O'Reilly Media. 2014. Publisher: O'Reilly Media; 6th edition (May 13, 2011), ISBN-13: 978-0596805524.

CS-405 Fundamentals of Data Mining (3-0-3)
Prerequisite: CS-206 Database Systems

Course Objectives:
After completing this course, the students will be able to:
- Introduce the techniques, tools and applications of data mining.
- Apply Data Mining techniques to a variety of research and application projects.

Course Outline:
Concepts of Data mining, data pre-processing and pre-mining (noisy and missing data, data normalization and discretization), outlier detection, Data mining learning methods, Data mining classes (association rule mining, clustering, classification), fundamental of other algorithms related to data mining(fuzzy logic, genetic algorithm and neural network), decision trees, rules, patterns and trends.

Text & Reference books:
1. Data Mining: Concepts and Techniques, 3rd Edition Jiawei Han, Micheline Kamber, Jian Pei; , 2011 Publisher: Morgan Kaufmann; 3 edition (July 6, 2011), ISBN-13: 978-9380931913.
2. Data Mning: Concepts, Models, Methods, and Algorithms, 2nd Edition, Mehmed Kantatardzic, 2011. Publisher: Wiley-IEEE Press; 2 edition (August 16, 2011), ISBN-13: 978-0470890455.
3. Data Mining, Introductory and Advanced Topics, 2006, Margaret H. Dunham and S. Sridhar, Pearson Education.
4. Principles of Data Mining, 2007, Max Bramer, Springer-Verlag. ISBN 13: 9781846287657.

CS-406 Mobile Applications Development (3-0-3)
Prerequisite: CS-104 Object Oriented Programming

Course Objectives:
After completing this course, the students will be able to:
- Discuss different architectures & framework for Mobile Application development.
- Develop mobile applications using current software development environments.
- Compare the different performance tradeoffs in mobile application development.

Course outline:
Mobiles Application Development Platform; HTML5 for Mobiles; Android OS: Architecture, Framework and Application Development; iOS: Architecture, Framework; Application Development with Windows Mobile; Eclipse; Fragments; Calling Built-in Applications using Intents; Displaying Notifications; Components of a Screen; Adapting to Display Orientation; Managing Changes to Screen Orientation; Utilizing the Action Bar; Creating the User Interface; Listening for UI Notifications; Views; User Preferences; Persisting Data; Sharing Data; Sending SMS Messages; Getting Feedback; Sending E-mail; Displaying Maps; Consuming Web Services Using HTTP; Web Services: Accessing and Creating; Threading; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages; Challenges with Mobility and Wireless Communication; Location-aware Applications; Performance/Power Tradeoffs; Mobile Platform Constraints; Emerging Technologies.

Text & Reference books:
1. Professional Android application development, Reto Meier, Wrox Programmer to Programmer, 2015. Publisher: Wrox; 1 edition (November 24, 2008), ISBN-13: 978-0470344712.

2. iOS Programming: The Big Nerd Ranch Guide, Conway, J., Hillegass, A., & Keur, C., 5th Edition, 2014. Publisher: Big Nerd Ranch Guides; 4 edition (February 21, 2014), ISBN-13: 978-0321942050.

3. Android Programming: The Big Nerd Ranch Guides, Phillips, B. & Hardy, B., 2nd Edition, 2014. Publisher: Big Nerd Ranch Guides; 3 edition (February 9, 2017), ISBN-13: 978-0134706054.

CS-407 Computational Intelligence (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course outline:
Introduction to Computational intelligence, Applicability and history, Fundamentals of Genetic Algorithms, Encoding, Fitness Function, Tournament Selection, Truncation Selection, Elitist Selection, Crossover, Mutation, Control Parameters Estimation, Parallel Genetic Algorithms, Handling Constraints, Fundamentals and background of Particle Swarm Optimization Techniques, Discrete PSO, Hybrid PSO (HPSO), Adaptive PSO
(APSO), Fundamentals of Ant Colony Search Algorithms, Behavior of Real Ants, The Max-Min Ant System, Use of Greedy Search and Constructive Heuristic Information, Fundamentals of Tabu Search, Neighbourhood Structure, Characterization of the Neighbourhood, Recency-Based Tabu Search, The Use of Long-Term Memory in Tabu Search, Fundamentals of Simulated Annealing, Cooling Schedule, Determination of Cooling Rate, Stopping Criterion, Fuzzy Systems, Creation of the Fuzzy Control, Evolutionary Algorithms, Differential Evolution, Key Operators for Differential Evolution.

Text & Reference Materials:
1. Computational Intelligence: An Introduction, Second Edition, 2007, Andries P. Engelbrecht, Print ISBN: 9780470035610,. ISBN-13: 978-0470035610, Publisher: Wiley; 2 edition (November 19, 2007).
2. Modern Heuristic Optimization Techniques: Theory and Applications to Power Systems, Kwang Y. Lee (Editor), Mohamed A. El-Sharkawi (Editor), IEEE Press Series on Power Engineering, Publication Date: February 8, 2008.

CS-408 Multi Agent Systems (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Understand the agent system terminology and development process of agent-based systems.
- Understand the techniques to design agent-based system.
- Understand how to modify architecture of the current software systems and restructure them to be agent-based.

Course Outline:
Intelligent Agents Introduction, Agents and Expert Systems, Abstract Architectures for Intelligent Agents reactive agents, deliberate agents Concrete Architectures for Intelligent Agents, Multiagent Systems and Societies of Agents, Agent Communications, Distributed Problem Solving and Planning, Task Sharing, Distributed Planning, Search Algorithms for Agents, Distributed Rational Decision Making, Task Allocation Negotiation, Learning in Multiagent Systems.

Text & Reference books:
1. Multi-agent systems: an introduction to distributed artificial intelligence. Steven J. Ferber. Addison-Wesley, 1999. Publisher: *Addison-Wesley* Professional, ISBN: 978-0201360486
2. Multiagent systems: a modern approach to distributed artificial intelligence. G. Weiss. The MIT Press, 1999. .
3. Introduction to Multi Agent Systems, Wooldridge, Michael, 2009, John Wiley & Sons. Publisher: Wiley; 2nd edition (June 22, 2009), ISBN-13: 978-0470519462.

CS-409 Natural Language Processing (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Identify techniques for information retrieval, language translation, and text classification.
- List the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks.
- Define and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each.
- Simulate, apply, or implement classic and stochastic algorithms for parsing natural language.

Course outline:
Deterministic and stochastic grammars, Parsing algorithms, CFGs, Representing meaning / Semantics, Semantic roles, Temporal representations, Corpus-based methods, N-grams and HMMs, Smoothing and backoff, POS tagging

and morphology, Information retrieval, Vector space model, Precision and recall, Information extraction, Language translation, Text classification, categorization, Bag of words model.

Text & Reference books:
1. Python Machine Learning, Sebastian Raschka. Publisher: Packt Publishing, 2015. Publisher: Packt Publishing; 1 edition (September 23, 2015), ASIN: B00YSILNL0.
2. Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit Latest Edition, Steven Bird, Ewan Klein and Edward Loper Publisher: O'Reilly Media, 2009. Publisher: O'Reilly Media; 1 edition (July 10, 2009), ISBN-13: 978-0596516499.
3. Speech and Language Processing, Latest Edition, Daniel Jurafsky and James H. Martin Publisher: Prentice Hall, 2000. Publisher: Prentice Hall; 2nd edition (May 16, 2008), ISBN-13: 978-0131873216.

CS-410 Game Development (3-0-3)
Prerequisite: CS-104 Object Oriented Programming

Course outline:
History of Computer and Video Games, Game Design Principles, Python Programming, Pygame, Storytelling, Sprites and Animation, Game Development Methodologies, Physics, Loose Ends, Audio, Sound, and Music (PDF), 2D Game Group Project Check-In, Game Testing, Ethics, MMORPGs, and Securing Online Games, Game Engines, iOS Development, Cocos2D, Games in 2012 and Beyond.

Text & Reference books:
1. Agile Game Development with Scrum, by Clinton Keith (Addison-Wesley, 2010). Publisher: Addison-Wesley Professional; 1 edition (June 2, 2010), ISBN-13: 978-0321618528.
2. AI for Game Developers, by David Bourg and Glenn Seemann (O'Reilly Media, 2004). Publisher: O'Reilly Media; 1 edition (August 2, 2004), ISBN-13: 978-0596005559.
3. The Art of Game Design: A Book of Lenses, by Jesse Schell (Morgan Kaufmann, 2008). Publisher: CRC Press; 1 edition (August 4, 2008), ISBN-13: 978-0123694966.
4. Fundamentals of Game Design, Second Edition, by Ernest Adams (New Riders, 2010). Publisher: New Riders; 2 edition (September 24, 2009), ISBN-13: 978-0321643377.

CS-411 Logical Paradigms of Computing (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Understand how formal methods (FM) help produce high-quality software
- Write and understand formal requirement specifications

Course Outline:
Introduction to logic, modal logic, propositional and predicate logic and their proof theories, relational and temporal logic, linear time temporal logic (LTL), Computation Tree Logic (CTL), CTL*, mu-Calculus, Introduction to Model checking and model checking algorithms, formal program verifications, partial order correctness, proof calculus for partial proof rules, introduction to statistical and stochastic processes (random walk, Markov chains, hidden Markov chains), introduction to process algebra, and evolutionary computing.

Reference Materials:
1. Logic in Computer Science Modelling and Reasoning about Systems 2nd Edition Michael Huth, Imperial College of Science, Technology and Medicine, London Mark Ryan, University of Birmingham, 2004. Date Published: August 2004, ISBN: 9780521543101.
2. Principles of Model Checking by Christel Baier and Joost-Pieter Katoen MIT Press, 2008. ISBN:026202649X 9780262026499, Verlag: The MIT Press, Year of Publication: 2008.

CS-412 Formal Methods (3-0-3)
Prerequisite: CS-201 Discrete Structures

Course Objectives:
After completing this course, the students will be able to:
- Describe the costs and benefits of formal methods.
- Construct formal models of sequential software systems.
- Implement sequential software systems based on formal models.
- Verify attributes of formal models.
- Demonstrate formal correctness of simple procedure.

Course outline:
Introduction to the use of mathematical models for specification and validation, Finite state machine models, models of concurrent systems, verification of models, and limitations. Analyzing well-formedness (e.g. completeness, consistency, robustness, etc.), Analyzing correctness (e.g. static analysis, simulation, model checking, etc.), Formal analysis, An introduction to VDM-SL, Sets, Sequences, Composite objects, Maps, VDM-SL, Comparative Formal Methods, Proofs, Introduction to Z.

Text & Reference books:
1. Modern Formal Methods and Applications, Hossam A. Gabbar, Springer-Verlag 2006. Publisher *Springer-Verlag* New York Inc, Publication date 01 Feb *2006,* ISBN 13: 9781402042225.
2. Formal Software Development: From VDM to Java, Charatan, Quentin, and Aaron Kans. Palgrave Macmillan, 2003 Publisher: Palgrave Macmillan; 2003 edition (9 Sept. 2003),. ISBN-13: 978-0333992814.
3. Understanding Z: a Specification Language and its Formal Semantics. J. M. Spivey. 1988. Cambridge University Press, New York, NY, USA. Publication:Cambridge University Press New York, NY, USA ©1988, ISBN:0-521-33429-2.

CS-413 System Programming (3-0-3)
Prerequisite: CS-302 Operating Systems

Course outline:
Introduction to Operating Systems, File Processing, Memory Management, Memory Mapped Files and DLLs, Process management, Threads and scheduling, Thread synchronization, Inter-process Communication, Input/Output, Device Drivers (USB or Parallel Port), File System Drivers, Filter Drivers.

Text & Reference books:
1. Windows System Programming 3rd edition, Johnson M. Hart, Addison Wesley.
2. The Windows NT Device driver book 2nd edition, Art Baker, Prentice Hall.

CS-414 Network Security (3-0-3)
Prerequisite: CS-305 Computer Networks

Course Outline:
Introduction; Cryptology and simple cryptosystems; Conventional encryption techniques; Stream and block ciphers; DES; More on Block Ciphers; The 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; Miscellaneous topics.

Text & Reference books:
1. W. Stallings, Cryptography and Network Security, Prentice Hall PTR, Upper Saddle River, NJ, 2003.
2. Kaufman, R. Perlman, M. Speciner, Network Security: Private Communication in a Public World Prentice Hall PTR, Upper Saddle River, NJ, 2002.
3. M. Bishop, Computer Security: Art and Science Addison-Wesley, 2003.
4. Stinson, Cryptography: Theory and Practice, CRC Press, Boca Raton, FL, 1995.
5. Richard A. Mollin, An Introduction to Cryptography, Chapman and Hall/CRC, 2001.
6. B. Schneier, Applied Cryptography, John Wiley and Sons, NY, 1996.

7. Menezes, P. Oorshcot, and S. Vanstone, Handbook of Applied Cryptography, CRC Press, Boca Raton, FL, 1997.

CS-415 Advanced Database Systems (3-0-3)
Prerequisite: CS-206 Database Systems

Course Outline:
Overview of Databases Management Systems, Object-Oriented Databases, Object-Relational Databases, Mobile Databases, Temporal, Spatial Databases, Geographic Databases, Distributed Database Design, Distributed Multimedia Database Systems, Data Warehouse and OLAP Systems, XML Data Models, XML Documents and DTD, XML Query Languages, Advance Database Designing Techniques and Trends. Modeling Tools and Techniques for Advance Database Systems. Implementation and Applications of Advance Database Systems. Research Trends in database systems.

Text & Reference books:
1. Advanced Database Systems by Carlo Zaniolo, Stefano Ceri, Christos Faloutsos, Richard T. Snodgrass, V. S. Subrahmanian, Roberto Zicari, Morgan Kaufmann; 1st Edition (May 15, 1997). ISBN-10: 155860443X
2. XQuery by Priscilla Walmsley ISBN: 0596006349
3. Spatial Databases: With Application to GIS by Hilippe Rigaux. ISBN: 1558605886
4. Foundations of Semantic Web Technologies by Pascal Hitzler. ISBN: 142009050X.