CURRICULUM

OF

COMPUTER SCIENCE, SOFTWARE ENGINEERING & INFORMATION TECHNOLOGY

FOR

BS/MS

(Revised 2013)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled **"Supervision of Curricula and Textbooks and Maintenance of Standard of Education".** With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

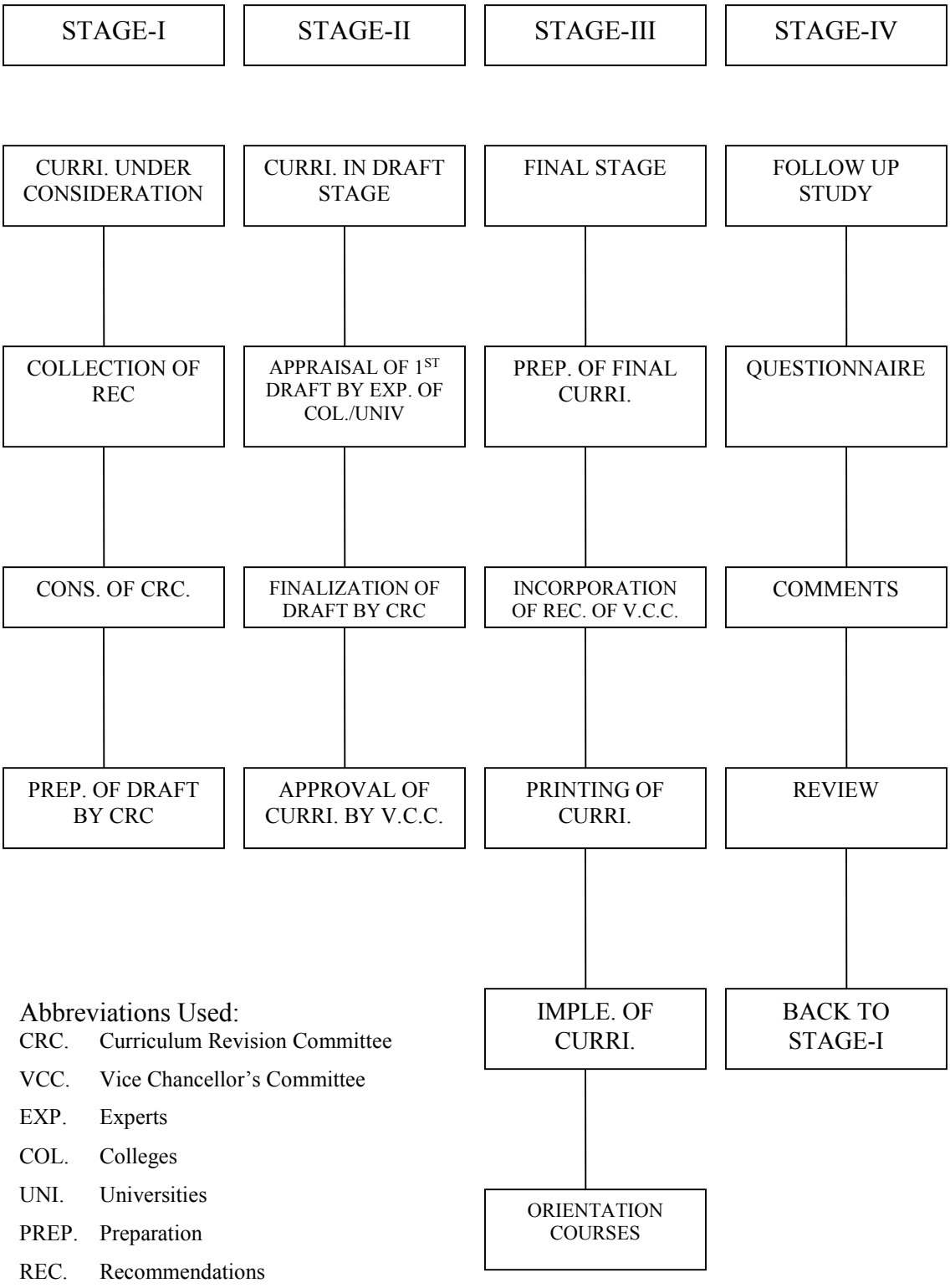
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC. Curriculum Revision Committee

VCC. Vice Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

REC. Recommendations

Introduction:

National Curriculum Revision Committee

A three day final meeting of the National Curriculum Revision Committee pertaining to revising the curriculum for Computer Science, Software Engineering, and IT degree programmes developed in 2008-09 was held from June 10-12, 2013 at HEC regional Centre, Lahore. The aims and objectives of the meeting were to discuss the deliberations and finalization of curricula drafted by committees of the last meeting, in the same areas, held in February 2013.

Committee Members:

The following members took part in revising the curricula of Computer Science under the supervision of Dr. Abu Turab Alam, convener of the revision committees. The information covered in this document was the effort of the people worked under the following structure:

National Curriculum Revision Committee (NCRC) year 2013
Convener: Dr. Abu Turab Alam
Sub-Committees
1. Computer Science (Chair: Dr. Shariffullah Khan)
2. Software Engineering (Chair: and Convener Dr. Abu Turab Alam)
3. Information Technology (Chair: Dr. Muhammad Anwar-ur-Rehman Pasha)

Committee Members and Curriculum for Computer Scinece

1.	Dr. Sharifullah Khan, Associate Professor, School of Electrical Engg & Computer Science National University of Science & TechnologyH-12 Islamabad.	(Chairperson CS committee)
2.	Dr. Imdad Ali Ismaili, Professor & PVC, Institute of Information & Communication Technology, University of Sindh, Allama I.I. Kazi Campus, Jamshoro, Sindh.	Member
3.	Dr. Hameedullah Kazi, Associate Professor & Chairperson, Dept. of Electrical Engg & Computer Science, ISRA University, Hyderabad, Sindh	Member
4.	Dr. Abdul Basit Siddiqui, Assistant Professor, Dept. of Software Engg,	Member

	Foundation University Institute of Engg. & Management Sciences, New Lalazar Rawalpindi	
5.	Dr. Syed Asad Raza Kazmi, Assistant Professor, Dept. of Computer Science, Government College University, Lahore.	Member
6.	Dr. Aurangzeb Khan, Director/Assistant Professor, Institute of Engg & Computing Sciences, University of Science & Tech, Bannu.	Member
7.	Dr. Muhammad Abuzar Fahiem, Head, Dept. of Computer Science, Lahore College for Women University, Lahore.	Member
8.	Mr. Asim Munir, Professor / Chairman, Dept. of Computer Science & Software Engg, International Islamic University, H-10, Islamabad.	Member
9.	Dr. Zahid Hussain, Professor, Head of Dept. Computer Science & Information Tech, The University of Lahore, Lahore.	Member
10.	Dr. Aftab Ahmed Shaikh, Associate Professor & Dean, Faculty of ICT Dept. of Computer Science, Balochistan University of Information Tech. Engg & Management Sciences, Quetta.	Member
11.	Mr. Amjad Hussain Zahid, Assistant Professor, Dept. of Computer Science, Forman Christian College, Ferozepur Road, Lahore.	Member

12.	Dr. Syed Jamal Hussain, Assistant Professor, Dept. of Computer Science, University of Karachi, Karachi.	Member
13.	Dr. Sehat Ullah, Assistant Professor, Dept. of Computer Science & IT, University of Malakand, Chakdara Dir (Lower).	Member
14.	Dr. Ayesha Maqbool. Assistant Professor & Coordinator Dept. of Computer Science, Shaheed Benazir Bhutto Women University,	Member
15.	Dr. Arshad Aziz Professor, Department of Electrical Engineering Pakistan Navy Engineering Colledge National University of Science and Technology PNS, Johar, Habib Rehmatullah Road	Member
16.	Prof. Dr. Aftab Ahmad Malik, Dean,Faculty of Computer Science Engg, GIK Institute of Engg & Tech, Topi, Swabi, KPK	Member
17.	Dr. Ehsan Ullah Munir, Associate Professor / HOD, Dept. of Computer Science, COMSATS Institute of Information Tech (CIIT), Quaid Avenue, Wah Cantt.	Member
18.	Dr. Syed Asif Ali, Associate Professor, Department of Computer Science, Sindh Madresatul Islam University, Awan-e-Tijarat Road, Karachi-74000	Member
19.	Dr. Syed M. Aqil Burney HoD, Depart of Actuarial Science, IoBM, Karachi.	Member

20.	Muhammad Anwaar Saeed Assistant Professor Computer Science Department, Virtual University of Pakistan, Islamabad Campus, 9-E, Rizwan Plaza, Blue Area, Islamabad, Pakistan.	Member

Curricula Consideration

The committee used the following basis, particularly on panel discussion, to revise the curricula of BS(CS), BS(SE), and BS(IT).

- Programme Objectives
- Programme Outcomes and Strategies
- Fast Changing Disciplines
- Emerging Technologies
- International Standards
- Industrial Challenges
- Possible Programme design structure

The committee unanimously approved the proposed objectives of each programme, its structure, eligibility criteria, general recommendation regarding the update and revise of the curricula.

The structure and other details of the programme proposed by the committee were designed inline to the recommendations of various leading bodies continuously in the quest of designing the educational programme of Computer Science and related disciplines. These bodies include IEEE and ACM.

Section-I

Computer Science Programme BS (CS)

Many changes were recommended in various sections of the curricula developed by this Committee in the last meeting held in February 2013. In the meeting scheduled on June 10-12 2013, the Committee finally agreed to the curriculum model presented in the following table.

Table-1.1: Course Category and Credit Hours for BS(CS)

S.No.	Category	Credit Hours	
1	**Computing Courses**		52
	Core Courses	40	
	Supporting Areas Courses	12	
2	**Computer Science Courses**		48
	Com. Sc. Core Courses	21	
	Com Sc. Supporting Courses	9	

	Comp. Sc. Electives	18	
3	**General Education Courses**	18	18
4	**University Elective Courses**	12	12
	Total Credit Hours		**130**

A complete detail of BS programme involving programme structure and distribution of credits among various components of programme are discussed in the following pages.

Recent Development in Technology:

Recent developments in computer hardware, software and communication technologies have offered new exciting opportunities and challenges for creation of innovative learning environments for Computer Science and its curricula design. One of the key elements here is to prepare the graduates for the future. The challenge of getting all newly emerging technologies incorporated in to the curriculum is becoming pivotal for the effectiveness of curricula. There is a need for curricula structures that are really able to grow as we put new demands on them. The curriculum is required to provide integration of all components and the foundations that allow accessing all of the new knowledge and technology to fulfil the vision of future.

The basic intention of an academic programme in Computer Science is to develop the student's critical professional thinking and intuition. The curriculum must be structured to provide a balanced mixture of learning experiences to make the graduate capable of sound professional decisions. As a result the graduate should be able to assume responsible positions in business, government, and education at the research, development, and planning levels. The programme should also provide an excellent foundation for further formal learning and training. The Computer Science curriculum is expected to provide environments to put into practice, the principles and techniques learnt during the course of implementation of academic programme.

The following summarizes some key characteristics for consideration as a basis of a successful academic programme in Computer Science:

The programme should provide a broad understanding of the field via introducing concepts, theory, and techniques.

Intensive education/training in focused areas of Computer Science is desirable.

The programme may encourage students to develop and use abstract models in addition to apply respective technology in practical situations.

Computer Science graduates require special communication skills both orally and in writing. They must be able to produce well-organized reports, which clearly delineate objectives, methods of solution, results, and conclusions for a complex task.

The programme should provide formal foundations for higher learning.

The programme should be dynamic and flexible enough to maintain currency with the latest scientific and technological developments in the field.

The programme should provide professional orientation to prepare students for industry.

Programme Structure:

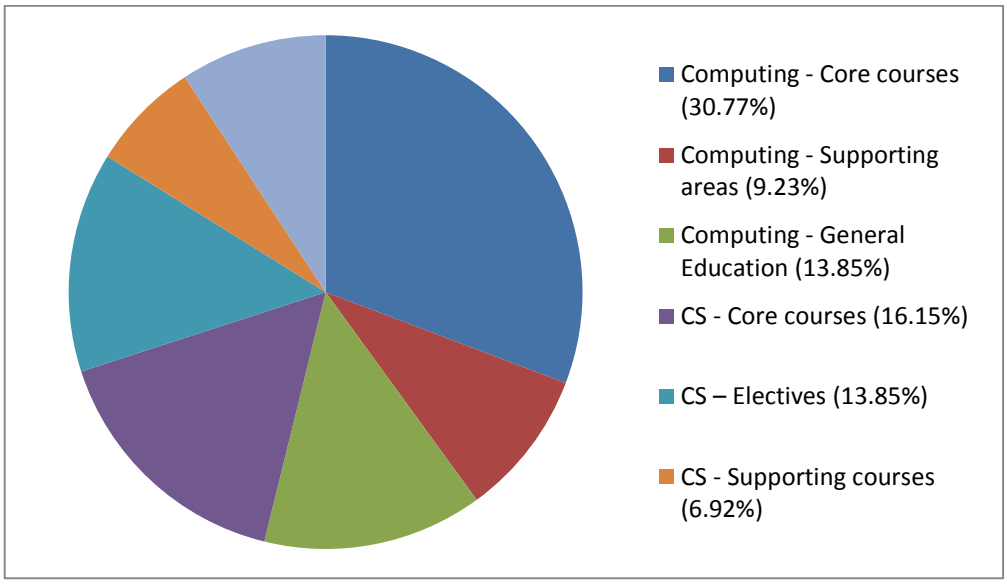
The structure of a BS programme in Computer Science is proposed to meet the needs of students with formal computing experience and with established relevant skills. The students are expected to learn theoretical and practical understanding of the entire field of Computer Science.

The proposed structure is dynamic and provides basis for various options including Breadth-Based, Depth-Based, and Integrated Breadth & Depth-Based specializations. Student may choose a particular option, which is most appropriate to their planned future career. The following are some relevant details:

- Minimum credit hours shall be 130 for BS (Computer Science) programme including computing related courses.
- The programme shall comprise 8 semesters spread over 4 years with two semesters a year.
- The major area of specialization shall be incorporated in the structure. Each major area shall comprise of 4-6 courses.
- The following table gives the percentage distribution of total credit hours.

Table 1.2: Percentage Distribution

Course Group	Credit hour	Percentage
Computing - Core courses	40	31%
Computing - Supporting areas	12	9%
Computing - General Education	18	14%
CS - Core courses	21	16%
CS – Electives	18	14%
CS - Supporting courses	9	7%
University Electives	12	9%



Some knowledge areas in Computer Science Electives Courses are listed below:

a) Networking
b) Information Management
c) Intelligent Systems
d) Graphics & Visualization
e) Software Engineering
f) Web Engineering
g) E-Commerce
h) Multimedia
i) Distributed Computing
j) Security
k) Languages and Translators
l) Computer Architecture
m) Systems Software
n) Scientific Computing
o) Soft Computing

University Electives:

It was unanimously recommended that 18 credit hours shall require to be taken from the list of general elective courses. The university may add any number of courses to the general elective courses preferably other than Computer Science courses.

Eligibility Criteria:

The eligibility criteria of the curriculum by the last meeting were opened for discussion in the House. It was thoroughly discussed by considering all input streams of BS (Computer Science). The House unanimously recommended the eligibility criteria for admission to BS (Computer Science) as given:

The candidates require intermediate or equivalent qualification. However, the university shall define their selection criteria.

General Recommendation Regarding Implementation of Programme:

Faculty level and orientation is vital for the successful implementation It is strongly recommended that the BS programme should be only implemented via experienced computer science faculty having formal education in Computer Science.

The access to state of the art computing and information technology is essential for creation of innovative learning environments. Professional areas of specialization such as computer graphics, multimedia systems, computer networking and virtual reality or design automation require very special and dedicated computing facilities. Dedicated computing facilities are essential for hands-on experience. Variety of programming languages systems and operating systems must be available.

		Computing - CS Core Courses		
#	**Pre Req**	**Course Title**	**Credit hours**	**Proposed Semester**
1	-	Programming Fundamentals	4 (3+1)	1
2	1	Object Oriented Programming	4 (3+1)	2
3	1	Data Structure and Algorithms	3 (2+1)	3
4		Discrete Structures	3	1
5	-	Digital Logic Design	3 (2+1)	3
6	3	Operating Systems	4 (3+1)	5
7	-	Database Systems	4 (3+1)	5
8	2	Software Engineering	3	6
9	-	Data Communications and Computer Networks	3 (2+1)	6
10	-	Human Computer Interaction	3 (2+1)	7
11	-	Final year Project	6	7, 8
		Total Credit hours	**40**	

Besides faculty and computing facilities, substantial library resources are important to support a rigorous graduate programme in information technology. Students should have access to digital libraries and knowledge resources via Internet technologies.

BS Computer Science Curriculum

Computing courses:

			Computing – Supporting Courses		
#	Code	Pre-Req	Course Title	Credit hours	Proposed Semester
12	MT	-	Calculus and Analytical Geometry	3	1
13	MT	-	Probability and Statistics	3	3
14	MT	-	Linear Algebra	3	2
15	EL	-	Basic Electronics	3 (2+1)	2
			Total Credit hours	12	

			Computing – General Education Courses		
#	Code	Pre-Req	Course Title	Credit hours	Proposed Semester
16	EG	-	English Composition and Comprehension	3	1
17	EG	-	Technical and Business Writing	3	2
18	EG	-	Communication Skills	3	3
19a	PK	-	Islamic Studies / Ethics	2	1
19b	PK	-	Pakistan Studies	2	2
20	SS	-	Professional Practices	3	7
21	CS	-	Introduction to Information and Communication Technologies	3 (2+1)	1
			Total Credit hours	**19**	

Computer Science Courses

			Computer Science – Core Courses		
#	Code	Pre-Req	Course Title	Credit Hours	Proposed Semester
22	CS	5	Microprocessor and Assembly Language	3 (2+1)	4
23	CS	-	Theory of Automata	3	5
24	CS	3	Design and Analysis of Algorithms	3	5
25	CS	3	Artificial Intelligence	3 (2+1)	6
26	CS	5	Computer Architecture and Organization	3	4
27	CS	23	Compiler Construction	3 (2+1)	7
28	CS	9	Information Security	3	7
			Total Credit Hours	**21**	

			Computer Science – Supporting Courses		
#	Code	Pre Req	Course Title	Credit Hours	Proposed Semester
29	CS	12	Numerical Computing	3 (2+1)	8
30	ST	12	Multivariate Calculus	3	4
31	ST	12	Differential Equations	3	5
			Total Credit Hours	**9**	

	Computer Science – Elective Courses Not limited to the list below		
#	Course Title	Credit hours	Proposed Semester
32	Computer Graphics	3 (2+1)	6
33	Digital Image Processing	3 (2+1)	6
34	Digital Signal Processing	3	6
35	Computer Vision	3	7
36	Distributed Computing	3 (2+1)	6
37	Data and Network Security	3	7
38	Wireless Networks	3 (2+1)	6
39	Social Computing	3	8
40	Mobile Application and Development	3 (2+1)	8
41	Web Design and Development	3 (2+1)	5
42	Data Warehousing	3 (2+1)	6
43	Expert Systems	3	
44	Artificial Neural Network	3	
45	Fuzzy Logic	3	
46	Web Engineering	3	
47	Fundamentals of Data Mining	3	
48	Computational Intelligence	3	
49	Multi Agent Systems	3	
50	Natural Language Processing	3	
51	Game Development	3	
52	Logical Paradigms of Computing	3	
53	Formal Methods for Software Engineering	3	

University Elective Courses

	Computer Science – University Elective Courses Not limited to the list below		
#	Course Title	Credit Hours	Proposed Semester
101	Financial Accounting	3	
102	Financial Management	3	4
103	Human Resource Management	3	5
104	Marketing	3	6
105	Economics	3	7
106	Psychology	3	6
107	International Relations	3	7
108	Foreign/Regional Language (French, German, Sindhi, Punjabi, Urdu etc.)	3	7-8
109	Philosophy	3	6-8

Structure of BS (CS) Programme

#	Category	Credit Hours	
1	Computing Courses		52
	Core Courses	40	
	Supporting Areas Courses	12	
2	Computer Science Courses		48
	Computer Science Core Course	21	
	Computer Science Supporting Courses	9	
	Computer Science Electives Courses	18	
3	General Education Courses	18	18
4	University Elective Courses	12	12
	Total Credit Hours		**130**

- Between 124-136 Credit hours are required for UG Degree
- 51-63 Credit hours should be taken in courses prescribed as major
- 34 Credit hours must be earned taking courses outside the major but within the same school as major
- 30 Credit hours must be earned taking multi-disciplinary courses outside the school of major.
- Regular students are required to take 12 Credit hours, but can take maximum 18 Credit hours if their CGPA is equal or more than 3.5
- Regular graduate students are required to take 9 Credit hours but can take maximum 12 if they meet the above conditions.

Proposed Scheme of Study for BS (CS)

4-Year Programme (8 Semesters)

Semester 1 (18 Cr. Hrs.)	Cr. Hrs.
Programming Fundamentals (Comp. Core)	4 (3+1)
Discrete Structures(Comp. Core)	3
Calculus and Analytical Geometry (Comp. Supporting)	3
Introduction to Information and Communication Technology (Intro to Information System) (Gen. Edu)	3 (2+1)
English Composition and Comprehension (English-I) (Gen. Edu)	3
Islamic Studies/Ethics (Gen. Edu.)	2

Semester 2 (12 Cr. Hrs.)	Cr. Hrs.
Object Oriented Programming (Comp. Core)	4 (3+1)
Linear Algebra (Com – Supporting)	3
Technical and Business Writing(Gen. Edu)	3
Pakistan Studies(Gen. Edu)	2
Basic Electronics (Comp. Supporting)	3 (2+1)

Semester 3 (15 Cr. Hrs.)	Cr. Hrs.
Data Structure and Algorithms(Comp. Core)	3 (2+1)
University Elective I	3
Digital Logic Design (Comp. Core)	3 (2+1)
Probability and Statistics (Comp. Supporting)	3
Communication Skills(Gen. Edu)	3
University Elective II	3

Semester 4 (15 Cr. Hrs.)	Cr. Hrs.
Microprocessor and Assembly Language (Comp. Sc. Core)	3 (2+1)
Computer Architecture and Organization (Comp. Sc. Core)	3
Multivariate Calculus (Comp Sc. Support)	3
University Elective III	3
University Elective IV	3

Semester 5 (17 Cr. Hrs.)	Cr. Hrs.
Operating Systems (Comp. Core)	4 (3+1)
Database Systems (Comp. Core)	4 (3+1)
Theory of Automata (Comp. Core)	3
Design and Analysis of Algorithms (Comp. Sc. Core)	3
Differential Equations (Comp. Sc. Supporting)	3

Semester 6 (15 Cr. Hrs.)	Cr. Hrs.
Introduction to Software Engineering (Comp. Core)	3
Data Communications and Computer Networks (Comp. Core)	3 (2+1)
Artificial Intelligence (Comp. Sc. Core)	3 (2+1)
Computer Science Elective I	
Computer Science Elective II	

Semester 7 (15 Cr. Hrs.)	Cr. Hrs.
Human Computer Interaction (Comp. Core)	3 (2+1)
Professional Practices (Gen. Edu.)	3
Compiler Construction(Comp Sc. Core)	3 (2+1)
Information Security(Comp. Sc. Core)	3
Computer Science Elective III	3
Final Year Project	3

Semester 8 (9 Cr. Hrs.)	Cr. Hrs.
Numerical Computing (Comp Sc Supp)	3 (2+1)
Computer Science Elective IV	3
Final Year Project (Comp. Core)	3

COURSE OUTLINE

Common Computing Core Courses to BS (CS), BS(IT), and BS(SE)

Course Name: **Discrete Structures**
Credit Hours: 3
Prerequisites: **None**

Course Outline:

Mathematical reasoning: introduction to logic, propositional and predicate calculus; negation disjunction and conjunction; implication and equivalence; truth tables; predicates; quantifiers; natural deduction; rules of Inference; methods of proofs; use in program proving; resolution principle; Set theory: Paradoxes in set theory; inductive definition of sets and proof by induction; Relations, representation of relations by graphs; properties of relations, equivalence relations and partitions; Partial orderings; Linear and well-ordered sets; Functions: mappings, injection and surjection, composition of functions; inverse functions; special functions; Peano postulates; Recursive

function theory; Elementary combinatorics; counting techniques; recurrence relation; generating functions.

Graph Theory: elements of graph theory, Planar Graphs, Graph Colouring, Euler graph, Hamiltonian path, trees and their applications.

Reference Materials:

1. *Discrete Mathematical Structure with Application to Computer Science*, J. P. Temblay and B Manohar, McGraw-Hill, 2nd Edition.
2. *Discrete Mathematics,* 7th edition, Richard Johnson Baugh, 2008, Prentice Hall Publishers.
3. *Discrete Mathematics and Its Applications,* 6th edition, Kenneth H. Rosen, 2006, McGraw-Hill Book Co.
4. *Discrete Mathematical Structures, 4th edition*, Kolman, Busby & Ross, 2000, Prentice-Hall Publishers.
5. *Discrete and Combinatorial Mathematics: An Applied Introduction,* Ralph P. Grimaldi, Addison-Wesley Pub. Co., 1985.
6. *Logic and Discrete Mathematics: A Computer Science Perspective* by Winifred Grassman, Jean-Paul Tremblay, Winifred Grassman, Prentice Hall, 1995

Course Name: **Programming Fundamentals**
Credit Hours: 4 (3+1)
Prerequisites: None

Course Outline:

This course covers overview of Computer Programming, Principles of Structured and Modular Programming, Overview of Structured Programming Languages, Algorithms and Problem Solving, Program Development: Analyzing Problem, Designing Algorithm/Solution, Testing Designed Solution, Translating Algorithms into Programs, Fundamental Programming Constructs, Data Types; Basics of Input and Output, Selection and Decision (If, If-Else, Nested If-Else, Switch Statement and Condition Operator), Repetition (While and For Loop, Do-While Loops), Break Statement, Continue Statement, Control Structures, Functions, Arrays, Pointers, Records, Files (Input-Output), Testing & Debugging.

Reference Materials:

1. *C How to Program*, Paul Deitel and Harvey Deitel, Prentice Hall; 7th edition (March 4, 2012)
2. *Programming in C*, Stephen G. Kochan, Addison-Wesley Professional; 4th edition (September 25, 2013). ISBN-10: 0321776410
3. *Java How to Program*, Paul Deitel and Harvey Deitel, Prentice Hall; 9th edition (March, 2011)
4. *C++ How to Programme*, Paul Deitel and Harvey Deitel, Prentice Hall; 9th edition (February, 2013).

Course Name: **Object Oriented Programming**
Credit Hours: 4 (3+1)
Prerequisites: **Programming Fundamentals**

Course Outline:

Evolution of Object Oriented Programming (OOP), Object Oriented concepts and principles, problem solving in Object Oriented paradigm, OOP design process, classes, functions/methods, objects and encapsulation; constructors and destructors, operator and function/method overloading, association, aggregation, composition, generalization, inheritance and its types, derived classes, function/method overriding, abstract and concrete classes, virtual functions, polymorphism, exception handling.

Reference Materials:

1. *An Introduction to Object-Oriented Programming with Java*, C. Thomas Wu (2010). 5th Edition. McGraw-Hill. ISBN: 9780073523309
2. *Java: How to Programme*, 5/e, Deitel and Deitel, Prentice Hall, 0131016210/ 0131202367 International Edition.
3. *Ivor Horton's Beginning Java*, 7/e, Ivor Horton
4. *C++: How to Programme*, Deitel and Deitel, 5/e, Pearson.
5. *Object Oriented Programming in C++*, 3rd Edition, Robert Lafore

Course Name: **Data Structures and Algorithms**
Credit Hours: **4(3+1)**
Prerequisites: **Programming fundamentals, Discrete Structures**

Course Outline:

Introduction to Data Structures and Algorithms; Complexity Analysis; Arrays; Sorting Algorithms: Insertion Sort, Selection Sort, Bubble Sort, Shell Sort, Heap Sort, Quick Sort, Merge Sort, Radix Sort, Bucket Sort; Linked Lists: Singly Linked Lists, Doubly Linked Lists, Circular List; Stacks, Queues, and Priority Queue; Recursion: Function call and Recursion Implementation, Tail Recursion, Non-tail Recursion, Indirect Recursion, Nested Recursion, Backtracking. Trees: Binary Trees, Binary Heap, Binary Search. Tree Traversal, Insertion, Deletion, and Balancing a Tree; Heap; B-Tree; Spanning Tree, Splay Trees; Graphs: Representation, Traversal, Shortest Path, and Cycle Detection; Isomorphic Graphs; Graph Traversal Algorithms; Hashing; Memory Management and Garbage Collection.

Reference Materials:

1. *Data Structures and Algorithm Analysis*, Mark Allen Weiss, Florida International University, Addison-Wesley (latest Edition)
2. *Algorithms*, Robert Sedgewick, Princeton University Publisher: Addison-Wesley Professional (latest Edition)
3. *Data Structures: Abstraction and Design Using Java*, Koffman and Wolfgang, Wiley; 2nd Edition (or latest Edition), 2010

4. *Data Structures and Algorithms in C++*, Adam Drozdek, Course Technology; 4th Edition, 2012.

Course Name: **Digital Logic Design**
Credit Hours: 3 (2+1)
Prerequisites: **Basic Electronics**

Course Outline:

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods K-Maps, Quinne, Mc-Cluskey,, Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, 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, etc.

Reference Materials:

1. *Digital Fundamentals* by Floyd, 11/e.
2. *Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e.*

Course Name: **Operating Systems**
Credit Hours: 4 (3+1)
Prerequisites: **Programming Fundamentals**

Course Outline:

History and Goals, Evolution of multi-user systems. Introduction to the techniques used to implement operating systems and related kinds of systems software. Among the topics covered will be process management (creation, synchronization, and communication); Multi-Threading, processor scheduling; deadlock prevention, avoidance, and recovery; main-memory management; virtual memory management (swapping, paging, segmentation and page-replacement algorithms); control of disks and other input/output devices; file-system structure and implementation; and protection and security. Lab assignments involving different single and multithreaded OS algorithms.

Reference Materials:

1. *Operating System Concepts,* 9th Edition, Silberschatz A., Peterson, J. L., & Galvin P. C. 2012.
2. *Modern Operating Systems,* 3rd Edition, Tanenmaum A. S., 2008.

Course Name: **Database Systems**
Credit Hours: 4 (3+1)
Prerequisites: **Data Structures and Algorithms**

Course Outline:

Basic database concepts, Database Architecture, DB Design Life Cycle, Schema Architecture, Conceptual, Logical and physical database Modelling and design, Entity Relationship diagram (ERD), Enhanced ERD ,Relational data model, mapping ERD to relational model, Functional dependencies and Normalization, Relational Algebra, Structured Query language (SQL), Transaction processing, concurrency control and recovery techniques, Query optimization concepts.

Reference Material:

1. *Database Systems A Practical Approach to Design, Implementation, and Management*, 4th Edition, Thomas Connolly, Carolyn Begg, Addison Wesley, 2005.
2. *Modern Database Management by Fred McFadden, Jeffrey Hoofer*, Mary Prescott, Prentice Hall; 11th Edition (July 26, 2012). ISBN-10: 0132662256
3. *Fundamentals of Database Systems* by R. Elmasri and S. Navathe. 6th Edition, Addison-Wesley (2010). ISBN-10: 0136086209.
4. *Database Design and Relational Theory: Normal Forms and All That Jazz* by C. J. Date, O'Reilly Media; 1st Edition (April 24, 2012). ISBN-10: 1449328016.

Course Name: **Data Communication and Networks**
Credit Hours: 4 (3+1)
Prerequisites: None

Course Outline:

Data Communication concepts, Analogue and digital Transmission, Noise, Media, Encoding, Asynchronous and Synchronous transmission. Network system architectures (OSI, TCP/IP), Error Control, Flow Control, Data Link Protocols, Bridging. Local Area Networks and MAC Layer protocols, Multiplexing, Switched and IP Networks, Inter-networking, Routing. Transport layer protocols TCP, UDP and SCTP. Application Layer Protocols. Wireless LANs.

Lab exercises using tools such as Wireshark, OpNet, Packet tracer etc.

Reference Material:

1. Data Communications and Networking, by Behrouz A. Forouzan, 5th edition, 2013
2. Computer Networks by A. S. Tanenbaum, D. J. Wetherall, 5th Edition Prentice Hall 2010
3. Data and Computer Communications By William Stallings 9th Edition 2011

Course Name: **Introduction to Software Engineering**
Credit Hours: 3
Prerequisites: **Data Structures and Algorithms**

Course Outline:

Overview of SE, Practice & Myths; the Software Processes, Generic Process Models: Framework Activity, Task Set, Process Patterns, Process Improvement, CMM Prescriptive, Process Models: Waterfall Model, Incremental Process Model, Evolutionary Process Model; Specialized Process Models: Component Based Development, the Formal Methods Models, Agile Development; Business Information Systems: Components, Types, and Evaluating methods. SDLC: Phases, System Planning, Preliminary Investigation, SWOT Analysis. The Importance of Strategic Planning; Evaluation of Systems Requests, Requirements Engineering. Difference between Structured Analysis and Object Oriented Analysis, Difference between FDD Diagrams & UML Diagrams; Data & Process Modelling; Diagrams: Data Flow, Context, Conventions, Detailed Level DFD's; Levelling and Balancing. Logical Versus Physical Models. The Design Process; Architecture Design Elements, Interface Design Elements, Component-Level Design Elements, Deployments Design Elements; System Architecture, Architectural Styles. User Interface Design. WebApps Interface Design; Software Quality Assurance. Validation Testing, System Testing; Internal and External View of Testing. Project Management. Risk Management; Maintenance and Reengineering.

Reference Materials:

1. *Software Engineering* 8E by Ian Sommerville, Addison Wesley; 8th Edition (2006). ISBN-10: 0321313798
2. *Systems Analysis and Design* by Gary B. Shelly, Thomas J. Cashman and Harry J. Rosenblatt, Course Technology; 7th Edition (2007). ISBN-10: 1423912225
3. *Software Engineering: A Practitioner's Approach by Roger S. Pressman*, McGraw-Hill Science/Engineering/Math; 7th Edition (2009). ISBN-10: 0073375977.

COMPUTING SUPPORTING COURSES FOR COMPUTER SCIENCE PORGRAMME

Course Name: **Calculus and Analytic Geometry**
Credit Hours: 3
Prerequisites: None

Course Outline:

Complex Numbers, DeMoivre's Theorem and its Applications, Simple Cartesian Curves, Functions and Graphs, Symmetrical Properties, Curve Tracing, Limit and Continuity, Differentiation of Functions. Derivative as Slope of Tangent to a Curve and as Rate of Change, Application to Tangent and Normal, Linearization, Maxima/Minima and Point of Inflexion, Taylor and Maclaurin Expansions and their convergence; Integral as Anti-derivative, Indefinite Integration of Simple Functions. Methods of Integration: Integration by Substitution, by Parts, and by Partial Fractions, Definite Integral as Limit of a Sum, Application to Area, Arc Length, Volume and Surface of Revolution.

Reference Materials:

1. *Calculus and Analytical Geometry*, Swokowski Olinick. Pence. 1994. 6th edition. Brooks/Cole Publishers.
2. *Calculus,* 7th edition.2002. John Wiley and Sons (WIE).
3. *Calculus,* William, E. Boyce .Richard, C. Diprima. John Wiley & Sons, ISBN: 0471093335.
4. *Calculus and Analytical Geometry* 10th edition. Thomas, F. John Wiley and Sons.
5. *Advanced Engineering Mathematics,* 7th edition. Erwin, K. 1993. John Wiley & Sons Inc.

Course Name: **Probability and Statistics**
Credit Hours: 3
Prerequisites: None

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; Regression and Correlation, Estimation and testing of hypotheses, use of elementary statistical packages for explanatory Data analysis.

Reference Materials:

1. *Probability & Statistics for Engineers & Scientists* Ronald, W. Myers, Y. 2008*", 8th edition*. Prentice Hall Publisher.
2. *Probability and Statistics for Engineering and the Sciences* Lay, L. Devore. 2003. Duxbury Publishers.
3. *Statistical Data Analysis*. G. Cowan.1998. Clarendon and Oxford.

Course Name: **Linear Algebra**
Credit Hours: 3
Prerequisites: None

Course Outline:

Vectors, Vector Spaces, Matrices & Determinants, Cofactor and Inverse, Rank, Linear Independence, Solution of system of Linear systems, 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.

Reference Materials:

1. *Elementary Linear Algebra with Applications* 9th edition Bernard, K. David, H. 2007. Prentice Hall PTR.
2. *Strang's Linear Algebra and Its Applications, 4th edition.* Gilbert, S. Strang, B. Coonley. Andy, B. Andrew, B. 2005. Brooks/Cole.
3. *Elementary Linear Algebra: Applications* Howard. A. Chris. 2005. Version, 9th edition.

Course Name: **Basic Electronics**
Prerequisites: None

Course Outline:

Fundamentals of Semiconductor physics: Band theory, semiconductors (intrinsic and extrinsic), PN junction, PN junctions as a rectifier, clipper and clamper circuits, Zener diode and voltage regulator, LED and LCD etc., *Transistors:* Bipolar Junction transistors, BJT biasing circuits, Q-point, BJT as a switch, BJT amplifiers, classes of amplifiers, power amplifiers, Metal oxide transistors, nMOS, pMOS and CMOS inverters circuits. Introduction to A/D and D/A conversion circuits.

Reference Materials:

1. *University Physics,* Freedman. Young. 10th and higher editions.
2. *College Physics,* Resnick. Halliday. Krane. 6th and higher editions.

Computing General Education

Course Name: **English Composition and Comprehension**
Credit Hours: 3
Prerequisites: None

Course Outline:

Principles of writing good English, understanding the composition process: writing clearly; word, sentence and paragraph. Comprehension and expression; Use of grammar and punctuation; Process of writing, observing, audience analysis, collecting, composing, drafting and revising, persuasive writing, reading skills, listening skills and comprehension, skills for taking notes in class, skills for exams.

Reference Materials:

1. John E. Warriner. *Warriner's English Grammar and Composition.*

Course Name: **Technical and Business Writing**
Credit Hours: 3
Prerequisites: None

Course Outline:

Overview of technical reporting, use of library and information gathering, administering questionnaires, reviewing the gathered information; Technical exposition; topical arrangement, exemplification, definition, classification and division, casual analysis, effective exposition, technical narration, description and argumentation, persuasive strategy, Organizing information and generation solution: brainstorming, organizing material, construction of the formal outline, outlining conventions, electronic communication, generation solutions. Polishing style: paragraphs, listening sentence structure, clarity, length and order, pomposity, empty words, pompous vocabulary, document design: document structure, preamble, summaries, abstracts, table of contents, footnotes, glossaries, cross-referencing, plagiarism, citation and bibliography, glossaries, index, appendices, typesetting systems, creating the professional report; elements, mechanical elements and graphical elements. Reports: Proposals, progress reports, Leaflets, brochures, handbooks, magazines articles, research papers, feasibility reports, project reports, technical research reports, manuals and documentation, thesis. Electronic documents, Linear verses hierarchical structure documents.

Reference Material:

1. *Technical and Business Writing for Working Professionals,* Ray E. Hardesty, Xlibris Corporation, 15-Dec-2010, ISBN = 1456819402
2. *Successful Technical Writing/Instructor's Guide*, Bill Wesley Brown, Goodheart-Willcox Publisher, 01-Mar-193-Technology and Engineering.

Course Name: **Communication Skills**
Credit Hours: 3
Prerequisites: None

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.

Reference Material:
1. *Practical Business English,* Collen Vawdrey, 1993, ISBN = 0256192740
2. Effective Communication Skills: The Foundations for Change, John Nielsen, 2008, ISBN = 1453506748

Course Name: **Pakistan Studies**
Credit Hours: 2
Prerequisites: None

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.

Reference Material:
1. *The Emergence of Pakistan*, Chaudary M., 1967
2. *The making of Pakistan,* Aziz. 1976

Course Name: **Professional Practices**
Credit Hours: 3
Prerequisites: None

Course Outline:

Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology); Definitions of Computing (software engineering, Computer Science, Information Technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities, software related contracts, Software house organization.

Reference Material:

1. *Professional Issues in Software Engineering* M.F. Bott et al.

Course Name: **Introduction to Information and Communication Technologies**
Credit Hours: 3 (2+1)
Pre-requisite: None

Course Outline:

Basic Definitions & Concepts, Hardware: Computer Systems & Components. Storage Devices, Number Systems, Software: Operating Systems, Programming and Application Software, Introduction to Programming, Databases and Information Systems, Networks, Data Communication, The Internet, Browsers and Search Engines, The Internet: Email, Collaborative Computing and Social Networking, The Internet: E-Commerce, IT Security and other issues, Project Week, Review Week

Reference Materials:

1. *Introduction to Computers* 6th International Edition, Peter, N. McGraw-Hill
2. *Using Information Technology: A Practical Introduction to Computer & Communications,* 6th Edition. Williams, S. McGraw-Hills.
3. *Computers, Communications & information: A user's introduction*, Sarah, E. Hutchinson. Stacey, C. Swayer.
4. *Fundamentals of Information Technology*, Alexis L Mathewsleon Leon Press.

Computer Science Core Courses

Course Name: **Microprocessor and Assembly Language**
Credit Hours: **3 (2+1)**
Prerequisites: **Digital Logic Design**

Course Outline:

Microprocessor Bus Structure: Addressing, Data and Control, Introduction to Registers and Flags. Addressing Modes, Instruction sets including Data Movement, Arithmetic and Logic, Programme Control, Stack and its operation. Peripheral Control Interrupts.

Introduction to the Assembler and Debugger, Manipulate and translate machine and assembly code, Describe actions inside the processing chip.

Reference Materials:

1. *The Intel Microprocessor 8th ed*, Barry B Brey.
2. *Assembly Language for Intel-based Computers, 6th Ed* Irvine, http://vig.prenhall.com/catalog/academic/product/0,1144,0132383101,00.html
3. *The 8086/8088 Microprocessor 4th Edition b*y Avtar Singh.

Course Name: **Theory of Automata**
Credit Hours: 3
Prerequisites: **Discrete Structures**

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: Context free grammars, 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.

Reference Materials:

1. *Introduction to computer theory,* Daniel I. A. Cohen, 2nd Edition
2. *Automata, Computability and Complexity: Theory and Applications,* by Elaine Rich, 2011
3. *An Introduction to Formal Languages and Automata,* By Peter Linz, 4th edition, Jones & Bartlett Publishers, 2006
4. *Theory of Automata, Formal Languages and Computation,* By S. P. Eugene, Kavier, 2005, New Age Publishers, ISBN (10): 81-224-2334-5, ISBN (13): 978-81-224-2334-1.

5. *Introduction to Automata Theory, Languages, and Computation*, John Hopcroft and Jeffrey Ullman, 2nd edition, 2001, Addison-Wesley.
6. *Introduction to Languages and the Theory of Computation,* By John C. Martin 3rd edition, 2002, McGraw-Hill Professional.

Course Name: **Design and Analysis of Algorithms**
Credit Hours: 3
Prerequisites: **Data Structures and Algorithms**

Course Outline:

Introduction; Asymptotic notations; Recursion and recurrence relations; Divide-and-conquer approach; Sorting; Search trees; Heaps; Hashing; Greedy approach; Dynamic programming; Graph algorithms; Shortest paths; Network flow; Disjoint Sets; Polynomial and matrix calculations; String matching; NP complete problems; Approximation algorithms.

Reference Materials:

1. *Introduction to Algorithms,* T. H. Cormen, C. E. Leiserson, and R. L. Rivest, MIT Press, McGraw-Hill, 3rd Edition, New York, NY, 2010.
2. *Algorithms in C++;* Robert Sedgewick

Course Name: **(Intro.) Artificial Intelligence**
Credit Hours: 3 (2+1)
Prerequisites: **Discrete Structures**

Course Outline:

Artificial Intelligence: Introduction, AI Paradigms and Hypothesis, Intelligent Agents. Difference between Cybernetic Intelligence and Artificial Intelligence, Objectives and Scope of Weak AI and Strong AI, Problem-solving: Solving Problems by Searching, Informed Search and Exploration, Constraint Satisfaction Problems, Adversarial Search. Knowledge and reasoning: Logical Agents, First-Order Logic, Inference in First-Order Logic, Knowledge Representation. Planning and Acting in the Real World. Uncertain knowledge and reasoning: Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions. Learning: Learning from Observations, Knowledge in Learning; Learning Methods, Reinforcement Learning. Communicating, perceiving, and acting: Communication, Probabilistic Language Processing, Perception and Robotics. Introduction to LISP/PROLOG and Expert Systems (ES) and Applications; Artificial General Intelligence, Issues in Safe AI, Introduction to Cognitive and Conscious Systems.

Reference Materials:

1. *Artificial Intelligence: Structures and Strategies for Complex Problem Solving:* International Edition by George F. Luger, 6th edition: Pearson Education, 2008.
2. *Artificial Intelligence: A Modern Approach,* by Stuart Jonathan Russell, Peter Norvig, John F. Canny, 3nd Edition, Prentice Hall.

3. *Prolog Programming for Artificial Intelligence*, Ivan Bratko, 3rd Edition, Addison Wesley, 2001.

Course Name: **Computer Architecture and Organization**
Credit Hours: 3
Prerequisites: **Digital Logic and Design**

Course Outline:

The design of computer systems and components. Processor design, instruction set design, and addressing; control structures and microprogramming; memory management, caches, and memory hierarchies; and interrupts and I/O structures. Pipelining of processor Issues and Hurdles, exception handling, Parallelism, Multiprocessor Systems.

Reference Materials:

1. *Computer Architecture: A Quantitative Approach* by Hennessy & Patterson, Morgan & Kauffman Series (2006) 4th Edition.
2. *Computer Organization & Design*: *The Hardware/Software Interface* By Patterson & Hennessy, Morgan & Kauffman Series (2008) 4th Edition.

Course Name: **Compiler Construction**
Credit Hours: 3
Prerequisites: **Theory of Automata**

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.

Reference Materials:

1. *Compilers: Principles, Techniques, and Tools* By Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Contributor Jeffrey D. Ullman, Addison-Wesley Pub. Co., 2nd edition, 2006 Original from the University of Michigan
2. *Modern Compiler Design, by* Dick Grune, Henri E. Bal, Ceriel J. H. Jacobs, Koen G. Langendoen, John Wiley, 2000.
3. *Modern Compiler Implementation in C,* by Andrew W. Appel, Maia Ginsburg, Contributor Maia Ginsburg, Cambridge University Press, 2004.
4. *Modern Compiler Design* by Dick Grune, Henri E. Bal, Ceriel J. H. Jacobs, Koen G. Langendoen, 2003, John Wiley & Sons.

Course Name: **Information Security**
Credit Hours: 3
Prerequisites: **Data Communication and Computer Networks**

Course Outline:

Basic notions of confidentiality, integrity, availability; authentication models; protection models; security kernels; Encryption, Hashing and Digital

Signatures; audit; intrusion detection and response; database security, host-based and network-based security issues operational security issues; physical security issues; personnel security; policy formation and enforcement; access controls; information flow; legal and social issues; identification and authentication in local and distributed systems; classification and trust modeling; risk assessment

Reference Materials:

1. *Computer Security: Art and Science*, Matthew Bishop
2. *Cryptography and Network Security* by William Stalling 6th Edition, 2012
3. *Principles of Information Security* 3rd E by Michael E. Whitman and Herbert J. Mattord

Computer Science Supporting Courses

Course Name: **Numerical Computing**
Credit Hours: 3 (2+1)
Prerequisites: **Calculus and Analytical Geometry**

Course Outline:

The concepts of efficiency, reliability and accuracy of a method; Minimising computational errors; Theory of Differences, Difference Operators, Difference Tables, Forward Differences, Backward Differences and Central Differences. Mathematical Preliminaries, Solution of Equations in one variable, Interpolation and Polynomial Approximation, Numerical Differentiation and Numerical Integration, Initial Value Problems for Ordinary Differential Equations, Direct Methods for Solving Linear Systems, Iterative Techniques in Matrix Algebra, Solution of non-linear equations.

Reference Materials:

1. *Numerical Methods in Scientific Computing b*y Germund, D. Åke, B.
2. *Numerical Methods for Scientific Computing* by J. H. Heinbockel.
3. *Numerical Analysis* by I. A. Khubaza.
4. *Numerical Analysis and Programming* by Shan S Kuo.
5. *Numerical Analysis* by Berden, F.
6. *Numerical Analysis by* Gerald.

Course Name: **Multivariate Calculus**
Credit Hours: 3
Prerequisites: **Calculus and Analytical Geometry**

Course Outline:

Functions of Several Variables and Partial Differentiation. Multiple Integrals, Line and Surface Integrals. Green's and Stoke's Theorem. Fourier Series: periodic functions, Functions of any period P-2L, Even & odd functions, Half Range expansions, Fourier Transform; Laplace Transform, Z-Transform.

Reference Materials:

1. *Multivariable Calculus*, 6th edition James, Stewart 2007 Cengage Learning publishers.
2. *Calculus and Analytical Geometry*, 6th edition. Swokowski, Olinick and Pence.1994.Thomson Learning EMEA, Ltd.
3. *Multivariable Calculus*, 5th edition Howard, A. Albert, H. 1995, John Wiley.

Course Name: **Differential Equations**
Credit Hours: 3 (3, 0)
Prerequisites: **Calculus and Analytical Geometry**

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.

Reference Materials:

1. *Advanced Engineering Mathematics* Michael, G.*1996,* Prentice Hall Publishers.
2. *Advanced Engineering Mathematics*, 7th edition, Erwin, K. 1993, John Wiley & Sons Inc.
3. *A First Course in Differential Equation* Zill. Prindle. Weber. Schmidt.1996. Brooks/Cole Publishing.
4. *Differential Equations with Boundary-Value Problems*, Dennis. G. Zill, Michael, R. Cullen. 1996, Brooks/Cole Publishing,
5. *Elementary Differential Equations with Applications* C. H. Edwards. David, E. 1993. Penney, Prentice Hall.

Computer Science Electives

Course Name: **Computer Graphics**
Credit Hours: 3 (2+1)
Prerequisites: **Programming Fundamentals**

Course Outline:

Graphics hardware. Fundamental algorithms. Applications of graphics. Interactive graphics programming — graph plotting, windows and clipping, and segmentation. Programming raster display systems, Differential Line Algorithm, panning and zooming. Raster algorithms and software — Scan-Converting lines, characters and circles. Scaling, Rotation, Translation, Region filling and clipping. Two and three dimensional imaging geometry (Perspective projection and Orthogonal projection) and transformations. Curve and surface design, rendering, shading, colour and animation.

Reference Materials:

1. *Fundamentals of Computer Graphics: 2nd Edition* by Peter Shirley A. K. Peters, 2005
2. *Computer Graphics, Principles and Practice,* J. D. Foley, A. van Dam, S. K. Feiner and J. F. Hughes, Addison-Wesley ISBN: 0-201-12110-7.
3. *Computer Graphics,* F. S. Hill, Maxwell MacMillan ISBN: 0-02-354860-6.
4. *Interactive Computer Graphics: Functional, Procedural and Device-level methods*; Peter Burger and Duncan. F. Gillies; Addison-Wesley, (2003)

Course Name: **Digital Image Processing**
Credit Hours: 3(2+1)
Prerequisites:

Course Outlines:

Introduction: Elements of digital image processing, Image model, Sampling and quantization, Relationships between pixels, Image Enhancement: Enhancement by point processing, Spatial filtering, Enhancement in the frequency domain, Colour Image Processing, image Segmentation: Discontinuity detection, Edge linking and boundary detection, Tresh holding, Region oriented segmentation, Use of motion for segmentation, Image Registration: Introduction to image registration, Techniques of image registration, Representation and Description: Boundary description, Regional description, Morphological Image Processing: Dilation and Erosion, Opening and Closing, Some basic morphological algorithms, Extensions to gray level images, Image Transforms: Discrete Fourier Transform, Discrete Cosine Transform, Haar Transform, Hadamard Transform

Reference Material:

1. *Digital Image Processing,* R. C. Gonzalez & R. E. Woods, 3rd edition, Prentice Hall, 2008, ISBN 9780131687288.
2. *Digital Image Processing (3rd Edition)* by Rafael C. Gonzalez, Prentice Hall; 3rd edition (2007)

3. *Understanding Digital Signal Processing (3rd Edition)* by Richard G. Lyons, Prentice Hall; 3rd edition (2010)

Course Name: **Computer Vision**
Credit Hours: 3
Prerequisite: **Data Structures and Algorithms**

Course Outline:

Concepts behind computer-based recognition and extraction of features from raster images. applications of vision systems and their limitations. Overview of early, intermediate and high level vision, Segmentation: region splitting and merging; quadtree structures for segmentation; mean and variance pyramids; computing the first and second derivatives of images using the Sobel and Laplacian operators; grouping edge points into straight lines by means of the Hough transform; limitations of the Hough transform; parameterisation of conic sections. Perceptual grouping: failure of the Hough transform; perceptual criteria; improved Hough transform with perceptual features; grouping line segments into curves. 3D vision, Triangulation principle, Stereoscopy.

Reference Materials:

1. *Computer Vision: A Modern Approach 2nd ed,* By David Forsyth, Jean Ponce, Prentice Hall, 2011.
2. *Computer Vision,* by Linda G. Shapiro, George C. Stockman, Prentice Hall, 2001.
3. *Handbook of Mathematical Models in Computer Vision,* by Nikos Paragios, Yunmei Chen, Olivier Faugeras, Birkhäuser, 2006.

Course Name: **Distributed Computing**
Credit Hours: 3
Prerequisites: **Operating Systems**

Course Outline:

Introduction to Parallel and Distributed Systems, Software Architectures: Threads and Shared memory, Processes and Message passing, Distributed Shared Memory (DSM), Distributed Shared Data (DSD). System Models, Networking and Internetworking, Communication Models and Abstractions (Message passing, stream-oriented communications, remote procedure calls, remote method invocation), Naming in Distributed Systems, Concurrency and Synchronization, Process Synchronization, Distributed Transaction and Concurrency Control, Distributed Data Replication, Security and Access Control, Overview of Web Services, Cloud Computing.

Reference Materials:

1. *Distributed Systems: Principles and Paradigms*, Andrew S. Tanenbaum and Maarten van Steen. Prentice-Hall, 2002.
2. *Distributed Systems: Concepts and Design* by 4th edition, George Coulouris, Jean Dollimore and Tim Kindberg. Addison-Wesley, 2005

3. *Web Services: Principles and Technology*. Michael P. Papazoglou. Pearson Prentice Hall, 2007.

Course Name: **Social Computing**
Credit Hours: 3
Prerequisites: **Web Programming**

Course Outline:

The topics covered will reflect the latest research and development activities in social networking e.g., Service architectures for social networks; Common APIs for popular architectures (Facebook, Open Social, etc.); Open ID and Shibboleth; Linked Data for social networks (FOAF, SKOS, etc); Social network properties and analysis methodologies; Social network interoperability; Social network topologies and ecosystems.

Social networks in e-learning, enterprise and media; Identity, privacy and ownership in social networks; Aspects of recommendation engines and information retrieval in social networks; Sentiment classification, opinion extraction, social knowledge acquisition, social group identification and clustering, outlier detection.

Reference Materials:

1. *Opinion Mining and Sentiment Analysis (Foundations and Trends(R) in Information Retrieval* by Bo Pang Lillian Lee
2. *Introduction to Social Network Theory* by Kadushin, Charles. (Feb 17, 2004).
3. *Social Network Analysis. Semantic studios,* Morville, Peter. (Feb 21, 2002).
4. *What is Web 2.0? O'Reilly, Behind the Cover.* O'Reilly, Tim. (Sep 30, 2005).
5. *Media Studies: The Essential Resource* by Rayner, Philip et al. Routledge Taylor and Francis Group. London.
6. *The Online Disinhibition Effect. The Psychology of Cyberspace.* Suler, John.

Course Name: **Mobile Application and Development**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Mobile Development Concepts, Activities, Resource Management and Media, Services and Content Providers, Data Storage, Security, Managing Evolution, Tablets Graphics Speech Sensors Networking, Processes and Threads, Deployment

Reference Materials:

1. *Android Wireless Application Development, third edition,* Lauren Darcey, Shane Conder, Addison Wesley, 2012, ISBN 0321813839

2. *Mobile Design and Development: Practical concepts and techniques for creating mobile sites and web apps,* by Brian Fling Publisher: O'Reilly Media, 2009.

Course Name: **Web Design and Development**
Course Structure: Lectures: 2, Labs: 1
Credit Hours: 3(2+1)
Prerequisites: **Fundamentals of programming**

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

Reference Materials:

1. *Web enabled Commercial application development using HTML, DHTML, JAVASCRIPT by* Ivon Bayross. BPS Publications.
2. *Beginning ASP by* Richard Anderson, Brain Francis. Wrox series Publications.

Course Name: **Data Warehousing**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Introduction of the business context for data warehousing and decision support systems. Differences between TPS and DSS environments. Data extraction, transformation and loading (ETL and ELT), Data warehouse Architecture. Data Marts. Differentiate Data Marts and Data Warehouse. Data Warehouse Design Methodology: De-normalization and Dimensional Modelling. Online analytical processing (OLAP) and data aggregations. Indexing techniques used in data warehousing. Hardware and software systems consideration for data warehousing. Data warehouse maintenance.

Reference Materials:

1. *Data Warehousing Fundamentals, 2nd Edition,* Paulraj Ponniah, 2010, John Wiley & Sons Inc., NY.
2. *Building the Data Warehouse, 4th Edition,* W. H. Inmon, 2005, John Wiley & Sons Inc., NY.
3. *The Data Warehouse Toolkit, 2nd Edition* Ralph Kimball and Margy Ross, 2002, John Wiley & Sons Inc., NY.

Course Name: **Expert Systems**
Credit Hours: 3
Prerequisite: **Discrete Structures**

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.

Reference Materials:

1. *Expert Systems: Principles and Programming,* Joseph C. Giarratano, Gary D. Riley*, 4th* Edition, Course Technology, 2004, ISBN: 0534384471.
2. *Jess in Action: Java Rule-Based Systems,* Ernest Friedman-Hill, Manning Publications, July 2003, ISBN: 1930110898.

Course Name: **Artificial Neural Networks (ANN)**
Credit Hours: 3 (2+1)
Prerequisites: **Discrete Structure**

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.

Reference Material:

1. *Neural Network Design,* Martin T. Hagan, Howard B. Demuth, Mark H. Beale, ISBN: 0-9717321-0-8

Course Name: **Fuzzy Logic System**
Credit Hours: 3 (2+1)
Prerequisites: **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.

Reference Material:

1. *A Course in Fuzzy Systems and Control,* Li-Xin Wang (Prentice-Hall)
   Hand out and research papers related with the subject.

Course Name: **Web Engineering**
Credit Hours: 3 (2+1)
Prerequisites: **Programming Fundamentals**

Course Outline:

XML, XSL, XLink, DOM, SMIL RDF, RDF-SCHEMA, Web 3.0 and the semantic web, Web Searching, web services.

Reference Materials:

1. *Ivon Bayross. Web enabled Commercial application development using HTML, DHTML, JAVASCRIPT*, BPS Publications.
2. *Richard Anderson, Brain Francis. Beginning ASP*, Wrox series Publications.

Course Name: **Fundamentals of Data Mining**
Credit Hours: 3
Prerequisites: **Database Systems**

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.

Reference Materials:

1. *Data Mining: Concepts and Techniques, 3rd Edition* Jiawei Han, Micheline Kamber, Jian Pei; , 2011

2. *Data Mning: Concepts, Models, Methods, and Algorithms*, 2nd Edition, Mehmed Kantatardzic, 2011.
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.

Course Name: **Computational Intelligence**
Credit Hours: 3
Prerequisite: **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.

Reference Materials:

1. *Computational Intelligence: An Introduction, Second Edition,* 2007, Andries P. Engelbrecht, Print ISBN: 9780470035610, Online ISBN: 9780470512517.
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.

Course Name: **Multi Agent Systems**
Credit Hours: 3
Prerequisites by topic: **Discrete Structure**

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

Reference Materials:

1. *Multi-agent systems: an introduction to distributed artificial intelligence.* Steven J. Ferber. Addison-Wesley, 1999.
2. *Multiagent systems: a modern approach to distributed artificial intelligence*. G. Weiss. The MIT Press, 1999.
3. *An Introduction to Multi Agent Systems,* Wooldridge, Michael, 2009, John Wiley & Sons.

Course Name: **Natural Language Processing**
Credit Hours: 3
Prerequisite: **Discrete Structures**

Course outline:

Introduction and Overview, Ambiguity and uncertainty in language, Regular Expressions. Chomsky hierarchy, regular languages, and their limitations. Finite-state automata. Practical regular expressions for finding and counting language phenomena. A little morphology. In class demonstrations of exploring a large corpus with regex tools, String Edit Distance and Alignment, Key algorithmic tool: dynamic programming, first a simple example, then its use in optimal alignment of sequences. String edit operations, edit distance, and examples of use in spelling correction, and machine translation, Context Free Grammars, Constituency, CFG definition, use and limitations. Chomsky Normal Form. Top-down parsing; bottom-up parsing, and the problems with each. The desirability of combining evidence from both directions, Information Theory, What is information? Measuring it in bits. The "noisy channel model." The "Shannon game"--motivated by language! Entropy, cross-entropy, information gain. Its application to some language phenomena, Language modeling and Naive Bayes, Probabilistic language modeling and its applications. Markov models. N-grams. Estimating the probability of a word, and smoothing. Generative models of language. Their application to building an automatically-trained email spam filter, and automatically determining the language, Part of Speech Tagging and Hidden Markov Models, The concept of parts-of-speech, examples, usage. The Penn Treebank and Brown Corpus. Probabilistic (weighted) finite state automata. Hidden Markov models (HMMs), definition and use, Probabilistic Context Free Grammars, Weighted context free grammars, Maximum Entropy Classifiers, The maximum entropy principle, and its relation to maximum likelihood. The need in NLP to integrate many pieces of weak evidence. Maximum entropy classifiers and their application to document classification, sentence segmentation.

Reference Materials:

1. Daniel Jurafsky and James H. Martin. 2008. *Speech and Language Processing: An Introduction to Natural Language Processing,*

Computational Linguistics and Speech Recognition. Second Edition. Prentice Hall.
2. *Foundations of Statistical Natural Language Processing,* Manning and Schütze, MIT Press. Cambridge, MA: May 1999

Course Name: **Game Development**
Credit Hours: 3
Prerequisites: **Programming Fundamentals, 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

Reference Materials:

1. *Agile Game Development with Scrum,* by Clinton Keith (Addison-Wesley, 2010)
2. *AI for Game Developers,* by David Bourg and Glenn Seemann (O'Reilly Media, 2004)
3. *The Art of Game Design: A Book of Lenses,* by Jesse Schell (Morgan Kaufmann, 2008)
4. *Fundamentals of Game Design,* Second Edition, by Ernest Adams (New Riders, 2010).

Course Name: **Logical Paradigms of Computing**
Credit Hours: 3
Prerequisites: **Discrete Structures**

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
2. *Principles of Model Checking* by Christel Baier and Joost-Pieter Katoen MIT Press, 2008.

Course Name: **Formal Methods in Software Engineering**
Course Structure: Lectures: 3
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

Introduction to formal methods, developing and acquiring formal methods, using and applying formal methods, a brief introduction to logic and set theory, Introduction to Hoare's Logic, logic and theorem proving, modelling software systems, sequential, concurrent and reactive systems, states, state spaces, transition systems, combining state spaces, fairness, partial order view, modelling formalism; Formal Specifications Linear temporal logic, automata on infinite words, specifications using Buchi-automata, completeness of specification; Automatic verification, state space verification, representing states, the automata framework, combining Buchi-automata, checking emptiness, translating LTL into automata, model checking examples, checking complexity of model checking, safety properties, state space explosion problem. Z-Specification, Structure and Schema.

Reference Materials:

1. *Software Reliability Methods*, Doron A. Peled , 2001 Springer-Verlag
2. *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
3. *Principles of Model Checking,* Christel Baier and Joost-Pieter Katoen MIT Press, 2008.

Curriculum for MS (Computer Science)

The recommendations of the last meeting held in August 2009 were also considered and very minor changes in the structure have been made in the light of committee's recommendations. The complete detail regarding proposed MS (Computer Sciences) Programme is available herein the following pages

- Minimum credit hours shall be 30 for MS (Computer Science) programme.
- The programme shall comprise 4 semesters spread over 2 years with two semesters a year.
- The additional major areas may be added in the list of specialization as appropriate to university

Category wise Credit Hours Distribution

Category or Area	Credit Hours
Core	6
Electives	18
Thesis	6
Total Credit Hours	**30**

Programme Objectives:

A challenging graduate programme may be structured on the basis of the classical objective, which is the preparation for study of doctoral level, and this remains an important aspect of such programmes, but it is believed that all programmes should prepare the student for study beyond the master's level.

Many people already in the field desire additional training in Computer Science. These individuals may have undergraduate degrees in Computer Science and desire to advance; or they may have considerable experience in Computer Science, but little formal education in the field. While this latter group should be declining in number as more undergraduate Computer Science majors enter the job market, the demand does exist and will continue to do so in the foreseeable future. In addition, there will be a continuing need for individuals with a bachelor's degree in Computer Science to update their training.

Among the objectives for students in master's programmes is entry into the Computer Science field at a relatively high level of responsibility and expertise. Computer Science is such a new and rapidly expanding field that individuals entering with a master's degree in this field will almost

immediately move to positions with great responsibility. This, in turn, implies the requirement for an advanced level of prior training in both technical and related areas (e.g. communication skills). In all these cases, the master's degree provides both motivations for the student and a standard for reward by the employer.

Programme Structure:

The graduate programme should embody sufficient flexibility to fulfill the requirements of either an "academic" degree (Breadth-Based) obtained in preparation for further graduate study or a terminal "professional" degree (Depth-Based). The discipline of Computer Science has matured enough that the distinction between academic and professional programmes is beginning to appear. However, the concept of an utterly terminal programme is not widely accepted in the field. All Computer Science academic programmes should provide the possibility of additional study in the field. The proposed programme is intended to establish an integrated breadth and depth based curriculum model to assure that the common aspects of various potential masters' programmes in Computer Science are captured.

The proposed curriculum structure may be implemented within four-semester time. A project/thesis work may be unified with student's chosen depth oriented specialties. Generally graduate programmes are structured with a common core of fundamental material and wide range of options for the rest of the course work.

Eligibility:

BS (CS) 4 Years Degree Programme (min 130 credit hours), or Computer Science Conversion Course 2 Years Degree Programme referred to as "MCS" or "MSc (CS)."

- BCS-3 years Degree Programme-Student will be required to complete the deficiency of difference of total earned credit hours and 130 credit hours.
- 16 year Science and Engineering graduates are eligible but they have to cover deficiency.

SCHEME OF STUDIES MS (CS)

Courses Requirements:

List of Core Course

#	Code	Course Title	Credit hours	Semester
1	CS	Advanced Theory of Computation	3	1
2	CS	Advanced Algorithm Analysis	3	1

List of Electives Courses:

Specialized Areas (not limited) to the list given below (Students will select 6 Courses of 18 credit hours.) Course details are not included.

Code	Specialization Areas	Crt. Hrs		Code	Specialization Areas	Crt. Hrs
CS	Software Engineering			CS	Artificial Intelligence	
CS	Advanced Software Development	3		CS	Design of Intelligent Systems	3
CS	Topics in Software Engineering	3		CS	Machine Learning	3
CS	Object Oriented Software Engineering.	3		CS	Neural Networks	3
CS	Software Quality Assurance	3		CS	Mathematical Reasoning	3
CS	Requirements Engineering	3		CS	Decision Support Systems	3
CS	Software Architecture	3		CS	Computer Vision	3
CS	Agent Oriented Software Engineering	3		CS	Automated Reasoning	3
CS	Software Project Management	3		CS	Knowledge based systems	3
CS	Software Design	3		CS	Planning systems	3
CS	Software Engineering and Formal Specifications	3		CS	Natural Language Processing	3
CS	Empirical Software Engineering	3		CS	Agents	3
CS	Software Process Improvement	3		CS	Robotics	3
CS	Component-Based Computing	3		CS	Symbolic Computing	3
CS	Programming Environment	3		CS	Genetic Algorithms	3
CS	Safety-Critical	3		CS	Semantic Web	3

	Systems					
	Information Management			CS	Computer Architecture and Organization	3
CS	Advanced DBMS	3		CS	Embedded Systems	3
CS	Multimedia Information Systems	3		CS	Parallel and Distributed Systems	3
CS	Database Design	3		CS	Design Verification	3
CS	Transaction Processing	3		CS	Integrated Circuit	3
CS	Distributed and Object Databases	3		CS	System on a chip	3
CS	Data Mining	3		CS	VLSI Development	3
CS	Spatial and Temporal Databases	3		CS	Device Development	3
CS	Semantic Databases	3				
CS	Data Warehousing	3		CS	Graphics and Visual Computing	
CS	Object Oriented Databases	3		CS	Advanced Computer Graphics	3
CS	Digital Libraries	3		CS	Multimedia & Hypermedia System	3
CS	Web-Based DBMS	3		CS	Virtual Reality	3
CS	Topics in DBMS	3		CS	Visualization	3
CS	Data Grids	3		CS	Geographical Information Systems	3
CS	Text Mining	3		CS	Computer Animation	3
				CS	Genetic Algorithms	3
	System Engineering			CS	Human Computer Interaction	3
CS	Digital Signal Processing	3				
CS	Switching and Fault Diagnosis	3			Computer Science Education	
CS	FPGAs and Verilog	3		CS	Educational Technology	3
CS	Control Systems and Robotics	3		CS	Multimedia and Hypermedia Sys	3
CS	Real Time Systems	3		CS	Computer Aided Instructions	3
CS	Parallel & Distributed Systems	3		CS	Web Based Education Systems	3
CS	Control Systems and Robotics	3		CS	Measurement of Learning	3
CS	Real Time Operating Systems	3		CS	Topics in Comp Science Education	3
CS	Embedded System	3			Research Methods	3
CS	ASIC Design	3				

CS	VHDL	3			Human Computer Interaction	3
				CS	Intelligent User Interfaces	3
CS	Net-Centric computing			CS	Information Retrieval Techniques	3
CS	Advanced Computer Networks	3		CS	Rich Internet Applications	3
CS	Network Security	3		CS	Graphical User Interfaces	3
CS	Topics in Computer Networking	3		CS	Computer-Supported Cooperative Work (CSCW)	3
CS	Broadband and Satellite Communication	3		CS	Multimedia Systems Development	3
CS	Mobile and Pervasive computing	3		CS	Interactive-Systems Development	3
CS	Wireless and Mobile Computing Networks	3				
CS	Intelligent and active networks	3			Social and Professional Issues (SP)	
CS	Network Performance Evaluation	3		CS	Social Context computing	3
CS	Cluster Computing	3		CS	Computing and Ethics	3
CS	Distributed Computing	3		CS	Computing Economics	3
CS	Data Compression	3		CS	Computer Law	3
CS	Network Management	3		CS	Intellectual Property	3
CS	Enterprise Networking	3		CS	Privacy and Civil Liberties	3
CS	Programming for the World-Wide Web	3				
	Programming Language Design and Translators			CS	Concurrent and Distributed Systems	3
CS	Compiler Construction			CS	Dependent Computing	3
CS	Programming Language Design	3		CS	Fault- Tolerance	3
CS	Programming Language Semantics	3		CS	Real- Time Systems	3
CS	Programming Paradigms	3				
CS	Functional	3			Advanced Discrete	

	Programming				Structures	
CS	Logic Programming	3		CS	Combinatorics	3
CS	Scripting Languages	3		CS	Probability and Statistics	3
CS	Algorithm and complexity (AL)	3		CS	Coding and Information Theory	3
CS	Advanced Algorithmic Analysis	3				
CS	Automata and Language Theory	3			Computational Science	
CS	Cryptography	3		CS	Computational Science	3
CS	Geometric Algorithms	3		CS	Numerical Analysis	3
CS	Parallel Algorithms	3		CS	Operations Research	3
				CS	Simulation and Modelling	3
CS	Grid and Cloud Computing			CS	Scientific Computing	3
CS	Autonomous Computing	3		CS	Computational Biology	3
CS	Data Grids	3				
CS	Semantic Grid	3			Web Engineering	
CS	Computational Grid	3		CS	Semantic Web	3
CS	Utility Computing	3		CS	Web Services	3
CS	Autonomous Computing	3				
CS	Data Grids	3				

MS (CS) Semester-wise Model Programme

Semester 1

S.No.	Code	Subjects	Credit Hrs.
1	CS	Advanced Theory of Computation	3
2	CS	Advanced Algorithm Analysis	3
4	CS	Research Methods (University Preferred Elective Course) Elective I	3
		Total:	9

Semester 2

S.No.	Code	Subjects	Credit Hrs.
1	CS	Elective II	3
2	CS	Elective III	3
3	CS	Elective IV	3
		Total:	9

Semester 3

S.No.	Code	Subjects	Credit Hrs.
1	CS	Thesis (partial registration)	3
2	CS	Elective V	3
		Elective VI	3
		Total:	9

Semester 4

S.No.	Code	Subjects	Credit Hrs.
1	CS	Thesis (full registration)	3
		Total:	3
		Total (all semesters)	**30**

MS (CS) Core Courses
Course Description

Course Name: **Advanced Theory of Computation**
Credit Hours: 3
Prerequisites: **Theory of Automata**

Course Outline:
Automata theory, formal languages, Turing machines, computability theory and reducibility, computational complexity, determinism, non-determinism, time hierarchy, space hierarchy, NP completeness, selected advanced topics.

Reference Materials:
1. Michael Sipser, *Introduction to the Theory of Computation*, 1st Edition, 1997, PWS Publishing Company.
2. Christos Papadimitriou, *Computational Complexity*, 1994, Addison-Wesley.
3. John Hopcroft and Jeffrey Ullman, *Introduction to Automata Theory, Languages, and Computation*, 1979, Addison-Wesley. (or the second edition).
4. Tao Jiang, Ming Li, and Bala Ravikumar, Formal models and Computability, in *Handbook of Computer Science*, CRC Press, 1996.
5. T.H. Cormen, et al., *Introduction to Algorithms,* MIT Press and McGraw-Hill Book Co., 1990.
6. Peter Linz*, An Introduction to Formal Languages and Automata*, ISBN: 0-669-17342-8.

Course Name: **Advanced Algorithm Analysis**
Credit Hours: 3
Prerequisites: **Data Structures and Algorithms**

Course Outline:
Advanced algorithm analysis including the introduction of formal techniques and the underlying mathematical theory. NP-completeness; Search Techniques; Randomized Algorithms. Heuristic and Approximation Algorithms; Topics include asymptotic analysis of upper and average complexity bounds using big-O, little-o, and theta notation. Fundamental algorithmic strategies (brute-force, greedy, divide-and-conquer, backtracking, branch-and-bound, pattern matching, and numerical approximations) are covered. Also included are standard graph and tree algorithms. Additional topics include standard complexity classes, time and space tradeoffs in algorithms, using recurrence relations to analyze recursive algorithms, non-computable functions, the halting problem, and the implications of non-computability. Algorithmic animation is used to reinforce theoretical results. Upon completion of the course, students should be able to explain the mathematical concepts used in describing the complexity of an algorithm, and select and apply algorithms appropriate to a particular situation.

Reference Materials:

1. Approximation Algorithms, By Vijay V. Vazirani, Springer, 2004.
2. Introduction to Algorithms, By Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 2nd edition, Published by MIT Press, 2001.
3. Algorithms and Theory of Computation Handbook, By Mikhail J. Atallah Contributor Mikhail J. Atallah, CRC Press, 1998.

MS (CS) Elective Courses with Course Details

Course Name: **Advanced Operating Systems**
Credit Hours: 3
Prerequisites: **Operating Systems**

Course Outline:

Characterization of Modern Operating Systems; file systems, memory management techniques, Process scheduling and resource management, System Models Architectural models, Inter-process Communication, Issues of Security in Distributed Systems (Partial coverage), Distributed File System, Concurrency Control in Distributed Systems, Problems of coordination and agreement in Distributed Systems, Replication, advantages and requirements, Fault-tolerant services, Mobile and Ubiquitous Computing.

Reference Materials:

1. *Distributed Systems Concepts and Design* 4th edition by George Coulouris, Jean Dollimore and Tim Kindberg
2. *Distributed Operating Systems: Concepts and Design* by Pradeep k. Sinha
3. *Advanced Concepts in Operating Systems* by Singhal and Shiviratri

Course Title: **Research Methods**
Credit Hours: 3
Prerequisites: **Probability and Statistics**

Course Outline:

Research: introduction to the nature of research, and types of Research; Research questions, and the nature of evidence: deciding what type of question to ask, and how to handle the various types of answer; Mud pits and how to avoid them: things that go wrong; Isms: necessary assumptions, dubious assumptions, and being caught in crossfire; Searching the literature: why, where, what for and how; Research in society agendas, context and the like: things we take for granted, and things that can cause you trouble; Research design: Types of design: which to use and how to use them; Surveys and sampling; Field experiments: doing research in the world.

Controlled experiments: changing things systematically and seeing what happens; Summary and technical terms; Generic advice; Arranging a study: subjects, equipment, procedures, things to remember, things to beware;

Handling subjects; Recording; Data collection; Data collection methods: the methods, and choosing and using the appropriate method; Reports: getting respondents to talk about how things happen; Observation: watching what happens; Card sorts: getting respondents to categorise things; Laddering: unpacking the respondents' concepts systematically; Repertory grids: a systematic representation for respondents' knowledge interviews: asking people questions; Face-to-face interactions with respondents: the nuts and bolts of asking questions; Questionnaires: when to use, when not to use, which questions to ask, what format to use; Data analysis; Content analysis: what is said in a text, how it is said, and how often it's said; Discourse analysis: who says what, about what, to whom, in what format.

Knowledge representation: formats, structures and concepts for making sense of knowledge; Statistics: describing things with numbers, and assessing the odds; Descriptive statistics: giving a systematic description of the numbers you've found; Measurement theory: types of measurement and their implications; Inferential statistics: what are the odds against your findings being due to random chance? Conclusion: the end game; Writing up: demonstrating your excellence efficiently, and practical points to remember; References and referencing: using and citing the right texts to demonstrate your excellence; what next; thinking forward about what you really want your life to be?

Reference Materials:

1. *A Gentle Guide to Research*, Gordon Rugg & Marian Petre, Open University Press McGraw-Hill Education, 2007
2. *Practical Research Methods,* CATHERINE DAWSON, How To Books Ltd, 3 Newtec Place, 2002.

Course Name: **Advanced Computer Architecture**
Credit Hours: 3
Prerequisites: **Computer Architecture**

Course Outline:

This course is aimed at the hardware aspects of parallel computer architectures including the design and protocols evaluation for memory coherence, inter-connection networks and system scalability. Advanced topics in this course will cover multiprocessors on a chip, reconfigurable computing and power aware designs. Various coarse-grained and fine-grained architectures with reference to SIMD and MIMD designs should also be covered.

Reference Materials:

1. *Advanced Computer Architecture: A Design Space Approach*, Dezso Sima, Terence Fountain, Peter Kacsuk, Addison-Wesley Publishers, 1997.
2. *Scalable Parallel Computing Technology, Architecture, Programming*, Kai Hwang, Zhiwei Xu, McGraw-Hill Publishers, 1998.

Course Name: **Digital Signal Processing**
Credit Hours: 3
Prerequisite: **Data Communications and Computer Networks**

Course Outline:

One and *N*-dimensional signals and systems, Sampling theorem, Discrete-time Fourier transform, discrete Fourier transform, fast Fourier transform, *z*-transforms: stability and minimum phase signals/systems, *Linear filtering of signal:* Time domain: Difference equations and convolution, Impulse invariance, bilinear transform, FIR filter design, 2D filter design, *Statistical signal processing:* Stochastic signals: correlation functions and power density spectra, Optimal filtering: Wiener filters, Adaptive filters: LMS and array processing.

Reference Material:

1. *Discrete-Time Signal Processing,* 2nd edition Alan V. Oppenheim and Ronald W. Schafer, Prentice-Hall.

Course Name: **Parallel and Distributed Computing**
Credit Hours: 3
Prerequisites: **Data Communications and Computer Networks**

Course Outlines:

Why use parallel and distributed systems? Why not use them? Speedup and Amdahl's Law, Hardware architectures: multiprocessors (shared memory), networks of workstations (distributed memory), clusters (latest variation). Software architectures: threads and shared memory, processes and message passing, distributed shared memory (DSM), distributed shared data (DSD). Possible research and project topics, Parallel Algorithms, Concurrency and synchronization, Data and work partitioning, Common parallelization strategies, Granularity, Load balancing, Examples: parallel search, parallel sorting, etc. Shared-Memory Programming: Threads, Pthreads, Locks and semaphores, Distributed-Memory Programming: Message Passing, MPI, PVM. Other Parallel Programming Systems, Distributed shared memory, Aurora: Scoped behaviour and abstract data types, Enterprise: Process templates. Research Topics.

Reference Materials:

1. B. Wilkinson and M. Allen, *Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, 1/e,* Prentice Hall, 1999.
2. W. Stevens, *Advanced Programming in the Unix Environment,* Addison Wesley, 1993.

Course Name: **Control Systems and Robotics**
Credit Hours: 3
Prerequisites: **Artificial Intelligence**

Course Outline:

Review of classical control analysis methods; Nyquist stability criterion; Classical design using frequency domain methods; phase lead and lag controllers; PID controllers; Relay auto tuning; Introduction to state space methods; State space models; state transformations; solution of the state equations; Controllability and observability; Design using state feedback. LQR design; pole placement; use of observers; Introduction to robotics; Transducers; actuators and robot control.

Reference Materials:

1. R.C. Dorf, Modern Control Systems, 7th (1995), 8th (1998) or 9th (2001) Edition, Addison-Wesley.
2. C.C. Bissell, Control Engineering, 2nd Edition, 1994, Publisher: Chapman & Hall.
3. K. Ogata, *Modern Control Engineering,* Prentice Hall, 2nd ed. 1990.

Course Name: **Real Time Operating Systems**
Credit Hours: 3
Prerequisites: **Operating Systems**

Course Outline:

The principles of real-time and embedded systems inherent in many hardware platforms and applications being developed for engineering and science as well as for ubiquitous systems, including robotics and manufacturing, interactive and multimedia, immersive and omnipresent applications. Real-time and quality of service system principles, understand real-time operating systems and the resource management and quality of service issues that arise, and construct sample applications on representative platforms. Platforms range from handheld and mobile computers to media and real-time server systems. Platforms may also include specialized systems used in application-specific contexts, such as autonomous robotics, smart sensors, and others.

Reference Material:

It is an advanced course and the instructor may make his notes from various resources from internet (this need revision before print ready format).

Course Name: **Advanced Networking**
Credit Hours: 3
Prerequisites: **Data Communications and Computer Networks**

Course Outline:

Review of basic concepts: The OSI Model, packet and circuit switching, network topology, ISDN. The TCP/IP protocol stack: IP, ARP, TCP and UDP,

DNS, ICMP, Internet Addressing, Routing, IP Multicast, RSVP, Next Generation IP Ipng, Wireless: Radio basics, Satellite Systems, WAP, current trends, Issues with wireless over TCP. Congestion Control: Control vs. Avoidance. Algorithms, Congestion in the Internet. Mobile IP, Voice over IP (VoIP), VPNs, Network Security. Management: Quality of Service (QoS), network vs. distributed systems management Protocols, web-based management

Reference Materials:

1. James F. Kurose and Keith W. Ross, “Computer Networking A Top-Down Approach Featuring the Internet”, Addison Wesley.
2. Coulouris, Dollimore, Kindberg, “Distributed Systems Concepts and Design”, Addison Wesley.
3. William Stallings, "Data and Computer Communications", Prentice-Hall Sixth Edition (for those who want to review basics of networking).

Course Name: **Network Security**
Credit Hours: 3
Prerequisites: **Data Communications and 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.

Reference Materials:

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

Course Name: **Topics in Computer Networking**
Credit Hours: 3
Prerequisites: **Data Communications and Computer Networks**

Course Outline:

This course offers an advanced introduction and research perspectives in the areas of switch/router architectures, scheduling for best-effort and guaranteed services, QoS mechanisms and architectures, web protocols and applications, network interface design, optical networking, and network economics; the course also includes a research project in computer networking involving literature survey, critical analysis, and finally, an original and novel research contribution; typical topics are listed below:

Overview of packet switching networks and devices; Fundamentals of Internet Protocol (IP) networking. Route lookup algorithms; Router architecture and performance; Detailed operation of Internet routing protocols such as Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP); Integrated and differentiated network service models; Traffic Engineering (TE) concepts and mechanisms including label assignment, label distribution, and constraint-based routing algorithms. Multi-protocol label switching and its generalization. Quality of service mechanisms for multimedia and real-time communications. TE-based routing and signalling protocols. Fundamentals of per-flow and aggregate scheduling algorithms. Application-level and network-level signalling protocols for data, voice, and video communications. Resource signalling and resource reservation protocols. Worst-case analysis for multimedia networking.

Reference Materials:

1. Puzmanov, *Switching and Routing*, Addison Wesley, 2002.
2. Garica and Widjaja, *Communication Networks: Fundamentals Concepts and Key Architectures,* McGraw-Hill, 2001.
3. Peterson and Davie, *Computer Networking a Systems Approach*, 3rd Edition, Morgan Kaufman, 2003.
4. William Stallings, *High-Speed Networks: TCP/IP and ATM Design Principles,* Prentice Hall; 1998, ISBN: 0135259657.
5. Andrew S. Tanenbaum, *Computer Networks, 3rd Edition.* Prentice Hall, March 1996.

Course Name: **Network Administration**
Credit Hours: 3
Prerequisites: **Data Communication and Networks**

Course Outline:

Through completion of this course, students will be able to plan, install, and configure a Web Server, manage, monitor, and optimize a Web Server, and design and implement a Web Site on the Web Server created.

Reference Materials:

1. *Information Technology Project Management,* (2002) Course Technology, ISBN: 0-619-03528-5.
2. *Principles of Web Design*. (2000) Course Technology. ISBN: 0-619-01526-8.

Course Name: **Wireless Networks**
Credit Hours: 3
Prerequisites: **Data Communications and Computer Networks**

Course Outline:

This course covers fundamental techniques in design and operation of first, second, and third generation wireless networks: cellular systems, medium access techniques, radio propagation models, error control techniques, handoff, power control, common air protocols (AMPS, IS-95, IS-136, GSM, GPRS, EDGE, WCDMA, cdma2000, etc), radio resource and network management. As an example for the third generation air interfaces, WCDMA is discussed in detail since it is expected to have a large impact on future wireless networks. This course is intended for graduate students who have some background on computer networks.

Reference Materials:

1. *Wireless Communications and Networks*, W. Stallings, Prentice Hall, 2002.
2. *Wireless Communications: Principles & Practice*, T.S. Rappaport, Second Edition, Prentice Hall, 2002.
3. *Mobile Communications*, J. Schiller, Addison Wesley, 2000.
4. *IS-95 CDMA and cdma 2000*, V.K. Garg, Prentice Hall PTR, 2000.
5. J.P. Castro, "The UMTS Network and Radio Access Technology Air Interface Techniques for Future Mobile Systems", Wiley, 2001.
6. H. Holma and A. Toskala, "WCDMA for UMTS Radio Access for Third Generation Mobile Communications", John Wiley & Sons, 2001.

Course Name: **Network Performance Evaluation**
Credit Hours: 3
Prerequisites: **Data Communications and Computer Networks**

Course Outline:

This is an advanced course in networks and protocols. Analytical, simulation and experimental methods should be used to evaluate and design networks and protocols. Investigate network management tools and techniques.

Reference Material:

1. T. G. Robertazzi, Computer Networks and Systems: Queuing Theory and Performance Evaluation, Springer-Verlag, 2nd edition, 1994.

Course Name: **Theory of Programming Languages**
Credit Hours: 3
Prerequisites: **Compiler Construction**

Course Outline:

Introduction and History, Syntax and Semantics, Control Structures, Types, Logic Programming, Functional Programming and Lambda calculus, Concurrent and Distributed Programming, Dataflow, Object-oriented Programming.

Reference Materials:

1. *Advanced Programming Language Design,* Raphael Finkel, Addison-Wesley. ISBN: 0805311912
2. *Introduction to the Theory of Programming Languages* Bertrand Meyer
3. *The Study of Programming Languages*, Ryan Stansifer
4. *The Anatomy of Programming Languages*, Fischer and Grodzinsky
5. *Concepts of Programming Languages*, Sebesta

Course Name: **Advanced Compiler Design I**
Credit Hours: 3
Prerequisites: **Compiler Construction**

Course Outline:

An in-depth study of compiler backend design for high-performance architectures. Topics include control-flow and data-flow analysis, classical optimization, instruction scheduling, and register allocation. Advanced topics include memory hierarchy management, optimization for instruction-level parallelism, modulo scheduling, predicated and speculative execution. The class focus is processor-specific compilation techniques, thus familiarity with both computer architecture and compilers is recommended.

Reference Materials:

1. *Compilers: Principles, Techniques, and Tools*, Alfred V. Aho, Ravi Sethi, and Jeffrey D. Ullman, Addison-Wesley, 1988.
2. *Advanced Compiler Design & Implementation*, Steven S. Muchnick, Morgan Kaufmann, 1997.
3. *Building an Optimizing Compiler*, Robert Morgan, Butterworth-Heinemann, 1998.

Course Name: **Advanced Compiler Design II**
Credit Hours: 3
Prerequisites: **Advanced Compiler Design I**

Course Outline:

The course should consist of one or two major projects. Theoretical study should depend on the level of the first course Design I and the student needs.

Reference Materials:

1. *Compilers: Principles, Techniques, and Tools*, Alfred V. Aho, Ravi Sethi, and Jeffrey D. Ullman, Addison-Wesley, 1988.
2. *Advanced Compiler Design & Implementation*, Steven S. Muchnick, Morgan Kaufmann, 1997.
3. *Building an Optimizing Compiler*, Robert Morgan, Butterworth-Heinemann, 1998.

Course Name: **Intelligent User Interfaces**
Credit Hours: 3
Prerequisites: **Human Computer Interaction**

Course Outline:

The increasing complexity of software and the proliferation of information make intelligent user interfaces increasingly important. The promise of interfaces that are knowledgeable, sensitive to our needs, agile, and genuinely useful has motivated research across the world to advance the state of the art and practice in user interfaces that exhibit intelligence. The text covers the topic well.

Reference Material:

1. *Readings in Intelligent User Interfaces*, Mark T. Maybury (Editor), Wolfgang Wahlster (Editor), Paperback - 736 pages (April 1998) Morgan Kaufman Publishers; ISBN: 1558604448.

Course Name: **Multimedia Database**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Introduction; Overview of Relational and Object-Relational Data Representations; Text/Document Databases; Multidimensional Data Structures, similarity based search (spatial, image, audio); XML Databases; Temporal Data Models; Logical Frameworks.

Reference Materials:

1. Principles of Multimedia Database Systems, by V.S. Subrahmanian, Morgan Kaufmann Publishing Company, San Francisco, CA. 1998. ISBN: 1558604669.
2. Principles of Database Query Processing for Advanced Applications (Morgan Kaufmann Series in Data Management Systems), by Clement T. Yu, Weiyi Meng, 1998. ISBN: 1558604340.
3. Databases and Transaction Processing, An Application-Oriented Approach, Philip M. Lewis, Arthur Bernstein, and Micheal Kifer. Addison Wesley Publishers, 2002. ISBN: 0201708728.

Course Name: **Computer Vision**
Credit Hours: 3
Prerequisites: **Data Structures and Algorithms**

Course Outline:

Concepts behind computer-based recognition and extraction of features from raster images. applications of vision systems and their limitations. Overview of early, intermediate and high level vision, Segmentation: region splitting and merging; quadtree structures for segmentation; mean and variance pyramids; computing the first and second derivatives of images using the isotropic, Sobel and Laplacian operators; grouping edge points into straight lines by means of the Hough transform; limitations of the Hough transform; parameterisation of conic sections. Perceptual grouping: failure of the Hough transform; perceptual criteria; improved Hough transform with perceptual features; grouping line segments into curves. Overview of mammalian vision: experimental results of Hubel and Weisel; analogy to edge point detection and Hough transform; Relaxation labeling of images: detection of image features; Grouping of contours and straight lines into higher order features such as vertices and facets; Depth measurement in images.

Reference Materials:

1. Computer Vision: A Modern Approach, by David Forsyth, Jean Ponce, Prentice Hall, 2003.
2. Computer Vision, by Linda G. Shapiro, George C. Stockman, Prentice Hall, 2001.
3. Handbook of Mathematical Models in Computer Vision, by Nikos Paragios, Yunmei Chen, Olivier Faugeras, Birkhäuser, 2006.

Course Name: **Rich Internet Applications**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

This course covers the concept and technology evolution regarding the internet applications and the use of interface tools. Mainly, the course can focus on any one of the technologies of modern day, for example, macromedia's FLASH. However, the course will use the concepts of data structures, object oriented programming, programming languages and the software design and engineering to develop projects of medium to large magnitude.

Reference Materials:

The contents and teaching approach depend on the instructor and the latest trends in the area. Macromedia's presence on the web can be utilized for information transfer.

MS (CS) Course Outlines

Following are some of the new course outlines for MS (CS) Programme suggested by Computer Science Committee.

1. Machine Learning
2. Advanced Optimization methods
3. Robotics
4. Intelligent Planning
5. Fuzzy Systems
6. Intelligent Data Modelling
7. Logic Programming & Automated Reasoning
8. Advanced statistical methods
9. Cybernetics
10. Evolutionary Computation/Algorithms
11. Knowledge Management (3 credits)
12. Visualization in Medicine
13. Virtual Reality
14. Advanced database systems
15. Distributed Databases
16. Web Mining
17. Text Mining
18. Decision Theory

Course Name: **Machine learning**
Credit Hours: 3
Prerequisites: **Artificial Intelligence**

Course Outline:

Basic concepts of Machine Learning; Supervised learning; Supervised learning setup. Logistic regression; Perceptron; Generative learning algorithms; Gaussian discriminant analysis; Support vector machines; Model selection and feature selection; Evaluating and debugging learning algorithms; Learning theory; Bias/variance tradeoff; Union and Chernoff/Hoeffding bounds; Unsupervised learning; K-means Clustering; EM algorithm.

Factor analysis; PCA (Principal components analysis); ICA (Independent components analysis); Reinforcement learning and control; Bellman equations; Value iteration and policy iteration; Linear quadratic regulation; Q-learning; Value function approximation

Reference Materials:

1. *Pattern Recognition and Machine Learning,* Bishop, C., 2006
2. *Machine Learning*, Mitchell, T., McGraw-Hill, (1997)
3. *The Elements of Statistical Learning,* Hastie, T., Tibshirani, R., and Friedman, J., *Neural Networks for Pattern Recognition,* 2009Bishop, C., 1995

Course Name: **Advanced Optimization methods**
Credit Hours: 3
Prerequisites: **Discrete Mathematics**

Course Outline:

A taxonomy of optimization problems and solution methods; Convex sets, convex functions and convex optimization; Linear and convex quadratic optimization problems. Combinatorial optimization; Geometric and semi-definite optimization. Duality; Computational complexity and NP-completeness; Algorithms for smooth unconstrained optimization; Algorithms for constrained optimization, including interior point methods; Sequential quadratic programming; Derivative-free optimization.

Outline of techniques for discrete optimization, including relaxation; Multi-objective Optimization.

Reference Materials:

1. *Constraint processing,* R. Dechter (2003): Morgan Kaufmann.
2. *Convex Optimization*, Boyd and Vandenberghe*,* Cambridge University Press, Cambridge, 2004.
3. *Convex optimization theory,* Bertsekas, Athena Scientific, Belmont, MA, 2009.
4. *Convex analysis and optimization*, Bertsekas, with Nedic and Ozdaglar*,* Athena Scientific, Belmont, MA, 2003.
5. *Numerical Optimization*, Nocedal and Wright*,* Second Edition, Springer, New York, 2006.
6. *Nonlinear Programming*, Bertsekas, Second Edition, Athena Scientific, Belmont, MA, 1999.
7. *Practical Optimization*, Gill, Murry and Wright, Academic Press, London, 1986.
8. *Optimization: Algorithms and Engineering Applications*, Antoniou and Lu*,* Practical Springer, New York, 2007.
9. *An Introduction to Optimization*, Chong and Zak, second edition, Wiley, 2001.

Course Name: **Robotics**
Credit Hours: 3
Prerequisites: **Artificial Intelligence**

Course Outline:

A brief history of robotics, types of robots; Potential applications of intelligent systems and robotics; Sensors and Actuators; Sonar, laser scanner, optical encoders; DC motors. Control; Feedback control; Localization and mapping; Dead-reckoning; Triangulation. Kalman filter; Uncertainty grid; Behavior based programming; Robot behaviors. Potential field approach; Behavior based architecture; Recent advances; Multi-robotic systems; Robot evolution.

Reference Materials:

1. *Robot Motion Planning*, Jean-Claude, Latombe Kluwer, Academic Publishers, Boston, 1991.
2. *Artificial Intelligence and Mobile Robots*, D. Kortenkamp, R. Bonasso, and R. Murphy, ed., AAAI Press, 1998.
3. *Handbook of Robotics*, Siciliano, Bruno; Khatib, Oussama (Eds.), Springer Springer 2008
4. *An Introduction to Intelligent and Autonomous Control,* P. Antsaklis and K. Passino, Kluwer, 1993.

Course Name: **Intelligent Planning**
Credit Hours: 3
Prerequisites: **Artificial Intelligence**

Course Outline:

Introduction to Planning Approaches; Plan generation and causal-link planning; Planning as constraint satisfaction; Planning Problems; Planning on a computational grid; Planning using temporal logics; Heuristic search planning; Knowledge representation for planning, ontologies, description logics; Reasoning about time: temporal reasoning and scheduling; Controlling Search; Complexity of planning problems; Learning search control knowledge & case-based planning; Distributed & multi-agent planning; Learning from an external environment; Planning and execution; Reactive systems; Probabilistic planning; Planning and decision theory, Markov decision processes; Mixed-initiative planning

Reference Materials:

1. *Planning in intelligent systems*, Wezel, Wout van and Jorna, René J., 2006, Wiley.
2. LaValle, Steven Michael, 2006, Planning Algorithms.
3. *Machine learning methods for planning*, Minton, Steven, 1993, Morgan Kaufmann Publishers.
4. Planning Algorithms, LaValle, Steven Michael, 2006.
5. *Planning with Markov Decision*, Kolobov, Andrey, 2012, Morgan & Claypool Publishers.
6. *Intelligent Task Planning Using Fuzzy Petri Nets*, Cao, Tiehua and Sanderson, A. Arthur C., 1996,. World Scientific Publishing Company Incorporated.
7. *Intelligent Techniques For Planning*, Vlahavas, Ioannis and Vrakas, Dimitris, 2005, Igi Global.
8. *Planning in intelligent systems*, Wezel, Wout van and Jorna, René J., 2006, Wiley.

Course Name: **Fuzzy Systems**
Credit Hours: 3
Prerequisites: **Discrete Mathematics**

Course Outline:

The Mathematics of Fuzzy Systems and Control; Fuzzy Sets and Operations on Fuzzy Sets; Fuzzy Relations and the Extension Principle; Fuzzy Logic and Approximate Reasoning; Fuzzy Systems and Their Properties; Fuzzy Rule Base and Fuzzy Inference Engine; Fuzzifiers and Defuzzifiers; Fuzzy Systems as Nonlinear Mappings; Approximation Accuracy of the Fuzzy System; Fuzzy Systems with Second-Order Approximation Accuracy; Approximation; Accuracy of Fuzzy Systems with Maximum; Design of Fuzzy Systems from Input-Output Data; A Table Look-Up Scheme; Gradient Descent Training; Recursive Least Squares; Design of Fuzzy; Systems Using Clustering; Non-adaptive Fuzzy Control; Adaptive Fuzzy Control; Fuzzy Linear Programming

Reference Materials:

1. *A course in fuzzy systems and control,* Wang, Li-Xin, 1997, Prentice Hall.
2. *Advanced Fuzzy Systems Design and Applications*, Jin, Yaochu, 2003, Physica Verlag.
3. *Advanced Concepts in Fuzzy Logic and Systems with Membership Uncertainty*, Starczewski, Janusz T., 2012, Springer.
4. *Advanced Fuzzy Systems Design and Applications*, Jin, Yaochu, 2003, PhysicaVerlag.
5. Siddique, Nazmul and Adeli, Hojjat, 2013, Computational Intelligence. Wiley.

Course Name: **Intelligent Probabilistic Data Modeling**
Credit Hours: 3
Prerequisites: **Probability and Statistics**

Course Outline:

Bayes' Theorem and Simple Bayesian Inference; Bayesian Decision Trees; Approximate Inference; Exact Inference; Graphical Models; Sampling and Resampling; Data Models and Distributions; Feature Reduction, Principal Component Analysis; Linear Discriminant Analysis; Support Vector Machines; Maximum Weighted Spanning Tree; Learning in Belief Networks; Hidden Markov Models; Probabilistic Relational models; Relational Uncertainty in Probabilistic Relational models

Reference Materials:

1. *Learning from Data,* Cherkassky, Vladimir and Mulier, Filip M., 2007, Wiley-IEEE Press.
2. *The Elements of Statistical Learning.* Hastie, Trevor J. et el, 2009, Springer.
3. *Computational Vision in Neural and Machine Systems*, Harris, Laurence R and Jenkin, Michael R. M., 2007

4. *The Art of the Sale,* Broughton, Philip Delves, 2013, Penguin Group USA.
5. *Optimized Bayesian Dynamic Advising,* Karny, Miroslav, 2006, Springer-Verlag New York Incorporated.
6. Scalable Optimization Via Probabilistic Modeling, Pelikan, Martin and Sastry, Kumara, 2006, Springer Verlag.

Course Name: **Logic Programming & Automated Reasoning**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

Propositional logic; Propositional logic reasoning using resolution; First-order/predicate logic; First-order reasoning using unrestricted resolution; Well-founded orderings; Multi-set and Multi-set orderings; Structural transformation; Fuzzy logic; Bayesian inference. Reasoning with maximal entropy.

Reference Materials:

1. *Probabilistic Inductive Logic Programming,* Raedt, Luc De, 2008, Springer-Verlag New York Incorporated.
2. *Meta-reasoning*, Cox, Michael T. and Raja, Anita, 2011, The MIT Press.
3. *Thinking As Computation*, Levesque, Hector J., 2012,. MIT Press (MA).
4. *Automated Theory Formation in Pure Mathematics,* Colton, Simon, 2002, Springer Verlag.

Course Title: **Evolutionary Computation/Algorithms**
Credit Hours: 3

Course Outline:

Introduction to Evolutionary Algorithm, Genetic Algorithms, Evolution Strategies, Evolutionary Programming, Genetic Programming, Learning Classifier Systems, Parameter Control in Evolutionary Algorithms, Multi-Modal Problems and Spatial Distribution, Hybridisation with Other Techniques: Memetic Algorithms, Theory of EAs, Constraint Handling Special Forms of Evolution, Working with Evolutionary Algorithms, Practical implementation of EAs.

Reference Materials:

1. *Introduction to Evolutionary Computing,* Agoston E. Eiben, J.E. Smith.
2. *Introduction to Genetic Algorithms*, S.N. Sivanandam, S. N. Deepa
3. *Evolutionary Computation*, Kenneth A. de De Jong, Kenneth A. De Jong
4. *Genetic Algorithms in Search, Optimization, and Machine Learning,* David E.Goldberg.
5. *Genetic Algorithms + Data Structures = Evolution Programs,* Zbigniew Michalewicz

Course Title: **Visualization in Medicine**
Credit Hours: 3
Prerequisite: **Probability and Statistics and Graph Theory**

Course outline:

Introduction: 2D and 3D Visualization in Medicine; Medical Image Data and Visual Perception; Acquisition of Medical Image Data; Medical Volume Data in Clinical Practice.

Image Analysis for Medical Visualization; Volume visualization Exploration of Medical Volume Data; Measurements in Medical Visualization; Virtual Endoscopy; Image Guided Surgery and Virtual Reality

Reference Material:

1. *Visualization in Medicine: Theory, Algorithms, and Applications,* Bernhard Preim, Dirk Bartz

Course Name: **Advanced Database Systems**
Course Structure: Lectures: 3
Credit Hours: 3
Prerequisites: **Introduction to Database Systems**

Course Outline:

Advance Normal Forms such as Multivalued Dependency, 4th and 5th normal forms, Domain Key normal form, Hierarchical structure of DBMS, Storage and File Organization, Storage Indexing and Hashing, Relational Calculus, Query Processing Transaction processing, ACID properties, Serializability, Recoverability, Concurrency control and Recovery, Protocols (Lock-based, Graph-based, Timestamp-based, Validation-based), Deadlock Handling techniques and prevention, Log-based Recovery, Failure with loss of Nonvolatile storage.

Reference Materials:

1. *Fundamentals of Database Systems*, By R. Elmasri and S. Navathe, 6th Edition, 2011.
2. *Database Management Systems*, By R. Ramakrishnan, J. Gehrke, 3rd Edition, 2003.
3. *Database System Concepts*, By Abraham Silberschatz, Henry F. Korth S. Sudarshan, 6th Edition, 2010.
4. *Database Systems,* The Complete Book. By H. Garcia-Molina, J. D. Ullman, and J. Widom; Prentice Hall, 2002.
5. *Database Systems,* C. J. Date, 8th Edition, 2004

Course Name: **Distributed Databases**
Credit Hours: 3
Prerequisites: **Advanced Database Systems**

Course Outline:

Introduction to distributed database systems (DDBMS), architectural models, DDBMS architecture, distributed database design strategies, design issues, fragmentation, allocation, view management, data security, semantic integrity control, distributed query processing problems, query decomposition, localization of distributed data, query optimization, join ordering in fragment queries, distributed query optimization algorithms, transaction processing, concurrency control mechanisms, serializability theory, locked-based and timestamp-based algorithms, optimistic algorithms, deadlock management, reliability concepts and measures, failures in DDBMS, local reliability protocols, distributed reliability protocols, dealing with site failures, Network partitioning, database integration, data processing in multi-databases and inter-operability issues.

Reference Materials:

1. *Principles of Distributed Database Systems*, M.T. Ozsu, P. Valduriez (eds.): (2nd Edition), Prentice Hall, 1999.
2. *Transactional Information Systems,* G. Weikum and G. Vossen, Morgan Kaufmann, 2002.

Course Name: **Web Mining**
Credit Hours: 3
Prerequisites: **Data Mining**

Course outline:

Introduction to web, usage, content, and structure mining, Use of Machine Learning and Computational Intelligence Techniques for web mining and information networks, mining information sites and streams, Web crawling, indexing, ranking and filtering algorithms using content and link analysis summarizing and analyzing web information, mining opinion and reviews, identifying and mining social networks and social media, Applications for searching, classification, recommendation, and Web intelligence.

Reference Materials:

1. *Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data*, Bing Liu 2011; 2nd Edition.
2. *Mining the Web*, Soumen Chakrabarti, Morgan-Kaufmann, 2011, 2nd Edition.

Course Name: **Text Mining**
Credit Hours: 3
Prerequisites: **Fundamental of Data Mining**

Course outline:

Introduction to text mining, Structuring Text, Normalization, Stop words, Stemming, part-of-speech tagging, phrase chunking, relation finding, and named-entity recognition. Document-Term Matrix Formation Processing, and Manipulations, Latent Semantic Indexing, Searching, Topic Modeling, Clustering and Classification, Spam Detection. Using different software tools such as Weka, GATE, covering programming and tuning existing modules.

Course Title: **Virtual and Augmented Reality Systems**
Credit Hours: 3

Course Outline:

Introduction to Virtual Reality, Human and its environment, I^3 diagram for VR (Interaction, Immersion, Imagination), Human centric reference model of VR, Sensory motor interfaces, Motion trackers, Stereoscopic vision(depth perception, stereoscopic image creation, active and passive stereoscopy), Design and evaluation of virtual environments, Application of (Medical, Psychotherapy, Fighting Simulation, Training Simulation, Assembling and Repairing, Biological and Physical Sciences, Collaborative Work, Ergonomic studies, Games VR, Introduction to Augmented Reality.

Reference Materials:

1. *Handbook of Virtual Environments: Design, Implementation, and Applications (Human Factors and Ergonomics),* Edited by Kay M Stanney, Lawrence Erlbaum Associates Virtual Reality Technology by GRIGORE

Course Title: **Knowledge Management**
Credit Hours: 3
Prerequisite: **Artificial Intelligence**

Course Outline:

Overview of Knowledge Management (KM), The Nature of Knowledge, KM Solutions, Organizational Impacts of KM, Factors Influencing KM, KM Assessment of an Organization, Technologies to Manage Knowledge, Knowledge-Based Systems, Converting Tacit Knowledge to Explicit, Discovering New Knowledge, Data Mining, Knowledge Discovery, Knowledge Capture Systems, Knowledge Sharing Systems, Knowledge Application Systems, The Future of Knowledge Management

Reference Materials:

1. *Knowledge Management Challenges, Solutions, and Technologies,* Irma Becerra-Fernandez, Avelino Gonzalez, Rajiv Sabherwal (2004). (edition with accompanying CD). Prentice Hall. ISBN: 0-13-109931-0.

2. *Essentials of Knowledge Management,* Bryan Bergeron, John Wiley & Sons, Inc. 2003

Course Title: **Decision Theory**
Credit Hours: 3
Prerequisite: **Probability and Statistics**

Course Outline:

Introduces the basic problems and techniques of decision making may be covered in two basic parts: 1. principles and approaches in decision making, 2. explores the methods and applications of information that are used in making an optimal decision. Differences between the classical frequencies approach and Bayesian approach in making decision, identify prior distributions and likelihood functions, and combine these two entities to obtain posterior distributions, which will then be combined with loss function to obtain Bayesian estimators. Concepts of conjugate distributions on prior and posterior distributions, important definitions in decision theory, proving admissibility and inadmissibility of a decision, process of making an optimal decision, utility and reward, and sensitivity analysis related to an optimal decision. Analysis of subjective probabilities

Reference Materials:

1. *Bayesian Data Analysis, Gelman*, A., Carlin, J. B. and Rubin, D. B. (2003), Chapman & Hall. (QA279.5.B3862003)
2. *Decision Making and Forecasting, Marshall*, K. T. & Oliver, R. M. (1995), McGraw-Hill, Inc. (T57.95.M351995)
3. *Statistical Decision Theory and Bayesian Analysis*, Berger J. O. (1985), 2nd Ed. Springer-Verlag. (QA279.4.B461985)
4. *A Bayesian Approach,* Smith, J. Q. (1988), Decision Analysis: Chapman & Hall, London (QA279.5.S641988)
5. *Bayesian Inference in Statistical Analysis,* Box, G. E. P. & Tiow, G. C. (1973), Addison-Wesley. (QA276.B681973)

National Curriculum Revision Committee
Software Engineering

The National Curriculum Revision Committee for Software Engineering (NCRC-SE) met on 6-8 February, 2013 to develop the vision for Software Engineering education and curriculum for software engineering programme. The Committee met again on 10-12 June, 2013 to finalize the curricula recommendations. Participants represented most of the universities and software industry of the country. Following experts participated in the meetings for sub-group on Software Engineering:

	Name and Address	
1.	Dr. Abu Turab Alam Professor, College of Computer Science & Information System, Institute of Business Management, Korangi Creek, Industrial Area, Karachi.	Convener and Chairperson of SE committee
2.	Dr. Mohammad Riaz Moghal, Professor, Computer Systems Engg, Mirpur University of Science & Tech, Main Campus, Mirpur A.K	Member
3.	Mr. Muhammad Shakeel, Assistant Professor, Dept. of Computer Sciences, GIFT University, Gujranwala	Member
4.	Dr. Fakhar-ul-Islam Lodhi, Dean, Deptt. Of Computer Sciences, GIFT University, Gujranwala.	Member
5.	Dr. Naveed Arshad, Assistant Professor, Dept. of Computer Science, Lahore University of Management Sciences (LUMS), Opp. Sector “U”, DHA, Lahore Cantt	Member

6.	Dr. Shahbaz Khan, Chairman, Dept. of Telecommunication Engg, University of Engg & Tech, Mardan Campus Peshawar.	Member
7.	Dr. Iftikhar Ahmed Khan, Assistant Professor, Dept. of Computer Software Engg, University of Engg & Tech, Mardan Campus, Peshawar.	**Member**
8.	Dr. Najmi Ghani Haider, Professor, Dept. of Computer & Information Systems Engg, NED University of Engg & Tech, Karachi.	Member
9.	Dr. Muaz Ahmad Khan Niazi, Professor, Dept. of Computer & Software Engg, Bahria University, E-8, Islamabad.	Member
10.	Dr. Muhammad Akram Shaikh Director General Pakistan Scientific & Technological Information Centre QAU Campus, Islamabad.	Member

The Discipline of Software Engineering:

Software Engineering is a bridge connecting the basic concepts and principles of Computer Science with the variety of users who can benefit from technologies based upon those principles. It includes the design and development of software systems which are effective, efficient, robust, maintainable, and maximally useful and usable. It also includes the design and development of techniques, processes and higher level tools by which these applications can be developed in a timely, cost effective and sustainable manner. At both levels it requires a systematic approach which deals with quantifiable measures of quality and effectiveness, as well as attention to the critical nature of the various products of the process.

Software engineering therefore requires familiarity with the basic needs and processes in the various application domains, with the principles of good

engineering practice and with the underlying concepts and principles of computer science. It requires facility in problem analysis, solution design, program development and documentation. It also requires a basic understanding of the ways in which humans interact with technological systems.

A software engineering programme should develop professionals who have a mastery of software development principles, theory, practice, and process.

Software Engineering and Computer Science differ in much the same way as do Electrical Engineering and Physics[1]. Generally, engineering should be concerned with applying what we already know to create products, while science is more theoretical. Therefore, the goal of Computer Science, according to Parnas[2], is to *learn* and to extend the science. SE on the other hand aims to use the science and technology already available to create products and tools for use.

Software Engineering derives its essence from computer science as other engineering disciplines do from natural or life sciences, with an emphasis on issues of process, design, measurement, analysis and verification providing a strong foundation in engineering principles and practices as applied to software development.

Definition:

Software Engineering is a discipline concerned with the development of software systems by applying engineering principles with the goal of developing cost-effective quality systems. There are many definitions in literature. Such as:

- "The establishment and use of sound engineering principles (methods) in order to obtain economically software that is reliable and works on real machines" [Bauer 1972].

- "Software engineering is that form of engineering that applies the principles of computer science and mathematics to achieving cost-effective solutions to software problems." [CMU/SEI-90-TR-003]

- "The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software" [IEEE 1990].

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[1] David Parnas, "Software Engineering Programmes are not Computer Science Programmes"*, IEEE Software, Nov/Dec. 1999, pp. 19-30.*

[2] David Parnas, "Software Engineering Programmes are not Computer Science Programmes"*, IEEE Software, Nov/Dec. 1999, pp. 19-30.*

- IEEE defines software engineering [IEEE-93] as

  "1. The application of systematic, disciplined, quantifiable approach to development, operation, and maintenance of software; that is application of engineering to software.
  2.The study of approaches as in 1."

Software Engineering could also be defined as:

"The application of systematic, disciplined, quantifiable approach to design, development, deployment, and maintenance of reliable and economical software systems."

Vision:

Software engineering is the discipline of creating high-quality software systems in a systematic, controlled and efficient manner. It involves the application of engineering concepts, techniques, and methods to the design, development, deployment and maintenance of software systems. A software engineering programme should develop professionals who have a mastery of principles, theory, practices, and processes necessary to produce quality software systems. The curriculum committee formalized the Vision Statement for SE education in Pakistan as follows:

The SE education in Pakistan will focus on imparting the knowledge and training which should enable students to harmonize theory with practice, concept with application, and problem with solution. It will prepare them to apply ably engineering principles, practices, and processes to design, develop, deploy, and maintain software systems. The programme will lead to development of student's professional and interpersonal skills. It will help students to enhance their ability in oral and written communication, and their adaptability to team environments. The programme will inculcate among students a strong sense of civic, professional and ethical responsibility. The programme will also strive to develop a capacity for innovation and a passion for lifelong learning.

SE curricula thus developed would reflect the aim to satisfy professional demands of the industry and academia both in terms of immediate needs and the capacity for longer term development. The graduates thus produced will be adequately equipped to exploit the opportunities and answer the challenges offered by the modern world.

Knowledge Areas of SE Curriculum Development ABET Engineering Criteria 2000 notes:

"The curriculum must provide both breadth and depth across the range of engineering and computer science topics implied by the title and objective of

the programme. The programme must demonstrate that graduates have: the ability to analyze, design, verify, validate, implement, apply, and maintain software systems; the ability to appropriately apply discrete mathematics, probability and statistics, and relevant topics in computer and management sciences to complex software systems."

SE curriculum specified here has been developed systematically by identifying the major knowledge areas of SE education, in the spirit of engineering criteria above. It is noted that efforts carried out by ACM and IEEE-CS to develop international software curricula are very relevant and provide excellent guidelines on the issue. Outcome of these efforts is documented in *Software Engineering Body of Knowledge* (SWEBOK)[3], Software Engineering Education Knowledge (SEEK)[4], and Computing Curriculum 2008[5].

The following major areas of relevant pedagogy have been identified to be appropriate for design of the software engineering curriculum:

1 Computing Foundation (CS/SE/CE)
2 Software Engineering (SE Major)
3 Software Engineering Application Domain
4 Supporting Areas (Mathematics and Natural Sciences)
5 General Education (Management, Humanities, Social Sciences)

The committee is of the view that good curriculum should focus on building a solid foundation in the early stages of learning. It should gradually introduce and strengthen the core professional competencies and desired skill-sets. Software engineering concepts should be taken up as early as the start of 2nd year. The main technical SE content should be covered during the third and fourth years. Practical component should use medium to large scale projects to develop in students a systematic approach to problem solving and program development. Good SE practices must be nurtured all through the education programme. The practice of software engineering is often in the context of non-software application domains. The graduates, therefore, should be provided an opportunity for reasonably broad exposure to at least one application area in the senior years. It will help them learn and demonstrate the application of software engineering practices. A capstone design project should provide the opportunity to bring together all the knowledge gained in a wide variety of courses to solve realistic problems in a team-based environment.

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[3] *Guide to Software Engineering Body of Knowledge,* 2004 Edition,.

[4] *Software Engineering – Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering, 2004August 23, 2004*

[5] Computing Curriculum 2008—Draft

Software Engineering Degree Programme:

Nomenclature:

The committee emphasized that the nomenclature followed for Software Engineering programs should correspond to international trends and standards. The following nomenclature was thus agreed upon for various degrees:

Bachelor of Science in Software Engineering — BS Software Engg — BS (SE)
Master of Science in Software Engineering — MS Software Engg— MS (SE)

Duration of Programme:

The committee defined a credit hour as one lecture hour in a course offered in a particular semester. It was agreed that 3 weekly lab hours shall be treated as one credit hour. In normal circumstances a semester comprises 15 to16 teaching weeks followed by the final examination. It is also recommended that one week may be given to students as preparation week before final exam.

The BS Software Engineering Degree would be a 4-year programme spread over 8 semesters and MS Software Engineering programme would be a 2-year programme spread over 4 semesters.

Admission Criteria:

The eligibility criteria for BS Software Engineering admission was agreed to be intermediate with mathematics or equivalent qualifications, however, universities may define their own admission criteria.

The eligibility criterion for admission to MS Software Engineering was unanimously agreed to be 4-year BS Software Engineering or equivalent qualifications, however, universities may define their own admission criteria.

Curriculum for BS Software Engineering-BS (SE)

Programme Objective:

The objective of the programme is to prepare students for professional careers and for graduate studies in software engineering. With a balance between computing theory and practical application of software engineering concepts including software project management, methodologies, tools and technologies in the modern software development environments.

Graduates of such a programme will be able to function as proficient software developers and effective team members. They will have grounding in communication, mathematics and science, and the cultural, historical, and social issues that influence and effect or relate to the development of high quality software systems. They will have knowledge of and experience with software product engineering and engineering management and an understanding of professional issues and practices. Graduates will be able to understand and assess their own software engineering capabilities and performance.

The curriculum is designed to ensure breadth across allied disciplines and supporting subjects; and depth in most areas of the software engineering body of knowledge. Various components have been included in the curriculum to ensure that the graduates will:

- Understand and be able to apply mathematics, physical science, computer science and related disciplines.
- Understand and be able to apply the principles of software engineering practice and process, subject to realistic constraints.
- Be able to model, analyze, document and track system requirements, both functional and non-functional.
- Be able to design, implement, deploy and maintain software systems.
- Be able to verify and validate the software systems.
- Have an awareness of current industry standards and practices.
- Be able to work in one or more application domains.
- Understand and apply the principles of the team process.
- Be able to understand and apply software project management skills: measurement, estimation, costing, planning, deployment and tracking of resources.
- Have strong communication and interpersonal skills.
- Be capable of independent learning.
- Understand professional responsibility and application of ethical principles.
- Have knowledge of economics, humanities and social sciences.

Programme Model:

The programme is designed to achieve systematically the objectives set out above. It has been structured to suit the needs of the students, the demands of the market and trends. During the first two years of the programme the students will be given core understanding of the programme may be similar to other focusing areas in computing—computer science, information technology. The students will be exposed to the discipline in a systematic, gradual and definite way. Students will also be trained in the skills and techniques which are rooted in the basic sciences like mathematics and physics. These areas will be taken care of in the supporting courses which have been allocated reasonably sufficient space. Students' personal traits and personality polishing will be cared for by the general education courses including communication and writing skills. A host of slots for elective courses have also been proposed to give to the students an opportunity to move towards their areas of interest.

During the senior years the students will be given exposure to the more specialized aspects of the discipline. They will also be given training in at least one application domain which will help institutions to prepare human resource well suited to the needs of different segments of the job market. In order to inculcate among them a scientific attitude they will go through a substantial lab work, which will prepare them for the industry and for further research oriented studies. The final year project will mark the crystallization and culmination of the students' four-year learning experience. Table for BS(SE) gives the credit hour distribution of the core and elective courses.

Table for BS (SE): The Credit Hour Distribution of the Core and Elective Courses

Major Areas	Core/ Required	Elective	Credit Hours
Computing Foundation	46	21	85 (64%)
Software Engineering	18		
Supporting Studies (Math/Science)	12	9	21 (17%)
General Education	15	12	27 (21%)
Total	**91 (68%)**	**42 (33%)**	**133**

Computing-Core Courses-45 Credit Hours

#	Pre-Req	Course Title	Credit hours	Proposed Semester
1	-	Introduction to Computing	4 (3+1)	1
2	-	Programming Fundamentals	4 (3+1)	1
3	2	Object Oriented Programming	4 (3+1)	2
4	-	Discrete Structures	3 (3-0)	2
5	3	Data Structure and Algorithms	4 (3+1)	3
6	3	Digital Logic Design*	4 (3+1)	3
7	5	Operating Systems	4 (3+1)	4
8	4	Introduction to Database Systems	4 (3+1)	4
9	3	Software Engineering *	4 (3+1)	4
10	6	Computer Communications and Networks*	4 (3+1)	5
11	-	Final Project	6 (0+6)	7,8

*: Labs preferred in these courses. However, implementation details are left upon the concerned Institutes.

Elective Computing and Software Engineering Courses (15/133)

Domain Specific Elective Courses (6/133)

In-depth treatment of one of the following SE Application Domains should be offered in the form of set of two to three courses of 3 credits each in the selected domain. The list below is by no means exhaustive. Institutions may add new domains.

Each domain treatment should be organized as domain introduction, computing concept of the domains and the domain specific computing examples with general sprit of implementation using SE principles. Common domains may include banking, insurance, oil exploration; textile and garments; agriculture, medicine, defense, etc.

		Domains	Topics /Component	Cr	
1	IS	Enterprise Systems Engineering	ERP Systems, SCM Systems, CRM Systems	6	
2	NS	Net-Centric Systems	Knowledge and skills in Web-based Technologies Depth in networking, Depth in security	6	
3	IS	Enterprise Security Architecture	Business issues related to security, Security weaknesses and risk analysis, Cryptography, cryptanalysis, steganography, etc., Depth in networks	6	

4	IS	Information Systems and Data Processing	Data warehousing, Depth in databases Depth in business administration	6	
5	IS	Financial and E-commerce Systems	Accounting; Finance Depth in security	6	
6	CE	Fault Tolerant and Survivable Systems	Knowledge and skills in heterogeneous, distributed systems; Depth in security, Intrusion detection Failure analysis and recovery	6	
7	CE	Safety Critical Systems	Depth in formal methods, Proof of correctness, etc. Knowledge of control systems	6	
8	CE	Embedded & Real time Systems	Hardware for embedded systems Languages and tools for development Depth in timing issues; Hardware verification	6	
9	BI	Bio-medical Systems	Biology and related sciences Related safety critical systems knowledge	6	
10	SS	Scientific Systems	Depth in related sciences; Depth in statistics Visualization and graphics	6	
11	TE	Telecommunication Systems	Depth in signals, information theory, etc. Telephony and telecommunication protocols	6	
12	AS	Avionic & Vehicular Systems	Mechanical engineering concepts Related safety critical systems knowledge Related embedded and real-time systems knowledge	6	
14	IE	Industrial Process Systems	Control systems Industrial engineering and other relevant areas Related embedded and real-time systems knowledge	6	
15	ES	Multimedia, game, and entertainment Systems	Visualization, haptics, and graphics Depth in human computer interface design Depth in networks	6	

16	WN	System for Small & mobile Platforms	Depth in human computer interfaces for small and mobile platforms, Wireless technology Related embedded and real-time systems knowledge Related telecom systems knowledge	6	
17	AI	Artificial Intelligence	Agent based Systems Machine learning, Fuzzy logic Knowledge engineering	6	

Bachelor of Science in Software Engineering: BS (SE)

Software Engineering Core Courses 15 Credit Hours

Required Software Engineering Courses (15/133)					
#	Code	Pre-Req	Course Title	Credit Hours	Semester
	SE	3,9	Object Oriented Software Engineering	3	4
	SE	9	Software Requirements and Specifications	3	5
	SE	13	Software Architecture Design	3	6
	SE	13	Software Vérification and Validation	3	6
	SE	9	Software Project Management	3	7

Software Engineering Elective Computing 15 Credit Hours

Elective Computing & Software Engineering Courses (15/133) (The list below is by no means exhaustive. Institutions may add new course)					
#	Code	Pre-req	Course Title	Credit hours	
	SE	9	Software Engineering Economics	3 (2+1)	
	MG	-	Information System Audit	3 (2+1)	
	CS	9	Business Process Engineering	3 (2+1)	
	SE	7,10	Distributed Computing	3 (2+1)	
	CS	3	Introduction to Soft Computing	3 (2+1)	
	CS	7,10	Real-time systems	3 (2+1)	
	CS	8	Data Warehousing	3 (2+1)	
	CS	8	Data Mining	3 (2+1)	
	CS	4	Artificial Intelligence	3 (2+1)	
	CS	3	Data Security and Encryption	3 (2+1)	

	CS	14	Secure Software Development	3 (2+1)	
	CS	4	Automata Theory and Formal Languages	3	
	CS	8	Advance Database Management Systems	3 (2+1)	
	CS	1,4	Introduction to Bioinformatics	3 (2+1)	
	CS	33	Bioinformatics Software Engineering	3 (2+1)	
	CS	2	Web-Engineering	3 (2+1)	
	CS	9	System Analysis and Design	3	
	CS	3	Event Driven Programming	3 (2+1)	
	SE	12	Aspect Oriented Software Design	3 (2+1)	
	SE	3	Agent Based Computing	3 (2+1)	
	SE	20	Cloud Computing	3 (2+1)	
	SE	-	Social Networks	3	
	SE	-	Intro. to Complex Networks	3	
	CS	2	Functional Programming	3 (2+1)	
	CS	2	Mobile Computing	3 (2+1)	
	SE	9	Formal Methods	3	

Computing Requirements-Supporting Sciences 12 Credit hours (refer to Computing part)

Elective Supporting Courses (9/130) ***(The list below is by no means exhaustive. Institutions may add new course)***					
	MT	1	Advanced Calculus	3	
	MT	3	Numerical and Symbolic Computing	3	
	MT	3	Stochastic Processes	3	
	Sc	-	Physics-II (Mechanics)	3	
	Sc	-	Bio-Chemistry	3	
	Sc	-	Biology/ genetics	3	
	EE	4	Digital Electronics	4 (3+1)	
	Sc	--	Software Engineering Economics	3	
	MT	--	Computational Linear Algebra	3	
	MT	--	Operation Research	3	
	MT	--	Simulation and Modeling	3	
	CS	--	Natural Language Processing	3	

Computing Requirements-General Education 15 Credit Hours (Refer to Computing part)

Elective General Education Courses (12/130) *(The list below is by no means exhaustive. Institutions may add new course)*					
1	SS	-	English Literature	3	5
2	SS	-	Economics	3	7
3	SS	-	Sociology	3	2-6
4	SS	-	Psychology	3	6
5	SS	-	International Relations	3	7
6	HU	-	Foreign Language (Arabic, French, German, etc.)	3	7-8
7	MG	-	Information System Audit	3	7
8	MG	-	Principles of Management	3	4
9	MG	-	Human Resource Management	3	5
1(	MG	-	Marketing	3	6-7
1	MG	-	Accounting and Finance	3	5-7

Sample Scheme of Study for BS (SE) 4-year Programme (8 Semesters) (130 Credit Hours)

Semester-wise 4-Year Plan				
Semester 1	**Cr. Hrs.**		**Semester 2**	**Cr. Hrs.**
Introduction to Computing	4 (3+1)		Calculus and Analytical Geometry	3
Programming Fundamentals	4 (3+1)		Object Oriented Programming	4 (3+1)
Discrete Structures	3		Supporting Elective-I	3
Physics	3		GE/University Elective-I	3
English-I (Functional English)	3		English-II (Communication Skills)	3
			Islamic Studies/Ethics	2
	17			18
Semester 3	**Cr. Hrs.**		**Semester 4**	**Cr. Hrs.**
Software Engineering	3		Object Oriented Software Engineering	4 (3+1)
Data Structures and Algorithms	4 (3+1)		Supporting Elective-II	3
Digital Logic & Design	4 (3+1)		GE/University Elective II	3
Linear Algebra	3		Introduction to Database Systems	4(3+1)
			Pakistan Studies	2

Operating Systems	4 (3+1)			
	18			16
Semester 5	**Cr. Hrs.**		**Semester 6**	**Cr. Hrs.**
Software Requirement and Specifications	3		GE/University Elective III	3
Probability and Statistics	3		Software Verification and Validation	3
Computer Communication and Networks	4 (3+1)		Software Architecture & Design	3
SE Elective I	3		Human Computer Interaction	3
Supporting Elective III	3		SE Application Domain Elective I	3
SE Elective II	3		English-III (Technical and Report Writing)	3
Total	19		Total	18

Semester 7	**Cr. Hrs.**		**Semester 8**	**Cr. Hrs.**
Final Year Project	3		Final Year Project	3
Software Project Management	3		SE Elective III	3
Professional Practice	3		SE Elective IV	3
SE Application Domain Elective –II	3		SE Elective V	3
GE/University Elective IV	3			
Total	15		Total	12

BS (SE)-Software Engineering (Core)

Course Name: **Object Oriented Software Engineering**
Credit Hours: 4
Prerequisites: **Object Oriented Programming**

Course Outline:

Introduction to Software Engineering, Modeling with UML, Project Organization and Communication, Requirements Elicitation, Analyses, System Design: Decomposing the System, System Design: Addressing Design Goals, Object Design: Reusing Pattern Solutions, Object Design: Specifying Interfaces, Mapping Models to Code, Testing, Rationale Management, Configuration Management, Project Management, Software Life Cycle, Methodologies: Putting It All Together.

Reference Materials:

1. *Object-Oriented Software Engineering: Using UML, Patterns, and Java,* Bernd Bruegge, Allen H. Dutoit, Prentice Hall, 2010 (or Latest Edition)
2. *Object-Oriented Software Construction*, Bertrand Meyer, 2nd Edition, Prentice Hall in 1997 (or Latest Edition)
3. *Formal Methods in Computing*, M. Ferenczi, and Andras Pataricza , Akademiai Kiao, 2005 (or Latest Edition)
4. *Code Complete: A practical handbook of software construction*, Microsoft Press, 2004. (or Latest Edition)
5. *Software Engineering*, Ian Sommerville, 8th edition, Addison & Wesley. 2006 (or Latest Edition)

Course Name: **Software Requirements and Specifications**
Credit Hours: 3
Prerequisites: **Introduction to Software Engineering**

Course Outline:

Definition of Requirements Engineering and role in system development, Fundamental concepts and activities of Requirements Engineering, Information elicitation techniques, Modeling scenarios.

Fundamentals of goal-oriented Requirements Engineering, Modelling behavioural goals, Modelling quality goals, Goal modelling heuristics, Object modelling for Requirements Engineering, Object modelling notations, Object modelling heuristics, Identifying objects from goals, Modelling Use Cases and state machines, Deriving operational requirements from goals, Requirements Specification, Requirements verification and validation.

Management of inconsistency and conflict, Techniques for requirements evaluation, selection and prioritization; Requirements management; Requirements traceability

Reference Materials:

1. *Requirements Engineering: Processes and Techniques,* Gerald Kotonya and Sommerville, John-Wiley Sons, 1998 (or Latest Edition).
2. *Software Requirements*, Karl E. Wiegers, Microsoft Press, 2003(or Latest Edition).
3. *Software Requirements Specification*, David Tuffley, CreateSpace Independent Publishing Platform, 2010 (or Latest Edition).
4. *System Requirements Engineering,* Loucopoulos and Karakostas, McGraw-Hill, 1995 (or Latest Edition).

Course Name: **Software Design and Architecture**
Credit Hours: 3
Prerequisites: **Software Engineering**

Course Outline:

Introduction to the discipline of design, generic design processes, and design management; software product design, including analysis activities such as

needs elicitation and documentation, requirements development activities such as requirements specification and validation, prototyping, and use case modelling; engineering design analysis, including conceptual modelling and both architectural and detailed design; survey of patterns in software design, including architectural styles and common mid-level design patterns.

Reference Materials:

1. *Software Architecture and Design Illuminated*, Kai Qian, Xiang Fu, Lixin Tao, Chong-Wei Xu, Jorge L. Diaz-Herrera, Jones and Bartlett Publishers, 1st Edition, 2009 (or Latest Edition).
2. *Introduction to Software Engineering Design: Processes, Principles and Patterns with UML2*, Christopher Fox, Addison-Wesley Professional, 2006 (or Latest Edition).
3. *Software Engineering Design: Theory and Practice*, Carlos Otero, CRC Press, 2012 (or Latest Edition).
4. *Software Engineering Techniques: Design for Quality*, Krzysztof Sacha, Springer, 2006 (or Latest Edition).

Course Name: **Software Verification and Validation**
Credit Hours: 3
Prerequisites: **(Intro to) Software Engineering**

Course Outline:

Introduction to software quality assurance, The Quality Challenge, Quality Control v/s Quality Assurance, Quality Assurance in Software Projects (Phases), Principles and Practices, Quality Management, Quality Assurance and Standards, Quality Planning and Quality Control, Verification and Validation, Planning Verification and Validation, Critical System Validation, Reliability Validation, Safety Assurance, Security assessment, Inspections and reviews, Principles of software validation, Software verification, Planning for Software Quality Assurance, Software Quality Assurance (SQA) Plans, SQA-Organizational Level Initiatives, SQA Planning (Observations, Numbers, Results), Software Testing, Specification based test construction techniques, White-box and grey-box testing, Others comprehensive software testing techniques for SDLC, Control flow oriented test construction techniques, Data flow oriented test construction techniques, Clean-room approach to quality assurance, Product Quality and Process Quality, Standards for process quality and standards for product quality, Walkthroughs and Inspections, Structure, Checklist, Audits, Roles and Responsibilities (Reviews, Inspections, etc), How to make Reviews and Inspections most effective.

Reference Materials:

1. *Fundamentals of Software Testing*, Bernard Hom, Wiley, 2012, (or Latest Edition).
2. “Software Quality Assurance: Principles and Practice”, Nina S. Godbole, Alpha Science, 2004 (or Latest Edition).

3. *Software Quality Engineering: Testing*, *Quality Assurance, and Quantifiable Improvement*, Jeff Tian, John-Wiley & sons, 2005 (or Latest Edition).
4. *Software Testing in the Real World: Improving the Process*, Kit, Edward, Addison-Wesley, 1998 (or Latest Edition).
5. *Perfect Software: And other illusions about testing*, Gerald M. Weinberg, Dorest House, 2008 (or Latest Edition).

Course Name: **Software Project Management**
Credit Hours: 3
Prerequisites: **(Intro. to) Software Engineering**

Course Outline:

Software Crisis and Software Engineering, Classic Mistakes, Overview of Project Management, PMI Process Groups, Software project Phases, Project charter, Statement of Work (SOW), Planning Phase: Development lifecycle models, matching lifecycles to projects, Project plans, Work Breakdown Structures (WBS), Estimation of effort and cost (Expert Judgment, FP and Use Case point methods), Scheduling: Project network diagram fundamentals, CPM, PERT, Gantt charts, Critical chain scheduling, Using MS-Project, Assigning Resources, Resource leveling, Team models, Managing conflict and motivating, Project Monitoring and Control: Status reporting, Project metrics, EVM, Communications Techniques, Risk management and Change control Project Recovery, Documentation, Cutover/Migration, Post Project Reviews, Closing.

Reference Materials:

1. *Software Project Management*, Bob Hughes, Mike Cotterell, McGraw-Hill Higher Education, 5th Edition, 2009 (or Latest Edition).
2. *The Software Project Manager's Handbook: Principles that work at work*, Dwayne Phillips, IEEE Computer Society Press and Wiley Interscience, 2nd Edition, 2004 (or Latest Edition).

BS (SE) - Software Engineering Courses (Electives)

Course Name: **Software Engineering Economics**
Credit Hours: 3
Prerequisites: **(Intro. to) Software Engineering**

Course Outline:

Programming aspects, economic aspects, human relations aspects, software trends: cost, social impact, the plurality of SE Means, The GOALS Approach to Software Engineering, The Software Work Breakdown Structure (WBS), Software Maintenance, introduction to COCOMO, definitions and assumptions, development effort and schedule, phase distribution, The Raylaigh Distribution, interpolation, basic software maintenance effort estimation. Performance Models, Optimal Performance, Sensitivity Analysis, Cost-Effectiveness Models.

Reference Materials:

1. *Software Engineering Economics*, Boehm, Prentice Hall, 1981(or Latest Edition).
2. *Software Cost Estimation with COCOMO II*, Boehm et al., Prentice Hall, 2000 (or Latest Edition).
3. *Making the Software Business Case: Improvement, Reifer, Don*, Addison Wesley, 2001, (or Latest Edition).

Course Name: **Information System Audit**
Credit Hours: 3
Prerequisites: None

Course Outline:

IS Audit charter, Polices, Procedures, Audit computer networks and communication, Auditing software development, Acquisition, Maintenance, Auditing IT infrastructure, Auditing Management and Organization, Business process re-engineering: IS audit proposal, report, evidence and follow-up, complaint to standard, Enterprise service agreement, IP pro count policies and process, Backup and procedures

Reference Materials:

1. *Auditing Information Systems*, Jack J. Champlain, John-Wiley & Sons, 2003 (or Latest Edition).
2. *Information Systems Control and Audit*, Ron Weber, Pearson, 2011 (or Latest Edition).
3. *CISA Review Manual*, Information System Audit and Control Association, 2004, www.isaca.org.

Course Name: **Business Process Re-Engineering**
Credit Hours: 3
Prerequisites: **Introduction to Software Engineering**

Course Outline:

Why Focus on Business Processes? Setting the Stage for Business Process; Organizing for Process Improvement; Flowcharting: Drawing a Process Picture; Understanding the Process Characteristics; Streamlining the Process; Measurements, Feedback, and Action; Process Qualification; Measurements, Feedback, and Action.

Reference Materials:

1. *Business Process Improvement; The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness*, H. J. Harrington,

Course Name: **Distributed Computing**
Credit Hours: 3
Prerequisites: **Operating Systems, Computer Communications and Networks**

Course Outline:

Introduction to distributed systems, Distributed data, Distributed processing system, Multithreading, Thread synchronization, Resource brokerage, Resource monitoring, Load balancing, Storage elements, Batch processing models, Middle layer architecture, Resource clustering, RMI, CORBA, Net, MPI. Mobile and ubiquitous computing, Web Services, Coordination of web services with the grid.

Reference Materials:

1. *Distributed Systems: Principles and Paradigms*, Tanenbaum, 2nd Edition, 2002 (or Latest edition).
2. *Distributed Systems: Concepts and Design*, George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair, 2011(or Latest Edition).

Course Name: **Introduction to Soft Computing**
Credit Hours: 3
Prerequisites: **Object Oriented Programming**

Course Outline:

Neural Networks, Classification Tree, Naïve Bayes, Applications of Predictive Models, Probabilistic Reasoning using Bayesian Networks: Knowledge Acquisition, Belief Updating, Exact and Simulation-based Propagation Algorithms, Parameter and Structure Learning. Influence Nets, Dempster-Shafter Theory of Belief Functions, Fuzzy Logic.

Reference Materials:

1. "Bayesian Artificial Intelligence", Kevin Korb, Ann Nicholson, CRC Press, 2010 (or Latest Edition).
2. "Artificial Intelligence Illuminated", Ben Coppin, Jones and Bartlett, 2004 (or Latest Edition).
3. "Soft Computing & Intelligent Systems Design: Theory, Tools and Applications", Fakhreddine O. Karray, Clarence W De Silva, Addison-Wesley, 1st. Edition, 2005 (or Latest Edition).

Course Name: **Real Time Systems**
Credit Hours: 3
Prerequisites: **Operating Systems**

Course Outlines:

Introduction to Real-Time and Embedded Systems: Reference Model, Hard versus soft real-time, Job Scheduling: Clock driven scheduling algorithms, Priority driven scheduling algorithms, Schedulers in commodity and real-time operating systems, Resource access control: Algorithms, Implementation, Real-time communication: On best-effort networks, Enhanced quality of service.

Reference Material:

1. *Real-Time Systems, Jane W. S. Liu, Prentice Hall*, 1st Edition, 2000 (or Latest Edition).
2. Real-Time Systems: Design Principles for Distributed Embedded Applications, Hermann Kopetz, Springer; 2nd Edition, 2011, (or Latest Edition).
3. *Real-Time Systems Design and Analysis: Tools for the Practitioner*, Phillip A. Laplante, Seppo J. Ovaska, Wiley-IEEE Press; 4th Edition, 2011 (or Latest Edition).

Course Name: **Introduction to Complex Networks**
Credit Hours: 3
Prerequisites: **None**

Course Outline:

Fundamentals of networks, Mathematics of Graphs and Networks, Measures and Metrics Degree and eccentricity Centrality, Shortest path between Centrality, Clustering coefficient, Matching index, Large-scale Nature of Networks, Network Models (Erdos-Renyi random, Small-world , Scale-free network models, Calculation of basic measures in networks), Network Modeling tools overview (Pajek, Network Workbench, Gephi, Visone, Cytoscape, Centibin etc.), Evolution of Online Social networks: Facebook, Google+, Twitter, LinkedIn and Beyond, Social Network Analysis, Modeling Software Components as Agents in Networks

Reference Materials:

1. *Networks: An Introduction* by Mark Newman, Oxford University Press, 2010 (latest Ed.)
2. *Exploratory Social Network Analysis with Pajek (Structural Analysis in the Social Sciences)* by Wouter De Nooy, Andrej Mrvar and Vladimir Batagelj, Cambridge University Press, 2011 (latest Ed.)
3. *Six Degrees: The Science of a Connected Age*, Duncan J. Watts, Vintage, 2004 (latest Ed).

Course Name: **Data Warehousing**
Course Structure: Lectures: 2 Lab: 1 Credit Hours: 3
Prerequisites: **Introduction to Database Systems**

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.

Reference Material:

1. *Data warehousing fundamentals for IT Professionals* by Paulraj ponniah, (2011). John Wiley and Sons. (Latest Edition)

Course Name: **Data Mining**
Credit Hours: 3
Prerequisites: **Introduction to Database Systems**

Course Outline:

Concepts of Data mining, Data Preparation Techniques: outlier and missing data analysis, Data Reduction Techniques, learning methods in Data mining, Statistical Methods in Data Mining, Cluster Analysis, hierarchal, agglomerative and Naïve Bayesian methods, Decision Trees and Decision Rules, Association Rules, Other Soft Computing Approaches in Data Mining, Artificial Neural Networks, Fuzzy Logic and Fuzzy Set Theory, Genetic Algorithm, evolutionary algorithms.

Reference Materials:

1. Mehmed Kantatardzic, *Data Mining: Concepts, Models, Methods, and Algorithms*, 2003, John Wiley and Sons. (latest edition)
2. Margaret H. Dunham and S. Sridhar, *Data Mining*, *Introductory and Advanced Topics,* 2006, Pearson Education, (latest edition)
3. David Hand, Heikki MAnnila and Padhraic Smyth, *Principles of Data Mining*, 2001, The MIT Press. (latest edition)

Course Name: **Artificial Intelligence**
Credit Hours: 3
Prerequisites: **Discrete Structures, Data Structures and Algorithms**

Course Outline:

Introduction to Common Lisp. AI classical systems: General Problem Solver, rules, simple search, means-ends analysis. ELIZA, pattern matching, rule based translators, OPS-5. Knowledge Representation: Natural language, rules, productions, predicate logic, semantic networks, frames, objects, scripts. Search: Depth first search, breadth first search, best first search, hill climbing, min-max search, A* search. Symbolic Mathematics: student, solving algebra problems, translating English equations, solving algebraic equations, simplification rules, re-write rules, meta-rules, Macsyma, PRESS, ATLAS. Logic Programming: Resolution, unification, horn-clause logic, Prolog, Prolog programming. Sample case studies of shells and Knowledge Based Systems. A brief appreciation of state of the art computational techniques like neural networks, genetic algorithm, fuzzy sets.

Reference Materials:

1. *Artificial Intelligence* by Luger, 6th Edition (latest), Pearson Education.
2. Artificial Intelligence: A Modern Approach, Russell and Norvig, 3rd Edition (latest), Pearson Education.

Course Name: **Data Security and Encryption**
Credit Hours: **3**
Prerequisites: **Discrete Structures, Data Structures and Algorithms**

Course Outline:

The course consists of three parts: mathematical background, cryptography, and network security. The first part (mathematical background) introduces the principle of number theory and some results from probability theory, including Primes, random numbers, modular arithmetic and discrete logarithms. The second part (cryptography) covers cryptographic algorithms and design principles, including conventional and symmetric encryption (DES, IDEA, Blowfish, Rijndael, RC-4, RC-5), public key or asymmetric encryption (RSA, Diffie-Hellman), key management, hash functions (MD5, SHA-1, RIPEMD-160, HMAC), digital signatures, and certificates. The third part (network security) deals with practical applications that have been implemented and are in use to provide network security, including authentication protocols (X.509, Kerberos), electronic mail security (S/MIME, PGP), web security and protocols for secure electronic commerce (IPSec, SSL, TLS, SET).

Reference Material:

1. *Cryptography and Network Security: Principles and Practice,* William Stallings, 6th edition (latest), Prentice Hall, 2005.

Course Name: **Secure Software Systems**
Credit Hours: 3
Prerequisites: **Software Architecture and Design**

Course Outline:

Different techniques to prevent or detect problems including: threat modeling, check lists and coding standards, To grasp static analysis tools, Understand code reviews, typing and static analysis, To comprehend language-based security (or platform-based security), security middleware and runtime monitoring.

Reference Materials:

1. Building Secure Software, by John Viega and Gary McGraw. Addison-Wesley, 2002. (latest edition)
2. The 24 Deadly Sins of Software Security, by Michael Howard, David LeBlanc and John Viega, McGraw-Hill, 2009 (latest edition)
3. Secure Coding: Principles & Practices, by Mark G. Graff and Kenneth R. van Wyk. O'Reilly, 2003. (latest edition)
4. Writing Secure Code, by Michael Howard and David LeBlanc, Microsoft Press, 2002. (latest edition).

Course Name: **Theory of Automata and Formal Languages**
Course Structure: Lectures: 3 / Labs: 0
Credit Hours: 3
Prerequisites: **Discrete Structures, Data Structures and Algorithms**

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:* Context free grammars, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Push-down Automata, Pumping lemma and non-context free languages, Decidability, Chomsky's hierarchy of grammars *Turing Machines Theory:* Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Context sensitive Grammars, Defining Computers by TMs.

Reference Materials:

1. Formal Languages and Automata, Peter Linz, Jones and Bartlett Learning, 5th Edition, 2011 (Latest edition)
2. *Introduction to Computer Theory*, by Denial Cohen, John Wiley & Sons, Inc., 1996 (Latest edition)
3. *Introduction to Automata Theory, Languages and Computation*, by J Hopcraft, D. Ullman, 2006. (Latest edition)
4. *Languages and Machines, An Into to the Theory of Comp. Sc*., by Thomas A. Sudkamp. (Latest edition)

Course Name: **Introduction to Bioinformatics**
Credit Hours: **3**
Prerequisites: **Introduction to Computing, Discrete Structures**

Course Outline:

Origin of the field , Advances in biology and computers , Brief overview of key Biological concepts related to DNA, RNA, nucleotides, amino acids, proteins, protein interaction, Databases and web resources, Algorithms how to write them, and calculate their complexities, etc. , Nucleotide analysis principals and tools , Sequence similarity, Dot Matrix, Dynamic Programming for local , Global pair wise alignment using Smith-Waterman and Needle-Wunsch algorithms, Gap penalties including Affine gap penalty, Scoring and Substitution Matrices (PAM & BLOSUM), Multiple Sequence Alignment, BLAST and FASTA, etc., Dynamic programming algorithms, Statistical models, Artificial intelligence algorithms, Protein analysis including protein structure prediction from a sequence. , Phylogenetics, Mutations, evolution and protein families, clustering, predictions using distance methods (such as UPGMA), etc.

Reference Materials:

1. *Introduction to Bioinformatics* by T K Attwood, D J Parry-Smith, Samiron Phukan, Pearson Education (Latest edition)
2. *Introduction to Bioinformatics* by Arthur Lesk
3. *Algorithms in Bioinformatics* by Gary Benson, Roderic Page, Springer
4. *Algorithmic Aspects of Bioinformatics* by Hans-Joachim Bockenhauer, Dirk Bongartz, Springer.

Course Name: **Web Engineering**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Introduction, Web Basics, Servlets and Sessions, Java Server Pages, XML and the Web Database Access for Web Applications, Design Patterns for Web Applications, Security and Privacy, Performance and Scalability, Performance Analysis, WAP Protocol, Wireless application development, Android Programming.

Reference Materials:

1. *Web Engineering: A Practitioners' Approach*, Roger S. Pressman, McGraw Hill (2008) or Latest Edition
2. *Web Engineering: The Discipline of Systematic Development of Web Applications*, Gerti Kappel, Birgit Prýýll, Siegfried Reich and Werner Retschitzegger, McGraw-Hill, (2006) or Latest Edition
3. *Web Engineering*, Emilia Mendes and Nile Mosley, Springer Verlag, (2010) or Latest Edition.

Course Name: **Human Computer Interaction**
Credit Hours: 3
Prerequisites: **Introduction to Software Engineering**

Course Outlines:

The Human, Computer and Interaction, Usability paradigm and principles, Introduction to design basics, HCI in software process, Design rules, prototyping, evaluation techniques, task analysis, Universal design and User support and Computer Supported Cooperative Work; Introduction to specialized topics such as Groupware, pervasive and ubiquitous applications.

Reference Materials:

1. "Human-Computer Interaction", Alan Dix, *Computing Department, Lancaster University* Janet E. Finlay, *Leeds Metropolitan University,* Gregory D. Abowd, *Georgia Institute of Technology,* Russell Beale, *University of Birmingham* ISBN-10: 0130461091 ISBN-13: 9780130461094 Publisher: Prentice Hall 3rd Ed *or Latest Edition*
2. "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Ben Shneiderman, *University of Maryland* Catherine Plaisant, *University of Maryland* ISBN-10: 0321197860 ISBN-13: 9780321197863 Publisher: Addison-Wesley 4th Ed or Latest Edition.

Course Name: **System Analysis and Design**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Concept of Entity; Relationships; System Outputs; System Inputs; People and Organizations; products; ordering of products; shipments; Invoicing; Account and Budgeting; Human resources; Creating the Data Warehouse Data model from the Enterprise Data Model.

Reference Materials:

1. *The Data Model Resource*, Revised Edition Volume 1; A Library of Universal Data Models for All Enterprises; Len Silverston; John Wiley & Sons, Inc.; (2001) or Latest Edition.

Course Name: **Event Driven Programming**
Credit Hours: 3
Prerequisites: **Object Oriented Programming**

Course Outline:

Introduction to the course and its importance, history and course format , Introduction to C# or Java, Event-driven programming basics, Maintaining state, On-demand Rendering in event-driven applications, Timer and perpetual tasks, Multithreading and event-driven programming, A "window/frame" as a drawing surface + event-handling unit , Interesting

widgets, GUI design patterns, Performance issues, Gui on mobile devices/smart phones.

Reference Materials:

1. Event Processing in Action, Opher Etzion (Latest Edition)
2. Windows Presentation Foundation Unleashed, Adam Nathan (Latest Edition)
3. Event-Based Programming: Taking Events to the Limit, Ted Faison, Apress (Latest Edition)

Course Name: **Aspect Oriented Software Design**
Credit Hours: 3
Prerequisites: **Object Oriented Software Engineering**

Course Outline:

AOSD is a novel programming paradigm that aims at a better separation of concerns. AOSD emerged from the academic world in the late nineties and experiences a significant acceptance by industry. The topics covered in the course are:

Separation of Concerns and AOSD, Aspect-Oriented Programming in Aspect J, Case study: Design Patterns in AOP, Framework-based AOP approaches, Case study: Aspects in Enterprise Software, Current research topics in AOSD

Reference Materials:

1. Using Aspect-Oriented Programming for Trustworthy Software Development, Vladimir O. Safonov, John Wiley and Sons (2008) or Latest Edition
2. *Aspect in Action: Enterprise AOP with Spring Applications*, Ramnivas Laddad. Manning Publication Co. (2009) or Latest Edition.

Course Name: **Agent Based Computing**
Credit Hours: 3
Prerequisites: **Object Oriented Programming**

Course Outlines:

Introduction to Agent-based Computing, Agent-based Models, Modeling Complex Real-world Problems using Agents, Introduction to Net Logo, Describing ABMs, From Animation to Science, Model Verification & Validation, Model Design, Emergence, Observation, Adaptive Behaviour, Prediction, Software Multiagent Systems, Intelligent Agents, Deductive Reasoning Agents, Agent Methodologies.

Reference Materials:

1. *Agent-Based and Individual-Based Modeling: A Practical Introduction*, Steven F. Railsback and Volker Grimm (Latest Edition)
2. *An Introduction to MultiAgent Systems*, Michael Woodridge, Wiley (Latest Edition)
3. *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modelling and Simulation*, Michael J. North and Charles M. Macal, Oxford University Press (Latest Edition)
4. *Cognitive Agent-based Computing-I,* Muaz A. Niazi and Amir Hussain, Springer (Latest Edition).

Course Name: **Cloud Computing**
Credit Hours: 3
Prerequisites: **Distributed Computing**

Course Outline:

Datacenter Architectures, Cloud Stack , Technology Trends, Consistency, Availability, Partitions, Cluster File Systems, Data-flow Computation Frameworks, Key-Value Store and Interactive Query Systems, Big Data in the Clouds, Geographic distributed Storage, Programming Languages for the Cloud, DBases in the Cloud, In-Memory Frameworks, Google file system, Hadoop file system, MapReduce, OSes and Clouds Networking: topologies, Networking: Traffic Management, Networking: Transport Protocol Improvements, Security, Scheduling and Resource Management in clouds, Software Level Agreements.

Reference Materials:

1. *Handbook of Cloud Computing,* Borko Furht. Springer (2010) or Latest Edition
2. *Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security, and More*, Kris Jamsa Jones & Bartlett Publishers, (2012) or Latest Edition
3. *Cloud Computing and SOA: Convergence in your enterprise*, David Linthicum (2009), Addison Wesley (Latest Edition)
4. *Distributed File Systems*: Hadoop, Lustre, Google File System, Andrew File System, Off system, Distributed File System", Ceph. General books LLC. (2010) or Latest Edition
5. *Map Reduce Design Patterns*, Donald Miner and Adam Shook. O' Reilly and Sons, (2012) or Latest Edition

Course Name: **Social Networks**
Credit Hours: 3
Prerequisites: None

Course Outline:

Link analysis and network community detection, diffusion and information propagation on the web, virus outbreak detection in networks, and connections with work in the social sciences and economics.

Reference Material:

1. *Social and Economic Networks*, Mathew O Jackson, Princeton University Press, (2010). or Latest Edition

Course Name: **Functional Programming**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Introduction. Functions, lists and Recursion; map, filter, fold; binding; algebraic data types, abstract types; type classes; logic and programs; applications and domains for functional programming.

Reference Materials:

1. *The Craft of Functional Programming*, Simon Thompson, Addison Wesley. (Latest Edition)
2. *Programming in Haskell*, Graham Hutton, Cambridge University Press. (Latest Edition)
3. *The Haskell School of Expression*, Paul Hudak, Cambridge University Press, (Latest Edition).

Course Name: **Mobile Computing**
Credit Hours: 3
Prerequisites: **Programming Fundamentals.**

Course Outline:

Types of Mobile Applications How are Users of Mobile Devices (Smartphones) Different from Users of Other Devices? Technologies Involved in Application Development. Differences from Desktop and Server Side Software Development, Software Design Concerns, Stakeholders in mobile applications: manufacturers, network operators, consumers, application developers, content providers, Android Platform Architecture and Application Fundamentals, Android application development tools. User Interface components, Data Storage and Content Providers, Services, Broadcast Receivers, Application Resources and other android structures, Using Android platform APIs, Web applications, Application Testing Framework, Introduction to games for mobile platforms, Introduction to

mobile gaming engines. Overview of game development using a game engine, Apple iOS, Java ME, Windows Phone, Comparison and limitations of popular Cross platform development tools.

Reference Materials:

1. *Pro Android 4*,Satya Komatineni and Dave MacLean, Professional Apress, (Latest Edition)
2. *The Busy Coder's Guide to Android Development*, Mark Murphy, CommonsWare, LLC. (Latest Edition)
3. *Professional Android 4 Application Development*, Reto Meier, Wrox. (Latest Edition)
4. *Beginning Android Games*, Mario Zechner et al, Apress, (Latest Edition)
5. *Designing the Mobile User Experience*, Barbara Ballard, Wiley. (Latest Edition).

Elective Supporting Courses

Course Name: **Linear Algebra**
Credit Hours: 3
Prerequisites: **Calculus**

Course Outline:

Background matrix algebra, measuring vectors, matrices, subspaces, and linear system sensitivity, numerical matrix algebra, Gaussian elimination, special linear systems, orthogonalization and least squares methods, the unsymmetrical eigenvalues problem, the symmetric eigenvalues problem, Lanczos methods, iterative methods for linear systems, functions of matrices.

Introduction of discrete transforms, discrete Fourier and cosine transforms and simple applications. Error analysis and estimation for all techniques studied.

Sample labs and assignments:

- Implementation and testing of algorithms for typical linear algebra problems, including an analysis of errors.

Reference Materials:

1. *Matrix Computations,* G. Golub, and C. Van Loan, *(3/e), (*1996) or Latest Edition
2. *Computational Methods of Linear Algebra, G.* Sewell, *(2/e)*, (2005) or Latest Edition
3. *Wavelets Made Easy*, Y. Nievergelt, (1999) or Latest Edition

Course Name: **Operations Research**
Credit Hours: 3
Prerequisites: **Probability and Statistics**

Course Outline:

Introduction to mathematical modeling. Linear program models, simplex method for solving LP models, sensitivity analysis, other solution techniques for LP models, specialized LP models (transport, assignment, etc.). Network based models, shortest path, min weight spanning tree, max flow, PERT/CPM. Decision models, dynamic programming, games theory. Probabilistic models, expected return models, Markov chains, stochastic processes, queuing models, stochastic inventory models.

Sample labs and assignments:

Given a scenario, select and develop an appropriate model, solve it for the given parameters, and analyze the sensitivity of the solution to changes in the problem parameters.

Reference Materials:

1. *Operations Research: An Introduction,* Hamdi A. Taha, *(8/e), (*2006) or Latest Edition
2. *Introduction to Operations Research, F.S.* Hillier, and G. J. Leibermann, (8/e), (2005) or Latest Edition

Course Name: **Simulation and Modelling**
Credit Hours: 3
Prerequisites: **Probability and Statistics, Data Structures**

Course Outline:

Introduction to Simulation and Modeling, Discrete-Event Simulation, Simulation of a Single-Server Queueing System, Alternative Approaches to Modeling and Simulations; Review of Basic Probability and Statistics; Estimation of Means, Variances, and Correlations, Confidence Intervals and Hypothesis Tests for the Mean, The Laws of Large Numbers; Random number generators; Simulation of discrete, continuous probability distributions and empirical distributions; tests on simulated distributions, rejection method, simulation of multivariate distributions, correlations, and stochastic processes, simulation of models of arrival processes, Poisson Processes, Nonstationary Poisson Processes, Batch Arrivals, tests on generators, Markov- Chain Monte-Carlo simulations; Variance-Reduction Techniques.

Reference Materials:

1. *Simulation Modelling and Analysis*, A.M. Law and W.D. Kelton, McGraw Hill, (2000) or Latest Edition
2. *Discrete-event System Simulation*, J. Banks, J.S. Carson and B.L. Nelson, Prentice Hall International, (1994) or Latest Edition

3. *Probabilistic Modelling*, Mitrani, Cambridge University Press, (1998) or Latest Edition
4. *Simulation and Modelling*, Sheldon M. Ross, (2002) or Latest Edition
5. *Stochastic Simulations*, Brian Ripley. (Latest Edition)

Course Name: **Professional Practices**
Credit Hours: 3
Prerequisites: **None**

Course Outline:

Introduction, Computing Ethics, Philosophy of Ethics, Ethics and the Internet. Intellectual Copy Right, Accountability and Auditing, Social Application of Ethics.

Reference Materials:

1. *Computer Ethics*, Deborah G. Johnson, Pearson Education (2001) 3rd edition or Latest Edition
2. *Professional Issues in Software Engineering*, M.F. Bott et. al. (Latest Edition).

Curriculum for MS Software Engineering, MS (SE)

Eligibility:

1. BS (SE/CS) 4 years degree programme,

OR

2. Computer Science conversion course two years degree programme referred to as MCS or M.Sc. (Computer Science),

OR

3. BCS 3-year programme degree applicants may be provisionally admitted in the MS (SE) programme. Candidates will be required to take additional courses to complete credit hour requirement of min. 130 before being formally enrolled in the MS (SE) programme.

Under eligibility criteria 1-3 the university/department may recommend additional deficiency courses, from the BS (SE) curriculum, considering the deficiency of the candidates.

OR

4. 16-years education science/engineering degrees.
   Under eligibility criterion 4 candidates will be required to complete the deficiency coursework prior to the MS (SE) coursework to ensure the pre-requisite competency in SE.
   The deficiency coursework will be determined on the basis of the core SE courses of the BS (SE) degree.

Duration:

- 4 semesters
- 30-36 credit hours from graduate Software Engineering courses including thesis

Degree Requirements:

In order to obtain MS (SE) degree a student must pass a minimum of:

i) Four (4) courses (12 credit hours) from the core courses
AND
ii) Four (4) courses of 12 credit hours graduate elective courses of which two graduate courses may be taken from other areas.
AND
iii) Satisfactorily complete a *Research Project Thesis* of 9 credit hours.

Core Courses:

Following two courses are considered as core courses for MS (SE) Program

S. No.	Code	Course Title	Cr. Hrs.	Semester
1	SE	Requirements Engineering	3	1-2
2	SE	Software Quality Assurance	3	1-2

List of Elective Courses:

Candidate has to select a total of four courses from the list of SE electives including electives offered in the areas to support the research in software engineering by the university.

Graduate Level SE courses (Institution may add courses to the list of Electives.)

S.No	Course Title	Credit Hours	Semester
	Software Risk Management	3	2-4
	Software Measurement and Metrics	3	2-4
	Software Configuration Management	3	2-4
	Reliability Engineering	3	2-4
	Component Based Software Engineering	3	2-4
	Design Patterns	3	2-4
	Complex Networks	3	2-4
	Agent Based Modelling	3	2-4
	Formal Methods	3	2-4
	Software Engineering Ontologies	3	2-4
	Semantic based Software Engineering	3	2-4
	Model Driven Software Development	3	2-4
	Software Process Engineering	3	2-4
	Advanced Web Services	3	2-4
	Advanced Human Computer Interaction	3	2-4
	Simulation and Modeling	3	2-4

Sample Scheme of Study for MS (SE)
2–year Programme (4 Semesters)
(30 Credit Hours)

Semester 1

S.No.	Code	Course Title	Cr. Hrs.
1	SE	Requirements Engineering	3
2	SE	Software Quality Assurance	3
3	SE	Research Methods (University Elective I)	3
		Semester Total	9

Semester 2

S.No.	Code	Course Title	Cr. Hrs.
1	SE	Elective II	3
2	SE	Elective III	3
3	SE	Elective IV	3
		Semester Total	9

Semester 3

S.No.	Code	Course Title	Cr. Hrs.
1	SE	Elective V	3
2	SE	Thesis (Partial Enrolment)	3
		Semester Total	6

Semester 4

S.No.	Code	Course Title	Cr. Hrs.
1	SE	Thesis (Full Enrolment)	3
2	SE	Elective VI	3
3	SE	Semester Total	6
		Total Credit Hours	30

Course Descriptions (Core)

Course Name: **Requirements Engineering**
Credit Hours: 3
Prerequisites: None

Course Outline:
Role of requirements engineering in system development, Fundamental concepts and activities of requirements engineering, Information elicitation techniques, Fundamentals of goal-oriented requirements engineering, Modeling behavioral goals, Modeling quality goals, Goal modeling heuristics, Deriving operational requirements from goals, Requirements Specification, Requirements verification and validation, Management of inconsistency and conflict, requirements engineering risks, requirement change control board and process, the role of quality goals in the requirements selection process, Techniques for requirements evaluation, selection and prioritization; Requirements management; Requirements traceability and impact analysis.

Reference Materials:

1. *Software Requirements*, Karl E. Wiegers, Microsoft Press, 2003(or Latest Edition).
2. *Software Requirements Specifictaion*, David Tuffley, CreateSpace Independent Publishing Platform, 2010 (or Latest Edition).
3. *System Requirements Engineering*, Loucopoulos and Karakostas, McGraw-Hill, 1995(or Latest Edition).
4. *Requirements Engineering: Processes and Techniques*, Gerald Kotonya and Sommerville, John-Wiley Sons, 1998 (or Latest Edition).

Course Name: **Software Quality Assurance**
Credit Hours: 3
Prerequisites: **Software Engineering**

Course Outline:

What Is Software Quality: Quality Assurance, Quality Engineering
Software Testing: Testing: Concepts, Issues, and Techniques, Test Activities, Management, and Automation, Coverage and Usage Testing Based on Checklists and Partitions, Input Domain Partitioning and Boundary Testing, Coverage and Usage Testing Based on Finite-State Machines and Markov Chains, Control Flow, Data Dependency, and Interaction Testing, Testing Techniques: Adaptation, Specialization, and Integration.

Quality Assurance Beyond Testing: Defect Prevention and Process Improvement, Software Inspection, Formal Verification, Fault Tolerance and Failure Containment, Comparing Quality Assurance Techniques and Activities.

Quantifiable Quality Improvement: Feedback Loop and Activities for Quantifiable Quality Improvement, Quality Models and Measurements, Defect Classification and Analysis.

Risk Identification for Quantifiable Quality Improvement, Software Reliability Engineering.

Reference Materials:

1. Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement, Jeff Tian, Wiley-IEEE Computer Society Press, 1st Edition, 2005(or Latest Edition).
2. “Mastering Software Quality Assurance: Best Practices, Tools and Techniques for Software Developers”, Murali Chemuturi, J. Ross Publishing, 2010 (or Latest Edition).

MS (SE) Elective Courses with course outline

Course Name: **Software System Architecture**
Credit Hours: 3
Prerequisites: **System Analysis and Design**

Course Outline:

Definition and overview of software architecture, the architecture business cycle, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, Evaluating software architecture, Architecture reuse Life-cycle view of architecture design and analysis methods, The QAW, a method for eliciting critical quality attributes, such as availability, performance, security, interoperability, and modifiability, Architecture Driven Design, Evaluating a software architecture (ATAM, CBAM, ARID), Principles of sound documentation, View types, styles, and views; Advanced concepts such as refinement, context diagrams, variability, software interfaces, and how to document interfaces; Documenting the behavior of software elements and software systems; Choosing relevant views; Building a documentation package, Future of Software Design, Architecture Description Languages , Introduction to AADL , AADL: Continued , Testing Architectures, Feature Modeling in SPLs, Testing a Family of Products.

Reference Materials:

1. *Software Architecture: Foundations, Theory, and Practice*, Taylor, Medvidovic, and Dashofy, Wiley, 1st Edition, 2009(or Latest Edition).
2. *Architecting Software Intensive Systems: A Practitioners Guide*, Anthony J. Lattanze, Auerbach Publications, 2008(or Latest Edition).
3. *Software Architecture in Practice*, Bass, Clements, and Kazman, 2nd Edition, Addison-Wesley Professional, 2003(or Latest Edition).
4. *Evaluating Software Architectures: Methods and Case Studies*, Clements, Kazman, Klein, Addison-Wesley Professional, 2001(or Latest Edition).
5. *Software Product Lines: Practices and Patterns*, P. Clements and L. Northrup, Addison-Wesley, 2002(or Latest Edition).

Course Name: **Software Risk Management**
Credit Hours: 3
Prerequisites: None

Course Outline:

Risk-Management Discovery, Risk-Management Process, Process steps, inputs, and outputs, Methods and tools, reusable process component. Risk-Management Infrastructure, Training metrics, establishing a baseline for quantitative process improvement, infrastructure, there is no strategic plan in place to institutionalize risk management. Senior managers, engineering

managers, and change agents should benefit from these organizational building blocks.

Risk-Management Implementation, standard process, Risk management activities, lifecycle planning, budgeting, scheduling, and staffing. Crisis and Control, risk-management evolution stages, Effective and ineffective practices.

Reference Materials:

1. *Managing Risk: Methods for Software Systems Development*, Elaine M. Hall, Addison-Wesley(or Latest Edition).

Course Name: **Software Measurements & Metrics**
Credit Hours: 3
Prerequisites: **Software Engineering**

Course Outline:

Introduction to foundations of measurement theory, models of software engineering measurement, software products metrics, software process metrics and measuring management. Measurement theory (overview of software metrics, basics of measurement theory, goal-based framework for software measurement, empirical investigation in software engineering).

Software product and process measurements (measuring internal product attributes: size and structure, measuring external product attributes: quality, measuring cost and effort, measuring software reliability, software test metrics, object-oriented metrics) Measurement management

Reference Materials:

1. *A Rigorous and Practical Approach Software Metrics*, N.E. Fenton, S.L. Pfleeger, PWS Publishing (or Latest Edition).
2. *Metrics and Models in Software Quality Engineering*, Stephen H. Kan, Addison-Wesley Professional (or Latest Edition).
3. *Software Engineering Measurement*, John C. Munson, Auerbach Publications (or Latest Edition).

Course Name: **Software Configuration Management**
Credit Hours: 3
Prerequisites: **System Analysis and Design**

Course Outlines:

Source Code Management, Build Engineering, Environment Configuration, Change Control, Release Management, Deployment, Architecting Your Application for CM, Hardware Configuration Management, Rightsizing Your Processes, Overcoming Resistance to Change, Personality and CM: A

Psychologist Loods at the Workplace, Learning From Mistakes, Establishing IT Controls and Compliance, Industry Standards and Framework.

Reference Materials:

1 *Software configuration management handbook*, Alexis Leon, Artech House, 2005 (or Latest Edition)
2 *Software Configuration Management Patterns: Effective Teamwork, Practical Integration*, Stephen P. Berczuk, Brad Appleton, Addison Wesley, 2004 (or Latest Edition).

Course Name: **Component Based Software Engineering**
Credit Hours: 3
Prerequisites: None

Course Outlines:

Introduction to CBSE, Reuse, Basic Concepts in CBSE, Modeling components with UML, Open-COM component model, Fractal component model, Component Models and Technology, Component contracts component specification techniques, Component integration and Predictable composition, Service Oriented Computing - Key Concepts and Principles, SOA.

Reference Materials:

1. *Component Software: Beyond Object Oriented Programming*, Clemens Szyperski, Second Edition, Addison Wesley, 2002 (latest ed.).
2. *Building reliable component based software systems*, Ivica Crnkovic, Magnus Larsson. Artech House, 2002 (latest ed.).
3. *Service-oriented Computing: Semantics, Processes, Agents*, Munindar P. Singh and Michael N. Huhns, 2005 (latest ed.)

Course Name: **Design Patterns**
Credit Hours: 3
Prerequisites: None

Course Outline:

Overview of Object-Oriented Analysis and Design, Design Patterns (Concepts, Major issues, Reuse of ideas), Creational Patterns, Structural Patterns, Behavioral Patterns. Applications of design patterns for: Organization of Work, Access Control, Service Variation and Service Extension, Object Management and Adaptation, Architectural Patterns, Patterns for Distribution, Patterns for Interactive Systems, Adaptable Systems.

Frameworks and Patterns, Idea of frameworks, Patterns for flexibility, Achieving benefits of frameworks, Failures of frameworks.

Reference Materials:

1. *Design Patterns: Elements of Reusable OO Software*, Ralph Johnson, John Vlissides, Richard Helm, Erich Gamma, Addison-Wesley Professional, 1994 (latest ed.)
2. *Pattern Hatching: Design Patterns Applied*, Vlissides, Addison-Wesley Professional, 1998.

Course Name: **Complex Networks**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

What are networks and why networks, Erdos-Renyi random, small-world and scale-free network models, Calculation of basic measures in networks, Degree and eccentricity Centrality, Shortest path between start and end nodes, case study of calculation, Clustering coefficient, Matching index and case study, Network tools overview, Pajek, Network Workbench, Gephi, Visone, Cytoscape, Centibin, Network Simulation (Agent-based simulation of networks), Biological networks, Social Networks, Scientometric study using Networks, Modelling Communication Networks as graphs/networks, Disk Graph models such as WSNs.

Reference Materials:

1. *Dynamical Processes on Complex Networks*, Alain Barrat, Marc Barthélemy, Alessandro Vespignani, Cambridge University Press, 2012. (latest ed.)
2. *The Structure and Dynamics of Networks*, Mark Newman, Albert-Lazlo Barabasi, Duncan J. Watts, Princeton University Press, 2006 (latest ed.)
3. *Exploratory Social Network Analysis with Pajek (Structural Analysis in the Social Sciences)*, Wouter De Nooy, Andrej Mrvar and Vladimir Batagelj, Cambridge University Press, Second Edition, 2011 (latest ed.)
4. *Analysis of Biological Networks (Wiley Series in Bioinformatics),* Björn H. Junker and Falk Schreiber, Wiley-Interscience, 2008 (latest ed.)

Course Name: **Agent-based Modeling**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to Agent-based Models, Introduction to NetLogo, Describing ABMs, First ABM Development, Animation to Science, Model Verification & Validation, Emergence, Adaptive Behavior, Prediction, Cognitive AB Computing Framework, Complex Network Modeling, Exploratory AB Modeling, Descriptive AB Modeling, Validated AB Modeling.

Reference Materials:

1. *Agent-Based and Individual-Based Modeling:* A Practical Introduction by Steven F. Railsback and Volker Grimm, 2011 (latest ed.).
2. *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation*, Michael J. North and Charles M. Macal, 2007.

Course Name: **Component Based Software Engineering**
Credit Hours: 3
Prerequisites: None

Course Outlines:

Introduction to CBSE, Reuse, Basic Concepts in CBSE, Modeling components with UML, Open COM component model, Fractal component model, Component Models and Technology, Component contracts - component specification techniques, Component integration and Predictable composition , Service Oriented Computing - Key Concepts and Principles , SOA.

Reference Materials:

1. *Component Software: Beyond Object Oriented Programming,* Clemens Szyperski. Second Edition, Addison Wesley, 2002 (latest ed.).
2. *Building reliable component based software systems,* Ivica Crnkovic, Magnus Larsson. Artech House, 2002 (latest ed.).
3. *Service-oriented Computing: Semantics, Processes, Agents*, Munindar P. Singh and Michael N. Huhns, 2005 (latest ed.)

Course Name: **Design Patterns**
Credit Hours: 3
Prerequisites: None

Course Outline:

Overview of Object-Oriented Analysis and Design, Design Patterns (Concepts, Major issues, Reusibility), Creational Patterns, Structural Patterns, Behavioral Patterns. Applications of design patterns for: Organization of Work; Access Control; Service Variation and Service Extension; Object Management and Adaptation; Architectural Patterns, Patterns for Distribution, Patterns for Interactive Systems, Adaptable Systems; Frameworks and Patterns, Idea of frameworks; Patterns for flexibility; Achieving benefits of frameworks; Failures of frameworks.

Reference Materials:

1. *Design Patterns: Elements of Reusable OO Software by Ralph Johnson, John Vlissides, Richard Helm, Erich Gamma, Addison-Wesley Professional, 1994 (latest ed.)*

2. *Pattern Hatching: Design Patterns Applied by Vlissides,* Addison-Wesley Professional, 1998. (latest ed.)

Course Name: **Complex Networks**
Credit Hours: 3
Prerequisites: **Data Communication and Network**

Course Outline:

What are networks and why networks, Erdos-Renyi random, small-world and scale-free network models, Calculation of basic measures in networks, Degree and eccentricity Centrality, Shortest search path, case study of calculation, Clustering coefficient, Matching index and case study, Network tools overview, Pajek, Network Workbench, Gephi, Visone, Cytoscape, Centibin, Network Simulation (Agent-based simulation of networks), Biological networks, Social Networks, Scientometric study using Networks, Modeling Communication Networks as graphs/networks, Disk Graph models such as WSNs.

Reference Materials:

1. *Dynamical Processes on Complex Networks* by Alain Barrat, Marc Barthélemy, Alessandro Vespignani, Cambridge University Press, 2012. (latest ed.)
2. *The Structure and Dynamics of Networks* by Mark Newman, Albert-Lazlo Barabasi, Duncan J. Watts, Princeton University Press, 2006 (latest ed.)
3. *Exploratory Social Network Analysis with Pajek (Structural Analysis in the Social Sciences)* by Wouter De Nooy, Andrej Mrvar and Vladimir Batagelj, Cambridge University Press, Second Edition, 2011 (latest ed.)
4. *Analysis of Biological Networks (Wiley Series in Bioinformatics)* by Björn H. Junker and Falk Schreiber, Wiley-Inter-science, 2008.

National Curriculum Revision Committee for Information Technology (IT)

The National Curriculum Revision Committee for Information Technology (NCRC-IT) met at HEC Regional Office Lahore on 6-8 February, 2013 to develop the vision for Information Technology education and curriculum for Information Technology programs. The Committee will met again on 10th to 12th June, 2013 to finalize the curricula recommendations. Following experts participated in the meetings for sub-group on Information Technology:

Sr. No.	Name & Address	
1.	Prof. Dr. Muhammad Anwar-ur-Rehman Pasha, Chairman, Department of Computer Science & Information Technology, University of Sargodha, Sargodha	Chairperson committee on BS(IT)
2.	Dr. Imdad Ali Ismaili, Professor & Director, Institute of Information & Communication Technology, University of Sindh, Allama I.I. Kazi Campus, Jamshoro, Sindh.	Member
3.	Dr. Mansoor-uz-Zafar Dawood, Dean, Faculty of Computer Sciences & IT, Institute of Business & Tech (IBT) Main Ibrahim Hydri Road, Karachi.	Member
4.	Prof. Dr. Madad Ali Shah, Professor and Head, Department of Electrical & Telecommunication Engineering, Sukkur IBA, Airport Road, Sukkur, Sindh.	Member
5.	Prof. Dr. Nisar Ahmed Memon, Professor, Dept. of Computer System, Quaid-e-Awam University of Engg Science & Technology, Nawabshah.	Member
6.	Dr. Mumtaz Hussain Mahar, Professor, Dept. of Computer Science, Shah Abdul Latif University, Khairpur.	Member
7.	Dr. Saeed Mahfooz, Associate Professor & Chairman, Dept. of Computer Science, University of Peshawar, Peshawar.	Member

8.	Dr. Muhammad Khalid Badini Chairperson Department of CS & IT UoB Quetta, Pakistan	Member
9.	Dr. Asfandyar Khan, Assistant Professor/Chairman, Department of Engineering, Institute of Engg & Computing Sciences, University of Science & Tech, Bannu.	Member

The National Curriculum Revision Committee for Information Technology (NCRC-IT) met at HEC Regional Office Lahore on meet again on 10th to 12th June, 2013 and finalized the curricula recommendations. The experts attended were same as in the first meeting.

The Discipline of Information Technology

According to ACM Curricula 2005[6]: "Information Technology" is a label that has two meanings. In the broadest sense, the term information technology is often referred to computing. Furthermore, it also refers to undergraduate degree programs that prepare students to meet the computer technology needs of business, government, healthcare, schools, and other kinds of organizations. Curriculum Guidelines for Undergraduate Degree Programs in Information Technology (2008) explains that "Information Technology (IT) in its broadest sense encompasses all aspects of computing technology. IT, as an academic discipline, is concerned with issues related to advocating for users and meeting their needs within an organizational and societal context through the selection, creation, application, integration and administration of computing technologies." Figure 1[7], depicts the key pillars of academic discipline of Information Technology

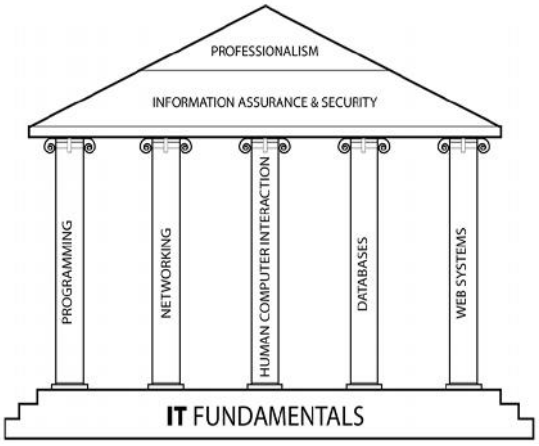

Figure 1:Key Pillars of IT

Information Technology as an academic discipline, as defined by The Information Technology Association of America (ITAA), is "the study, design, development, application, implementation, support or management of computer-based information systems, particularly software applications and computer hardware". It deals with the use of electronic computers and computer software to securely convert, store, protect, process, transmit, input, output, and retrieve information. [Wikipedia]

[6] Computing Curricula 2005: The Overview Report, IEEE and ACM Press.
[7]Curriculum Guidelines for Undergraduate Degree Programs in Information Technology (2008)

IT Programs' Rational

The digital revolution not only reshaped the way scientists conduct their research but also expedite the pace of inventions. Consequently, the latest advancements in technologies for communication, computation, and delivery of information brought a paradigm shift in the business world - from data processing to information processing - converting computer technology into information technology (IT) and industrial society into an "information society". While this paradigm shift improves productivity, it also created new work place challenges regarding the development, operation, maintenance, and up-gradation of organizational IT infrastructure. Inventions like the Internet, the World Wide Web, email, bulletin board systems, virtual communities, E-business and other online technologies forced organizations to find IT based solutions to all kinds of business challenges. For this, organizations need appropriate systems that work properly and professionals who make these systems secured, upgraded, and maintained. In parallel, employees require support from these professionals to make technology effective for enhancing organizational productivity. This has created a huge demand of IT professionals both locally and globally. Meeting this demand is the key rationale behind the IT programs. In this regard, the IT programs offer a curriculum structure that can produce graduates who can meet above discussed challenges of the 21st century's knowledge driven complex work places. The curriculum structure will create, expand, disseminate and teach the information technology body of knowledge through academics, applications and research which positively impact society (locally, nationally, and internationally). It will also provide an integration of all components that allow accessing all of the new knowledge and technologies for meeting the above discussed challenges (See Fig. 2).

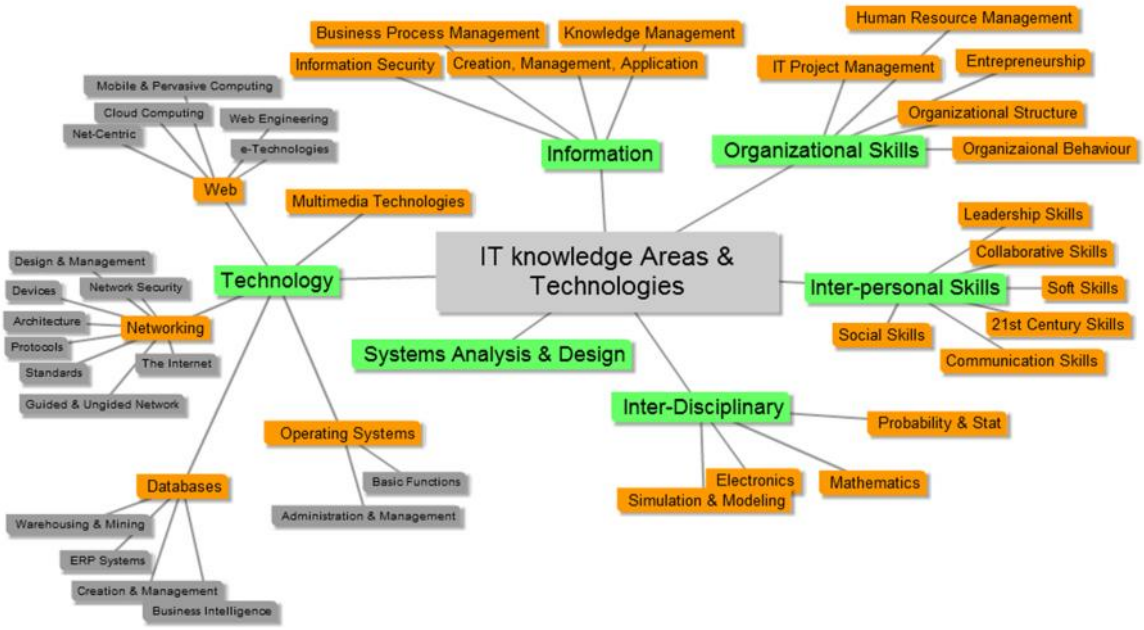

Figure 2 IT Knowledge Areas and Technologies

Vision of Information Technology Education

As defined in cc2008 “Information Technology is very much an integrative discipline; it pulls together the IT pillars of databases, human-computer interaction, networking, programming, and web systems and uses a solid background in each of them to enable graduates to solve all types of computing and informational problems, regardless of their origin. As a discipline, IT emphasizes the pervasive themes of user centeredness and advocacy, information assurance and security, and the management of complexity through abstraction and modeling, best practices, patterns, standards, and the use of appropriate tools.” In the light of this explanation, the curriculum committee formalized the Vision Statement for IT education in Pakistan as follows:

The IT education in Pakistan will focus on imparting the knowledge and training which enable students:

1. to understand and contribute to the scientific, mathematical and theoretical foundations on which information technologies are built;
2. to use and apply current technical concepts, techniques, skills, tools and practices to analyze the local and global impact of IT on individuals, organizations, and society and to identify their computing needs, and select, design, create, implement, administer and evaluate a computer-based system, process, component, or program to meet the desired needs and integrate them into the user environment;
3. to develop students’ interpersonal and organizational skills to communicate effectively with a range of audience, create operative project plans and work in a collaborative environment;
4. to strengthen students’ understanding of professional, ethical, legal and social issues and responsibilities;
5. to develop students’ capacity for innovation and passion for lifelong learning.

IT curriculum thus aims to achieve the targets set in the vision statement. It should strive to meet the professional demands of the industry and academia both in terms of immediate needs and the capacity for longer term development to avail the opportunities and face the challenges of the modern world. The committee is of the view that the curriculum must focus on building a solid foundation in the early stages of learning. Thus, Information Technology concepts should be taken up as early as the start of 1st year. These should gradually be strengthened through developing the core competencies and desired skill-sets during the second, third and fourth years. The students must also be provided opportunities to bring together the knowledge gained in a wide variety of courses to solve realistic problems in a team-based environment through lab sessions, practical assignments, course projects and a capstone design project.

Information Technology Degree Programs

Nomenclature:

The committee emphasized that the nomenclature followed for Information Technology programs should correspond to international trends and standards. The following nomenclatures were thus agreed:

1. Bachelor of Science in Information Technology, BS (IT)
2. Master of Science in Information Technology, MS (IT)

Duration of Programs:

The committee defined a credit hour as 15 lecturing hours in a course offered in a particular semester. It was agreed that 3 weekly lab hours shall be treated as one credit hour for a course. In normal circumstances a semester comprises 15 teaching weeks followed by the final examination. The notation used for this purpose is X(Y+Z), X represents total credit hours, Y represents credit hours for theory and Z represents credit hours for practical lab work.

The BS Information Technology Degree would be a 4-year program spread over 8 semesters and MS Information Technology program would be a 2-year program spread over 4 semesters.

Admission Criteria:

The eligibility criteria for BS Information Technology program shall be intermediate or equivalent qualifications; however, universities/institutions may define their own admission criteria.

The eligibility criterion for admission to MS Information Technology shall be 4-year BS Information Technology or equivalent qualifications; however, universities/institutions may define their own admission criteria.

Curriculum for BS Information Technology, BS (IT)

Program's Aims & Objectives:

The aim of the BS (IT) program is to produce entrepreneurs of great character, competence, vision and drive equip with up-to-date knowledge, marketable skills, valuable competencies, unique expertise, globally compatible dispositions and culturally and professionally acceptable values to take on appropriate professional roles in information technology domain or proceed to further or higher education or training. One of the key objectives of the program is to equip students with skills and knowledge that enable them to take on appropriate professional positions in IT and grow into leading roles. The goals of the program are to produce, in coordination with organizational management, IT graduates who have ability to:

1. Apply knowledge of computing and mathematics appropriate to the discipline.

2. Analyze a problem, and identify and define the computing requirements appropriate to its solution.
3. Design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
4. Function effectively on teams to accomplish a common goal.
5. Understand the professional, ethical, legal, security and social issues and responsibilities.
6. Communicate effectively with a range of audiences.
7. Analyze the local and global impact of computing on individuals, organizations, and society.
8. Recognize the need for and an ability to engage in continuing professional development.
9. Use the current techniques, skills, and tools necessary for computing practice.
10. Use and apply the latest technical concepts and practices in the core information technologies.
11. Identify and analyze user needs and take them into account in the selection, creation, evaluation and administration of computer-based systems.
12. Integrate IT-based solutions into the user environment.
13. Understand the best practices and standards and their application.
14. Assist in the creation of an effective project plan.

Structure of BS Information Technology:

The structure of BS (IT) program is dynamic and provides basis for various options including Breadth-Based, Depth-Based, and Integrated Breadth & Depth-Based specializations. Students may choose a particular option, which is the most appropriate to their planned future career. Followings are the distribution of total credit hours:

#	Category	Credit Hours
1	Computing Courses	
	Core	40
	Supporting Areas	12
2	Information Technology Courses	
	Core	21
	Electives	21
	Supporting	15
3	General Education Courses	18
4	University Elective Courses	9
	Total Credit Hours	**136**

Computing — Core Courses (40 Credits Hours) Required Computing Courses				
#	**Code**	**Pre-req**	**Course Name**	**Cr. Hrs.**
1	CMP	-	Programming Fundamentals	4 (3+1)
2	CMP	1	Object Oriented Programming	3*
3	CMP	-	Discrete Structures	3
4	CMP	3	Data Structures and Algorithms	4 (3+1)
5	CMP	-	Digital Logic Design	4 (3+1)
6	CMP	-	Operating Systems	3*
7	CMP	-	Database Systems	4 (3+1)
8	CMP	-	Software Engineering	3
9	CMP	-	Computer Communications and Networks	3*
10	CMP	-	Human Computer Interaction	3
11	CMP	-	IT Capstone Project	6 (0+6)
Total Credit Hours				**(40/136)**

* Labs are preferred in these courses. However, implementation details are left upon the Institutes.

IT — Core Courses (21 Credits Hours) Required IT Core Courses				
#	**Code**	**Pre-req**	**Course Name**	**Cr. Hrs.**
16	IT	-	Web Systems and Technologies	3*
17	IT	-	Multimedia Systems and Design	3 (2+1)
18	IT	6	Systems and Network Administration	3*
19	IT	-	Network Security	3 (3+ 0)
20			Cloud Computing	3 (3+ 0)
	IT	-	System Integration and Architecture	3
21	IT	-	Technology Management	3
Total Credit Hours				**(21/136)**

* Labs are preferred in these courses. However, implementation details are left upon the concerned Institutes.

IT — Supporting Courses (15 Credits Hours) Required Supporting Courses				
#	**Code**	**Pre-req**	**Course Name**	**Credit hours**
23	IT	8,21	IT Project Management	3
24	IT	9	Internet Architecture & Protocols	3
25	IT	8	Object Oriented Analysis & Design	3*
26	IT	7	Database Administration & Management	3 (2+1)
27	IT	-	Information Systems	3 (3+ 0)
Total Credit Hours				**(15/136)**

General Education (18 Credits Hours) Required General Education Courses				
#	**Code**	**Pre-req**	**Course Name**	**Cr. Hrs**
1	ENG	-	Functional English (English-I)	3
2	ENG	-	Communication Skills (English-II)	3
3	ENG	-	Technical Report Writing (English-III)	3
4	SS	-	Islamic Studies /Ethics	2
5	SS	-	Pakistan Studies	2
6	SS	-	Professional Practices	2
	IT	-	Information & Communication Technologies	3 (2+1)
Total Credit Hours				**(18/136)**

University Electives (9 Credits Hours) University Elective Courses				
#	**Code**	**Pre-req**	**Course Name**	**Cr. Hrs.**
34	MNG	-	Principles of Accounting	3
35	MNG	-	Human Resource Management	3
36	MNG	-	Principles of Management	3
37	MNG	-	Organizational Behaviour	3
38	SS	-	Principles of Philosophy	3
39	SS	-	Principles of Psychology	3
40	SS	-	Foreign/Regional Language	3
41	MNG	-	Entrepreneurship	3

IT Electives

(7 Courses; 21 Credits Hours)

Following is a suggestive list of the elective courses for different domain including Databases, Networking, Multimedia Systems, Web Base Application Development, and Software Engineering. Universities/institutions may add other courses in this list. A student must select at least 4 courses from one domain for his/her major area of specialization.

IT		Telecommunication Systems	3
IT		Routing & Switching	3
IT		Network Design and Management	3
IT		Network Programming	3
IT		Computer Game Development	3
IT		Multimedia Technologies	3
IT		3D Modeling & Animation	3
IT		Mobile Computing	3
IT		Software Agents Technology	3
IT		E-Commerce Applications Development	3
IT		Enterprise Application Development	3
IT		Distributed Computing	3

IT		Mobile Application Development	3
IT		Web Engineering	3
IT		Data Warehousing	3
IT		Data Mining	3
IT		Business Intelligence and Analytics	3
IT		Distributed Database Systems	3
IT		Enterprise Resource Planning Systems	3
IT		Information Systems Auditing and Assurance	3
IT		Business Process Management	3
IT		Knowledge Management	3
IT		Artificial Intelligence	3
SE		Formal Methods in Software Engineering	3
SE		Software Requirement Engineering	3
SE		Software Design and Architecture	3
SE		Software Quality Engineering	3
SE		Software CASE Tools & Applications	3
SE		Software Construction	3
SE		Software Engineering Economics	3
SE		Design Patterns	3
IT		Service-Oriented Architecture	3
IT		Computer Graphics	3
IT		Bioinformatics	3
IT		Biometric Systems	3

Proposed Scheme of Study for BS (IT) Model 1

4-Year Program (8 Semesters) (136 Credit Hours)

Semester 1 (18 Cr. Hrs.)	Cr. Hrs.
Programming Fundamentals (Comp. Core)	4 (3+1)
Basic Electronics (Comp. Supporting)	3
Calculus and Analytical Geometry (Comp. Supporting)	3
Fundamentals of ICT (IT Core)	3 (2+1)
Functional English(English-I) (Gen. Edu)	3
Islamic Studies/Ethics (Gen. Edu.)	2 (2+0)

Semester 2 (18 Cr. Hrs.)	Cr. Hrs.
Object Oriented Programming (Comp. Core)	3
Digital Logic Design (Comp. Core)	3 (2+1)
Discrete Structures (Comp. Core)	3
Principles of Psychology (Uni. Elective)	3
Communication Skills (English-II) (Gen. Edu.)	3
Probability and Statistics (Comm. Supporting)	3

Semester 3 (19 Cr. Hrs.)	Cr. Hrs.
Data Structures and Algorithms (Comp. Core)	4(3+1)
Computer Communication and Networks (Comp. Core)	3*
Principles of Accounting (Uni. Elective)	3
Information Systems (IT – Supporting)	3
Technical and Report Writing (English-III) (Gen. Edu.)	3
Linear Algebra (Comp. Supporting)	3

Semester 4 (18 Cr. Hrs.)	Cr. Hrs.
Organizational Behaviour (Uni. Elective)	3
Internet Architecture & Protocols (IT – Supporting)	3
Software Engineering (Comp. Core)	3
Database Systems (Comp. Core)	4 (3+1)
Multimedia Systems and Design (IT Core)	3 (2+1)
Pakistan Studies (Gen. Edu.)	2 (2+0)

Semester 5 (18 Cr. Hrs.)	Cr. Hrs.
IT Elective-I	3
Operating Systems (Comp. Core)	3*
OO Analysis & Design (IT – Supporting)	3
DB Administration & Management (IT – Supporting)	3*
Web Systems and Technologies (IT Core)	3
Technology Management (IT Core)	3

Semester 6 (18 Cr. Hrs.)	Cr. Hrs.
Human Computer Interaction (Comp. Core)	3
Systems and Network Administration	3*
IT Elective II	3
IT Elective –III	3
System Integration and Architecture (IT Core)	3
IT Project Management (IT – Supporting)	3

Semester 7 (15 Cr. Hrs.)	Cr. Hrs.
Capstone Project Part I (Comp. Core)	3
Data & Network Security (IT Core)	3
IT Elective IV	3
IT Elective V	3
Cloud Computing	3

Semester 8 (12 Cr. Hrs.)	Cr. Hrs.
Capstone Project Part II (Comp. Core)	3
Professional Practices (Gen. Edu.)	2(2+0)
IT Elective VI	3
IT Elective VII	3

* Labs are preferred in these courses. However, implementation details are left upon the concerned Institutes.

Proposed Scheme of Study for BS (IT) Model 2

4-Year Program (8 Semesters) (136 Credit Hours)

Semester 1 (19 Cr. Hrs.)	**Cr. Hrs.**
Programming Fundamentals (Comp. Core)	4(3+1)
Basic Electronics (Comp. Supporting)	3
Calculus and Analytical Geometry (Comp. Supporting)	3
Fundamentals of ICT (IT Core)	3 (2+1)
Functional English(English-I) (Gen. Edu)	3
Islamic Studies/Ethics (Gen. Edu.)	2 (2+0)

Semester 2 (19 Cr. Hrs.)	**Cr. Hrs.**
Object Oriented Programming (Comp. Core)	4 (3+1)
Information Systems (IT – Supporting)	3
Discrete Structures (Comp. Core)	3
Principles of Psychology (Uni. Elective)	3
Communication Skills (English-II) (Gen. Edu.)	3
Probability and Statistics (Comm. Supporting)	3

Semester 3 (19 Cr. Hrs.)	**Cr. Hrs.**
Data Structures and Algorithms (Comp. Core)	3
Pakistan Studies (Gen. Edu.)	2 (2+0)
Principles of Accounting (Uni. Elective)	3
Digital Logic Design (Comp. Core)	4 (3+1)
Technical and Report Writing (English-III) (Gen. Edu.)	3
Linear Algebra (Comp. Supporting)	3

Semester 4 (19 Cr. Hrs.)	**Cr. Hrs.**
Organizational Behaviour (Uni. Elective)	3
Computer Communication and Networks (Comp. Core)	3
Software Engineering (Comp. Core)	3
Database Systems (Comp. Core)	4 (3+1)
Multimedia Systems and Design (IT Core)	3 (2+1)
Operating Systems (Comp. Core)	3*

Semester 5 (18 Cr. Hrs.)	**Cr. Hrs.**
Internet Architecture & Protocols (IT – Supporting)	3
Systems and Network Administration	3*
OO Analysis & Design (IT – Supporting)	3
DB Administration & Management (IT – Supporting)	3*
Web Systems and Technologies (IT Core)	3
Technology Management (IT Core)	3

Semester 6 (15 Cr. Hrs.)	Cr. Hrs.
Human Computer Interaction (Comp. Core)	3
IT Elective-I	3
IT Elective II	3
IT Elective –III	3
IT Project Management (IT – Supporting)	3
Cloud Computing	3

Semester 7 (15 Cr. Hrs.)	Cr. Hrs.
Capstone Project Part I (Comp. Core)	3 (0+3)
Data & Network Security (IT Core)	3
IT Elective IV	3
IT Elective V	3
System Integration and Architecture (IT Core)	3

Semester 8 (12 Cr. Hrs.)	Cr. Hrs.
Capstone Project Part II (Comp. Core)	3
Professional Practices (Gen. Edu.)	2
IT Elective VI	3
IT Elective VII	3

* Labs are preferred in these courses. However, implementation details are left upon the concerned Institutes.

BS Information Technology, BS (IT), COURSE CONTENTS

Computing Core Courses:

Course Name: **Programming Fundamentals**
Credit Hours: 4 (3+1)
Prerequisites**:** **None**

Course Outline:

This course covers overview of Computer Programming, Principles of Structured and Modular Programming, Overview of Structured Programming Languages, Algorithms and Problem Solving, Program Development: Analyzing Problem, Designing Algorithm/Solution, Testing Designed Solution, Translating Algorithms into Programs, Fundamental Programming Constructs, Data Types. Basics of Input and Output, Selection and Decision (If, If-Else, Nested If-Else, Switch Statement and Condition Operator), Repetition (While and For Loop, Do-While Loops), Break Statement, Continue Statement, Control Structures, Functions, Arrays, Pointers, Records, Files (Input-Output), Testing & Debugging.

Reference Materials:

1. *C How to Program* by Paul Deitel and Harvey Deitel, Prentice Hall; 7 edition (March 4, 2012). ISBN-10: 013299044X
2. *Programming in C* by Stephen G. Kochan, Addison-Wesley Professional; 4 edition (September 25, 2013). ISBN-10: 0321776410
3. *Java How to Program* by Paul Deitel and Harvey Deitel, Prentice Hall; 9th edition (March, 2011)
4. *C++ How to Program* by Paul Deitel and Harvey Deitel, Prentice Hall; 9th edition (February, 2013)

Course Name: **Object Oriented Programming**
Credit Hours: **3**
Prerequisites: **Programming Fundamentals**

Course Outline:

Evolution of Object Oriented Programming (OOP), Object Oriented concepts and principles, problem solving in Object Oriented paradigm, OOP design process, classes, functions/methods, objects and encapsulation; constructors and destructors, operator and function/method overloading, association, aggregation, composition, generalization, inheritance and its types, derived classes, function/method overriding, abstract and concrete classes, virtual functions, polymorphism, exception handling.

Reference Materials:

1. *Java: How to Programme,* Harvey M. Deitel and Paul J. Deitel, Prentice Hall; 8 edition (March 27, 2009). ISBN-10: 0136053068

2. *C++: How to Programme*, Prentice Hall; 8 edition (March 25, 2011). ISBN-10: 0132662361
3. *Object Oriented Programming in C++* by Robert Lafore, Sams Publishing; 4 edition (December 29, 2001). ISBN-10: 0672323087
4. J*ava Programming: From the Ground Up* by Ralph Bravaco and Shai Simonson, McGraw-Hill Higher Education New York, 2010, ISBN 978–0–07–352335–4
5. *Beginning Java by Ivor Horton*, John Wiley & Sons, Inc, 7th Edition, 2011, ISBN: 978-0-470-40414-0

Course Name: **Discrete Structures**
Credit Hours: 3
Prerequisites: None

Course Outline:

Please See in BS (CS) Section

Reference Materials:
Please See in BS (CS) Section

Course Name: **Data Structure and Algorithms**
Credit Hours: 4 (3+1)
Prerequisites**:** **Discrete Structures**

Course Outline:

Introduction to Data Structures and Algorithms. Complexity Analysis. Arrays. Sorting Algorithms: Insertion Sort, Selection Sort, Bubble Sort, Shell Sort, Heap Sort, Quick Sort, Merge Sort, Radix Sort, Bucket Sort. Linked Lists: Singly Linked Lists, Doubly Linked Lists, Circular List. Stacks, Queues, and Priority Queue. Recursion: Function call and Recursion Implementation, Tail Recursion, Non-tail Recursion, Indirect Recursion, Nested Recursion, Backtracking. Trees: Binary Trees, Binary Heap, Binary Search. Tree Traversal, Insertion, Deletion, and Balancing a Tree. Heap. B-Tree, B+Tree, Spanning Tree, Splay Trees. Graphs: Representation, Treversal, Shortest Path, and Cycle Detection; Isomorphic Graphs. Graph Traversal Algorithms. Hashing. Memory Management and Garbage Collection.

Reference Materials:

1. *Data Structures & Problem Solving Using Java* by Mark Allen Weiss, Addison-Wesley, 4th Edition (October 7, 2009). ISBN-10: 0321541405 (or Latest Edition)
2. *Algorithms*, Robert Sedgewick, Princeton University Publisher: Addison-Wesley Professional (latest Edition)
3. *Data Structures: Abstraction and Design Using Java* by Koffman and Wolfgang, Wiley; 2nd Edition (January 26, 2010). ISBN-10: 0470128704

4. *Data Structures and Algorithms in C++* by Adam Drozdek, Course Technology; 4th Edition (August 27, 2012). ISBN-10: 1133608426
5. *Data Structures Using C++* by D. S. Malik, Course Technology; 2nd Edition (July 31, 2009). ISBN-10: 0324782012
6. *Data Structures and Other Objects Using C++* by Michael Main and Walter Savitch, Prentice Hall; 4th Edition (March 6, 2010). ISBN-10: 0132129485

Course Name: **Digital Logic and Design**
Credit Hours**:** 3
Prerequisites**:** **Basic Electronics**

Course Outline:

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods K-Maps, Quinne, Mc-Cluskey,, Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, 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, etc.**

Reference Materials:

1. *Digital Fundamentals* by Thomas L. Floyd, Prentice Hall; 11th edition.
2. *Fundamentals of Digital Logic with Verilog Design* by Stephen Brown and Zvonko Vranesic, McGraw-Hill; 3rd Edition (February 12, 2013). ISBN-10: 0073380547
3. *Digital Fundamentals: A Systems Approach* by Thomas L. Floyd, Prentice Hall; (July 13, 2012). ISBN-10: 0132933950
4. *Digital Design*, by M. Morris Mano, Michael D. Ciletti, 4th Edition, Prentice Hall (2007). ISBN-10: 0131989243
5. *Fundamentals of Logic Design* by Jr. Charles H. Roth and Larry L Kinney, CL Engineering; 6th Edition (March 13, 2009). ISBN-10: 0495471690

Course Name: **Operating Systems**
Credit Hours: 3*
Pre-requisites: None

Course Outline:

History and Goals, Evolution of operating systems. Operating System: Services, Structure, User Interface. Virtual Machines concept, System Boot, System Calls, Types of System Calls. Processes: Concept, Scheduling, Operations on Processes, Inter-process Communication. Threading: Multithreading Models, Thread Libraries, Threading Issues, processor scheduling; deadlock prevention, avoidance, and recovery; main-memory management; virtual memory management (swapping, paging, segmentation and page-replacement algorithms); Disks management and other

input/output devices; file-system structure and implementation; protection and security. Case studies: Linux/Windows Operating Systems.

*Lab assignments involving different single and multithreaded OS algorithms.

Reference Materials:

1. *Operating System Concepts* by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne, Wiley; 9th edition (December 17, 2012). ISBN-10: 1118063333
2. *Operating Systems: Internals and Design Principles* by William Stallings, Prentice Hall; 7 edition (March 10, 2011). ISBN-10: 013230998X
3. *Applied Operating Systems Concepts* by Silberschatz A., Peterson, J.L., & Galvin P.C. Wiley; 8th Edition (2011). ISBN-10: 1118112733
4. *Modern Operating Systems* by Tanenmaum A.S., Prentice Hall; 3rd Edition (2007). ISBN-13: 978-0136006633

Course Name: **Database Systems**
Credit Hours: 4 (3+1)
Prerequisites: **Programming Fundamentals**

Course Outline:

Basic Database Concepts, Database Architecture, DB Design Life Cycle, Schema Architecture, Conceptual, Logical and Physical Database Modelling and Design, , Entity Relationship Diagram (ERD), Enhanced ERD, Relational Data Model, Mapping ERD to Relational Model, Functional Dependencies and Normalization, Relational Algebra, Structured Query Language (SQL), Transaction Processing, Concurrency Control And Recovery Techniques, Query Optimization Concepts.

Reference Materials:

1. *Database Systems A Practical Approach to Design, Implementation, and Management*, Thomas Connolly and Carolyn Begg, Prentice Hall; 7th edition (March 10, 2011)
2. *Modern Database Management* by Fred McFadden, Jeffrey Hoofer, Mary Prescott, Prentice Hall; 11th Edition (July 26, 2012). ISBN-10: 0132662256
3. *Fundamentals of Database Systems* by R. Elmasri and S. Navathe. 6th Edition, Addison-Wesley (2010). ISBN-10: 0136086209.
4. *Database Design and Relational Theory: Normal Forms and All That Jazz* by C. J. Date, O'Reilly Media; 1st Edition (April 24, 2012). ISBN-10: 1449328016.
5. *Modern Database Management* by Fred McFadden, Jeffrey Hoofer, Mary Prescott, Prentice Hall; 11th Edition (July 26, 2012). ISBN-10: 0132662256

Course Name: **(Intro. to) Software Engineering**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Overview of SE, Practice & Myths; the Software Processes, Generic Process Models: Framework Activity, Task Set, Process Patterns, Process Improvement, CMM. Prescriptive Process Models: Waterfall Model, Incremental Process Model, Evolutionary Process Model. Specialized Process Models: Component Based Development; The Formal Methods Models, Agile Development. Business Information Systems: Components; Types; and Evaluating methods. SDLC: Phases; System Planning; Preliminary Investigation, SWOT Analysis; the Importance of Strategic Planning; Evaluation of Systems Requests; Requirements Engineering. Difference between Structured Analysis and Object Oriented Analysis; Difference between FDD Diagrams & UML Diagrams; Data & Process Modelling. Diagrams: Data Flow, Context, Conventions, Detailed Level DFD's; the Design Process; Architecture Design Elements, Interface Design Elements, Component-Level Design Elements, Deployments Design Elements; System Architecture, Architectural Styles; User Interface Design; WebApps Interface Design; Software Quality Assurance. Validation Testing, System Testing. Internal and External View of Testing. Project Management. Risk Management; Maintenance and Reengineering.

Reference Materials:

1. *Software Engineering 8E* by Ian Sommerville, Addison Wesley; 8th Edition (2006). ISBN-10: 0321313798
2. *Software Engineering: A Practitioner's Approach* by Roger S. Pressman, McGraw-Hill Science/Engineering/Math; 7th Edition (2009). ISBN-10: 0073375977

Course Name: **Computer Communications and Networks**
Credit Hours: 3
Prerequisites: None

Course Outline:

Data Communication concepts, Analogue and digital Transmission, Noise, Media, Encoding, Asynchronous and Synchronous transmission. Network system architectures (OSI, TCP/IP), Error Control, Flow Control, Data Link Protocols, Bridging. Local Area Networks and MAC Layer protocols, Multiplexing, Switched and IP Networks, Inter-networking, Routing. Transport layer protocols TCP, UDP and SCTP. Application Layer Protocols. Wireless LANs.

Lab exercises using tools such as Wireshark, OpNet, Packet tracer etc.

Reference Materials:

1. *Data Communications and Networking*, by Behrouz A. Forouzan, McGraw-Hill Science; 5th edition (February 17, 2012). ISBN-10: 0073376221
2. *Data and Computer Communications* by William Stallings, Prentice Hall; 9th Edition (August 13, 2010). ISBN-10: 0131392050
3. *Computer Networks* by Andrew S. Tanenbaum and David J. Wetherall, Prentice Hall; 5th Edition (October 7, 2010). ISBN-10: 0132126958
4. *Computer Networks and Internets* by Douglas E. Comer, Prentice Hall; 5th Edition (April 28, 2008). ISBN-10: 0136066984

Course Name: **Human Computer Interaction**
Credit Hours: 3
Prerequisites: None

Course Outline:

The human and the computer and their interaction, Human psychology and ergonomics, Interaction Paradigms, Interaction design basics, HCI in the software process, Design rules, Implementation support, Evaluation techniques, Universal design, User support, ,Cognitive models, Socio-organizational issues and stakeholder requirements, Communication and collaboration models, Task analysis, Dialog notations and design , Models of the system, Modeling rich interaction, Groupware, Ubiquitous computing and augmented realities

Reference Materials:

1. *Human-Computer Interaction* by Alan Dix, Janet E. Finlay, Gregory D. Abowd, Russell Beale, Prentice Hall; 3rd Edition (December 20, 2003). ISBN-10: 0130461091
2. *Human-Computer Interaction*: Concepts And Design by J. Preece, Y. Rogers, H. Sharp, D. Benyon, S. Holland, T. Carey, Addison Wesley; 1st Edition (April 30, 1994). ISBN-10: 0201627698.
3. *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications* by Julie A. Jacko, CRC Press; 3 Edition (May 4, 2012). ISBN-10: 1439829438
4. *Interaction Design: Beyond Human - Computer Interaction* by Yvonne Rogers, Helen Sharp, and Jenny Preece, Wiley; 3rd Edition (June 15, 2011). ISBN-10: 0470665769
5. *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules* by Jeff Johnson, Morgan Kaufmann; 1st Edition (June 3, 2010). ISBN-10: 012375030X.

Computing Supporting Elective Courses

Course Name: **Calculus and Analytical Geometry**
Credit Hours: 3
Prerequisites: None

Course Outline:

Real Numbers and the Real Line, Coordinates, Lines, and Increments, Functions, Shifting Graphs, Trigonometric Functions. Limits and Continuity: Rates of Change and Limits, Rules for Finding Limits, Target Values and Formal Definitions of Limits, Extensions of the Limit Concept, Continuity, Tangent Lines. Derivatives: The Derivative of a Function, Differentiation Rules, Rates of Change, Derivatives of Trigonometric Functions, The Chain Rule, Implicit Differentiation and Rational Exponents. Applications of Derivatives. Integration: Indefinite Integrals, Integration by Substitution, Definite Integrals, Substitution in Definite Integrals. Numerical Integration. Applications of Integrals. Transcendental Functions: Inverse Functions and Their Derivatives, Natural Logarithms, The Exponential Function, a^x and $\log_a x$, Growth and Decay, L'Hôpital's Rule, Relative Rates of Growth, Inverse Trigonomic Functions, Derivatives of Inverse Trigonometric Functions; Hyperbolic Functions. Conic Sections, Parametrized Curves, and Polar Coordinates. Graphing in Polar Coordinates. Polar Equations for Conic Sections. Integration in Polar Coordinates. Vectors and Analytic Geometry in Space; Vectors in the Plane Dot Products; Vector-Valued Function Cartesian (Rectangular) Coordinates and Vectors in Space. Dot Products; Cross Products. Lines and Planes in Space; Cylinders and Quadric Surfaces; Cylindrical and Spherical Coordinates.

Reference Materials:

1. *Calculus and Analytic Geometry* by George B. Thomas and Ross L. Finney, Addison Wesley; 10th Edition (1995) ISBN-10: 0201531747
2. *Calculus and Analytical Geometry* by Swokowski, Olinick and Pence, 6th Edition, 1994, Brooks/Cole Publishers.
3. *Calculus* by Howard Anton, Irl C. Bivens, Stephen Davis, Wiley; 10th Edition (2012), ISBN-10: 0470647728
4. *Calculus with Analytic Geometry: Student Solution Manual* by Howard Anton, Wiley; 5th Edition (1995). ISBN-10: 0471105899

Course Name: **Probability and Statistics**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies.

Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, F-Quantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

Reference Materials:

1. *Probability and Statistics for Engineers and Scientists* by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, Pearson; 9th Edition (January 6, 2011). ISBN-10: 0321629116
2. *Probability and Statistics for Engineers and Scientists* by Anthony J. Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10: 0495107573
3. *Schaum's Outline of Probability and Statistics*, by John Schiller, R. Alu Srinivasan and Murray Spiegel, McGraw-Hill; 3rd Edition (2008). ISBN-10: 0071544259
4. *Probability: A Very Short Introduction* by John Haigh, Oxford University Press (2012). ISBN-10: 0199588481

Course Name: **Linear Algebra**
Credit Hours: 3
Prerequisites: **Calculus and Analytical Geometry**

Course Outline:

Introduction to Vectors. Solving Linear Equations. Elimination Factorization. Vector Spaces and Subspaces. Orthogonality. DeTerminants. Eigenvalues and Eigenvectors. Linear Transformations. Linear Transformation, Applications of Matrices in Engineering. Graphs and Networks, Markov Matrices, Population, and Economics. Linear Programming. Fourier Series. Linear Algebra for Functions, Linear Algebra for Statistics and Probability, Computer Graphics. Numerical Linear Algebra. Complex Vectors and Matrices. Discrete Transforms and Simple Applications. Cosine Transform, The Discrete Fourier Transform. Simplification and Factorization of the DFT

Matrix. Fast Fourier Transforms. The Discrete Time Fourier Transform. The Z-Transform.

Reference Materials:

1. *Introduction to Linear Algebra* by Gilbert Strang, Wellesley Cambridge Press; 4th Edition (February 10, 2009). ISBN-10: 0980232716
2. *Linear Algebra: A Modern Introduction by David Poole* by Brooks Cole; 3rd Edition (May 25, 2010).ISBN-10: 0538735457
3. *Elementary Linear Algebra with Applications* by Bernard Kolman, David Hill, 9th Edition, Prentice Hall PTR, 2007. ISBN-10: 0132296543
4. *Strang's Linear Algebra And Its Applications* by Gilbert Strang, Strang, Brett Coonley, Andy Bulman-Fleming, Andrew Bulman-Fleming, 4th Edition, Brooks/Cole, 2005
5. *Elementary Linear Algebra: Applications Version* by Howard Anton, Chris Rorres, 9th Edition, Wiley, 2005.

Course Name: **Basic Electronics**
Credit Hours: 3
Prerequisites: None

Course Outline:

Zero Reference Level, Ohm's Law, Linear & Non-Linear Resistors, Cells in Series and Parallel. Resistive Circuits. Resistors, Inductors, Capacitors, Energy Sources. Magnetism and Electromagnetism; Theory of Solid State; P-N Junction; Forward Biased P-N Junction; Forward V/I Characteristics; Reverse Biased P-N Junction; Reverse Saturation Current; Reverse V/I Characteristics, Junction Breakdown, Junction Capacitance. Opto-electronics Devices; Spectral Response of Human Eye; Light Emitting Diode (LED); Photoemission Devices, Photomultiplier Tube, Photovoltaic Devices, Bulk Type Photoconductive Cells, Photodiodes, P-N Junction Photodiode, PIN Photodiode, and Avalanche Photodiode; DC Power Supplies; Rectifiers. Filters, Voltage Multipliers, Silicon Controlled Rectifier SCR; The Basic Transistor; Transistor Biasing, Transistor Circuit Configuration; Modulation and Demodulation; Carrier Waves; Integrated Circuits.

Reference Materials:

1. *Basic Electronics Solid State* by B. L. Theraja, S Chand & Co Ltd, 5th Edition, 2007, ISBN-13: 978-8121925563
2. *Electronic Principles* by Albert Paul Malvino, 6th Edition, 1999, ISBN 0-07-115604-6

Contents of General Education Elective Courses

Course Name: **Functional English (English I)**
Credit Hours: 3
Prerequisites: None

Course Outline:

Punctuation Principles. Spelling Rules. Writing Mechanics. Frequently Confused Words. Frequently Misused Words, Phrases, Synonyms, Antonyms, Idioms. General Vocabulary. Use of Articles and One, A Little/ A Few, This, That, Care, Like, Love, Hate, Prefer, Wish, All, Each, Every, Both, Neither, Either, Some, Any, No, None, etc. Interrogatives. Kins of Nouns. Prepositions. Possessive, Personal, Reflexive, and Relative Pronouns and Clauses. Classes of Verbs. Usage of May, Can, Ought, Should, Must, Have To, Need for Obligation, Must, Have, Will and Should. The Auxiliaries Dare and Used. The Gerund & The Participles. Commands, Requests, Invitations, Advice, Suggestions. The Subjunctive. The Passive Voice. Indirect Speech. Conjunctions. Purpose. Clauses: Noun Clauses; Clauses of Reason, Result, Concession, Comparison, Time. Numerals, Dates, Weights and Measures. Phrasal Verbs. Irregular Verbs. Overview of Present, Past, Future and Perfect Tenses.

Reference Materials:

1. *A Practical English Grammar* by A. J. Thomson and A. V. Martinent,4th Edition Oxford University Press (1986).
2. *Basic English Usage* by Michael Swan, Oxford Univ Pr (Sd) (January 1986). ISBN-10: 0194311872
3. *Functional English In Aglobal Society: Vocabulary Building and Communicative Grammar* by Nicanor L. Guintomary Ann R. Sibal Brian D. Villaverde Dept. of Languages, Literature and Humanities College of Arts and Sciences Southern Luzon State University (2012)
4. *English Composition and Grammar: Complete Course* by John E. Warriner, Harcourt Brace Jovanovich; Complete Course Benchmark Edition (January 1988). ISBN-10: 0153117362
5. *Companion to English: Vocabulary (Learners Companion)* by George Davidson, Prim-Ed Publishing (March 1, 2003). ISBN-10: 9814070904

Course Name: **Communication Skills (English II)**
Credit Hours: 3
Prerequisites: None

Course Outline:

What is Communication, The Importance of Communication, Communication Skills. The Communication Process. Perspectives in Communication. Factors Affecting Communication Perspective. Language as a Representational System. Internal Representation of Our World: Visual, Auditory &

Kinaesthetic Representational System. Elements of Communication. Communication Styles. Listening: Self-Awareness, Pseudo Listening, Active Listening, Effective Listening, Total Listing. Types of Expression. Rules of Effective Expression. Body Language. Para-language and Meta-messages. Hidden Agendas. Language Models. Communication Styles. Assertiveness. Responding to Criticism. Making Contact. The Art of Conversation. Negotiations. Prejudgment. The Power of Validation. Validation Strategies. Influencing Others. Public Speaking. Preparing Formal Oral Presentations: Design elements, elements of effective Delivery, Tension & Nerves, Handle Questions, Handling Tough Situations, Common Mistakes & Their Remedies, Dealing with Unexpected Disasters, Presentation for International Audience, Dealing People with Disabilities. Interviewing. Elements of Effective Written Communication. Building Rapports.

Reference Materials:

1. *Effective Communication Skills*, MTD Training & Ventus Publishing ApS. (2010) ISBN 978-87-7681-598-1 (TB1)
2. *Messages: The Communication Skills Book* by Matthew McKay PhD, Martha Davis PhD, and Patrick Fanning, New Harbinger Publications; 3rd Edition (March 3, 2009). ISBN-10: 1572245921
3. *Secrets of Successful Presenters: A Guide for Successful Presenters* by Dr. M. A. Pasha & Dr. S. Pasha, Lambert Academic Publishing (2012). ISBN-10:3659217557
4. *Communication Skills in English* by Prof P N Kharu, Dr Varinder Gandhi Publisher: Laxmi. EAN: 9788131806920
5. *Essential Communication Skills*, Teacher Edition with Talking Points by Patty Ann, Patty Ann; 1st Edition (July 5, 2012). ASIN: B008HYUDWQ

Course Name: **Technical and Report Writing (English III)**
Credit Hours: 3
Prerequisites: None

Course Outline:

Characteristics of Academic, Public, Work and Electronic Communities. Myths and Realities about Writing. Effective Writing: Discovering and Planning; Purpose, Thesis, and Audience; Drafting: Drafting Collaboratively, Drafting in Digital Environments; Revising, Editing, and Proofreading. Paragraphs: Unfocused Paragraphs, Incoherent Paragraphs, Poorly Developed Paragraphs, Special-Purpose Paragraphs. Unclear, Clear and Emphatic Sentences. Reasoning Critically. Reading Critically. Arguing Persuasively & Logically. Designing Documents. Writing in Online Communities. Speaking Effectively. Academic Writing for Social and Natural Sciences: Goals of Writing, Audiences, Writing Tasks, Types of Writing: Abstract, Informative Report, Lab Report, Research Report, Project Reports. Public Writing: Goals of Public Writing, Public Audiences, Public Writing Tasks, Types of Public Writing, Public Flyer, Letter to the Editor.

Researching and Writing: Types of Research Writing, Developing a Research Question, Developing a Preliminary Thesis, Creating a Research File and a Timeline, Reading and Note taking, Summarizing, Paraphrasing, and Synthesizing. Writing a Position Paper.

Reference Materials:

1. *Writer's Companion – The Longman* by Chris M. Anson, Robert A. Schwegler and Marcia F. Muth, Pearson Longman, 4th Edition 2007. ISBN10: 0-20556-252-3
2. *Technical English: Writing, Reading, and Speaking* by Pickett and Laster. 8th Edition
3. *The Technical Writer's Companion* by Alred, Gerald, Charles T. Brusaw and Walter E. Oliu, 3rd Edition. ISBN 0-312-25978-6.

ISLAMIC STUDIES
(Compulsory)

Objectives:

This course is aimed at:

1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul-Quran

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)

2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction To Islamic Law & Jurisprudence

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quranic & Science

Islamic Economic System

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History

1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam

1) Basic Concepts of Social System of Islam
2) Elements of Family
3) Ethical Values of Islam

Reference Books:

1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2) Hameed ullah Muhammad, "Muslim Conduct of State"
3) Hameed ullah Muhammad, 'Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,"
5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
7) Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

Course Name: **Ethics**
Prerequisites: None

Course Outline:

Follow Institution/University syllabus

Pakistan Studies (Compulsory)

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.
2. **Government and Politics in Pakistan**

   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books:

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Bangladesh.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.

7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Course Name: **Professional Practices**
Credit Hours: 2
Prerequisites: None

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.

Reference Materials:

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.

5. *The Dark Side of Software Engineering: Evil on Computing Projects* by Johann Rost and Robert L. Glass, Wiley-IEEE Computer Society Pr; 1st Edition (2011). ISBN-10: 0470597178

University Elective Courses

Course Name: **Principles of Accounting**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to Accounting, Accounting Principles, Book Keeping, Basics of Financial Statements, Adjustments to Financial Statements, The Cash Book, Bank Reconciliation, Control Accounts, Statement of Cash Flows, Financial Activities, Property, Plant and Equipment (PPE), Accounting Errors, Accounting for Partnerships, Balance Sheet.

Reference Materials:

1. *Fundamentals of Accounting* by Wang'ombe, D. K., Focus Publishers (2008). ISBN-10: 9966-01-087-4
2. *Fundamental Accounting Principles with Connect Plus* by John Wild, Ken Shaw, and Barbara Chiappetta, McGraw-Hill/Irwin; 20th Edition (December 27, 2010). ISBN-10: 0077505980
3. *Financial & Managerial Accounting* by Jan Williams, Sue Haka, Mark Bettner and Joseph Carcello, McGraw-Hill/Irwin; 16th Edition (2011). ISBN-10: 0078111048
4. *Principles of Managerial Finance* by Lawrence J. Gitman and Chad J. Zutter, Prentice Hall; 13th Edition (2011). ISBN-10: 0136119468
5. *Fundamentals of Financial Management* by J. Van Horne and John M Wachowicz, Prentice Hall; 13th Edition (2008). ISBN-10: 0273713639.

Course Name: **Principles of Management**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to Managers and Management. Organizational Culture and Environment. Decision Making. The Essence of Manager's Job. Planning. Organization Structure and Design. Motivation. Leadership. Communication. Controlling. The Personnel Function. Job Design and Analysis. Human Resource Planning. Recruitment and Selections/Testing and Interview. Union and Management, Compensation Administration, Health and Safety.

Reference Materials:

1. *Management* by Robbins, S.P. & Coulter, Mary, Prentice Hall; 10th Edition (November 3, 2008). ISBN-10: 0132090716

2. *Fundamentals of Management* by Robbins, S.P. & DeCenzo, David A, Prentice Hall; 7th Edition (January 13, 2010). ISBN-13: 978-0132090711
3. *Principles of Management* by Charles W. L. Hill and Steven McShane, McGraw-Hill/Irwin; 1st Edition (2006). ISBN-10: 0073530123
4. *Management* by Richard L. Daft, South-Western College Pub; 10th Edition (January 27, 2011). ISBN-10: 0538479531
5. *Fundamentals* of Management by Stephen P. Robbins, David A. DeCenzo and Mary Coulter, Prentice Hall; 7th Edition (January 13, 2010). ISBN-10: 0136109829.

Course Name: **Human Resources Management**
Credit Hours: 3
Prerequisites: None

Course Outline:

Managing Human Resources. Understanding the External and Organizational Environments. Ensuring Fair Treatment and Legal Compliance. HR Planning for Alignment and Change. Using Job Analysis and Competency Modeling. Recruiting and Retaining Qualified Employees. Selecting Employees to Fit the Job and the Organization. Training and Developing a Competitive Workforce. Conducting Performance Management. Developing an Approach to Total Compensation. Using Performance-Based Pay to Achieve Strategic Objectives. Providing Benefits and Services for Employees' Well-Being, Risk Management. Employee Relations. Risk Management. Health, Safety, and Employee Well-Being. Understanding Unionization and Collective Bargaining.

Reference Materials:

1. *Managing Human Resources* by Susan E. Jackson, Randall S. Schuler and Steve Werner, South-Western College Pub; 11th Edition (June 16, 2011).ISBN-10: 1111580227
2. *Management of Human Resources* by Gary Dessler, Carolin Rekar Munro and Nina D. Cole, Pearson Education Canada; 3rd Edition (February 28, 2010). ISBN-10: 0321687140
3. *Human Resource Management* by Robert L. Mathis and John H. Jackson, South-Western Cengage Learning; 13th Edition (August 19, 2010). ISBN-10: 053845315X
4. *Human Resource Management Applications: Cases, Exercises, Incidents, and Skill Builders* by Stella M. Nkomo, Myron D. Fottler and R. Bruce McAfee, South-Western Cengage Learning; 7th Edition (September 29, 2010). ISBN-10: 0538468076

Course Name: **Organizational Behaviour**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to OB. People-Centered Organizations and Ethical Conduct. Organizational Culture. Socialization. Mentoring. Key Individual Differences. Values. Attitudes. Job Satisfaction and Counterproductive Work Behaviors. Social Perceptions and Attributions. Foundations of Motivation. Improving Job Performance with Goals, Feedback, Rewards, and Positive Reinforcement. Group Dynamics. Developing and Leading Effective Teams. Individual and Group Decision Making. Managing Conflict and Negotiating. Communicating in the Digital Age. Leadership, Influence, Empowerment, and Politics. Organizational Design, Effectiveness, and Innovation.

Reference Materials:

1. *Organizational Behavior* by Robert Kreitner and Angelo Kinicki, McGraw-Hill/Irwin; 10th Edition (January 17, 2012). ISBN-10: 0078029368
2. *Organizational Behavior* by Stephen P. Robbins and Timothy A. Judge, Prentice Hall; 15th Edition (January 16, 2012). ISBN-10: 0132834871
3. *Meeting the Ethical Challenges of Leadership: Casting Light or Shadow* by Craig E. Johnson, SAGE Publications, Inc; 4th Edition (February 28, 2011). ISBN-10: 1412982227

Course Name: **Principles of Philosophy**
Credit Hours: 3
Prerequisites: None

Course Outline:

The Nature of Philosophy. Philosophical Theories: History and Back Ground, Realism and Idealism, Monism and Dualism, Rationalism, Empiricism, Criticism, and Empiricism. The Start of Modern Philosophy. Perception and Reality. Knowledge, Belief and Logic. Space, Time, Causality and Substance. Mind & Body. Knowledge. Language. Science. Morality. Politics. Law. Metaphysics.

Reference Materials:

1. *An Introduction to Philosophy* by Jon Nuttall, Polity; 1st Edition (July 29, 2002). ISBN-10: 0745616631
2. *An Introduction To Philosophy* by George Stuart Fullerton, CreateSpace Independent Publishing Platform (July 18, 2011). ISBN-10: 1463688881
3. *Philosophy: An Introduction to the Art of Wondering* by James L. Christian, Wadsworth Publishing; 11th Edition (January 26, 2011). ISBN-10: 1111298084
4. *Pleasures of Philosophy* by Durant, Touchstone; Revised Edition (December 31, 1999). ISBN-13: 978-0671581107

5. *Philosophy Basics: A Jargon-Free Guide for Beginners* by Doug Erlandson, Doug Erlandson (September 15, 2011). ASIN: B005NJRTUW

Course Name: **Principles of Psychology**
Credit Hours: 3
Prerequisites: None

Course Outline:

Basics concepts of Psychology and Research Methods. Brain and Behaviour. Human Development. Sensation and Perception. States of Consciousness. Conditioning and Learning. Memory. Cognition, Language, Creativity, and Intelligence. Motivation and Emotion. Sex, Gender, and Sexuality. Personality. Health, Stress, and Coping. Social Behaviour.

Reference Materials:

1. *Psychology: Modules for Active Learning* by Dennis Coon and John O. Mitterer, Wadsworth Publishing; 12th Edition (January 1, 2011). ISBN-10: 1111342849
2. *Introduction to Psychology* by James W. Kalat, Wadsworth Publishing; 9th Edition (January 1, 2010). ISBN-10: 0495810762
3. *Introduction to Psychology* by Rod Plotnik and Haig Kouyoumdjian, Wadsworth Publishing; 9th Edition (February 25, 2010). ISBN-10: 0495903442
4. *Psychology* by David G. Myers, Worth Publishers; 9th Edition (January 10, 2009). ISBN-10: 1429215976

Course Name: **Foreign/regional Language (French/ German/ Chinese/ Arabic)**
Credit Hours: 3
Prerequisites: None

Course Outline:

Institution/Universities follow their approved syllabus

Course Name: **Entrepreneurship**
Credit Hours: 3
Pre-requisite: None

Course Outline:

Entrepreneurship and the Entrepreneurial Mind-Set. Entrepreneurial Intentions and Corporate Entrepreneurship. Entrepreneurial Strategy. Generating and Exploiting New Entries. Creativity and the Business Idea. Identifying and Analyzing Domestic and International Opportunities. Intellectual Property and Other Legal Issues for the Entrepreneur. The Business Plan. Creating and Starting the Venture. The Marketing Plan. The Organizational Plan. The Financial Plan. Sources of Capital. Informal Risk

Capital, Venture Capital, and Going Public. Strategies for Growth and Managing the Implication of Growth. Succession Planning and Strategies for Harvesting and Ending the Venture.

Reference Materials:

1. *Entrepreneurship* by Robert Hisrich, Michael Peters and Dean Shepherd, McGraw-Hill/Irwin; 9th Edition (September 27, 2012). ISBN-10: 0078029198
2. *Entrepreneurship: Ideas in Action* by Cynthia L. Greene, South-Western Educational Pub; 5th Edition (January 6, 2011). ISBN-10: 0538496894
3. *Entrepreneurship* by William D. Bygrave and Andrew Zacharakis, Wiley; 2nd Edition (October 12, 2010). ISBN-10: 0470450371
4. *Entrepreneurship: Theory, Process, and Practice* by Donald F. Kuratko, South-Western College Pub; 8th Edition (November 14, 2008). ISBN-10: 0324590911
5. *Entrepreneurship: Successfully Launching New Ventures* by Bruce R. Barringer and Duane Ireland, Prentice Hall; 4th Edition (October 27, 2011)

Information Technology Core Courses

Course Name: **Web Systems and Technologies**
Credit Hours: 3*
Prerequisites: **Database Systems**

Course Outline:

Introduction to Web Applications, TCP/IP Application Services. Web Servers: Basic Operation, Virtual hosting, Chunked transfers, Caching support, Extensibility. SGML, HTML5, CSS3. XML Languages and Applications: Core XML, XHTML, XHTM MP. Web Service: SOAP, REST, WML, XSL. Web Services: Operations, Processing HTTP Requests, Processing HTTP Responses, Cooki Coordination, Privacy and P3P, Complex HTTP Interactions, Dynamic Content Delivery. Server Configuration. Server Security. Web Browsers Architecture and Processes. Active Browser Pages: JavaScript, DHTML, AJAX. JSON, Approaches to Web Application Development. Programing in any Scripting language. Search Technologies. Search Engine Optimization. XML Query Language, Semantic Web, Future Web Application Framework.

Reference Materials:

1. *Web Application Architecture: Principles, protocols and practices* by Leon Shklar and Richard Rosen, Wiley; 2nd Edition (May 5, 2009). ISBN-10: 047051860X
2. *Web Technologies: A Computer Science Perspective* by Jeffrey C. Jackson, Prentice Hall; 1st Edition (August 27, 2006). ISBN-10: 0131856030

3. *Web Technologies* by Uttam Kumar Roy, Oxford University Press, USA (June 13, 2011). ISBN-10: 0198066228

Course Name: **Multimedia Systems and Design**
Credit Hours: 3
Prerequisites: None

Course Outline:

What is Multimedia? Multimedia Authoring Tools, Multimedia Authoring, Multimedia Production, Multimedia Presentation, Automatic Authoring, Editing and Authoring Tools- (Proprietary/open Source), VRML, Making Multimedia: Handling Images, Sound, Animation and Video, Planning & Costing, Designing and Producing. Multimedia Skills and Talent, The Internet and Multimedia. Designing for the World Wide Web. Delivering Multimedia Product.

Instructors can devise a Lab work plan using a multimedia Authoring tool in line with the contents of the syllabus.

Reference Materials:

1. *Multimedia Making It Work, 8th Edition* by Tay Vaughan, McGraw-Hill Osborne Media; 8th Edition (October 29, 2010). ISBN-10: 0071748466
2. *Fundamentals of Multimedia* by Z. M. Li and M. S. Drew, Prentice Hall (2004), ISBN: 0-13-127256-X
3. *Digital Multimedia* by N. Chapman and J. Chapman. 2nd Edition, Wiley 2004, ISBN: 0-470-85890-7
4. *The Technology of Video and Audio Streaming* by David Austerberry, Focal Press; 2nd Edition (2004). ISBN-10: 0240805801
5. *Multimedia Foundations: Core Concepts for Digital Design* by Vic Costello, Ed Youngblood and Susan Youngblood, Focal Press; 1st Edition (2012). ISBN-10: 0240813944

Course Name: **Systems and Network Administration**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks, Operating Systems**

Course Outline:

Introduction To System Administration. SA Components. Server Environment (Microsoft and Linux). Reliable Products, Server Hardware Costing, Maintenance Contracts and Spare Parts, Maintaining Data Integrity, Client Server OS Configuration, Providing Remote Console Access. Comparative Analysis of OS: Important Attributes, Key Features, Pros and Cons. Linux Installation and Verification, Configuring Local Services and Managing Basic System Issues. Administer Users and Groups. Software Management. Managing Network Services and Network Monitoring Tools. Boot

Management and Process Management. IP Tables and Filtering. Securing Network Traffic. Advanced File Systems and Logs. Bash Shell Scripting. Configuring Servers (FTP, NFS, Samba, DHCP, DNS and Apache).

Reference Materials:

1. *The Practice of System and Network Administration*, Second Edition by Thomas Limoncelli, Christina Hogan and Strata Chalup, Addison-Wesley Professional; 2nd Edition (2007). ISBN-10: 0321492668
2. *Red Hat Enterprise Linux 6 Bible: Administering Enterprise Linux Systems* by William vonHagen, 2011
3. *Studyguide for Practice of System and Network Administration* by Thomas A. Limoncelli, Cram101; 2nd Edition (2011). ISBN-10: 1428851755
4. *Networking Systems Design and Development* by Lee Chao, CRC Press; 1st Edition (December 21, 2009). ISBN-10: 142009159X (TB2)
5. *Windows Administration* Latest Edition, Microsoft Press
6. *Linux Administration* Guide Latest Edition

Course Name: **Network Security**
Credit Hours: 3
Prerequisites: **System and Network Administration**

Course Outline:

Security Concepts, Such as Confidentiality, Integrity, Authenticity, Availability etc. Symmetric and Asymmetric Cryptography and Their Uses; Key Distribution and Digital Signatures; Discretionary and Mandatory Access Control Policies for Confidentiality and Integrity. Communication Protocols for Authentication, Confidentiality and Message Integrity. Network Security; System Security, Intrusion Detection and Malicious Code. Security Models and Security Evaluation. Administration of Security. Legal Aspects of Computer Security.

Reference Materials:

1. *Security in Computing* by Charles P. Pfleeger and Shari Lawrence Pfleeger, Prentice Hall; 4th Edition (2006). ISBN-10: 0132390779
2. *Network Security Fundamentals* by Gert DeLaet and Gert Schauwers, Cisco Press; 1st Edition (September 18, 2004). ISBN-10: 1587051672
3. *Network Security Bible* by Eric Cole, Wiley; 2nd Edition (September 8, 2009). ISBN-10: 0470502495
4. *Network Security Essentials*: *Applications and Standards* by William Stallings, Prentice Hall; 4th Edition (March 22, 2010). ISBN-10: 0136108059

Course Name: **Cloud Computing**
Credit Hours: 3
Prerequisites: **Internet Architecture and Protocols**

Course Outline:
Overview of Distributed Computing, Emergence of Cloud Computing, Global Nature of the Cloud, Cloud-Based Service Offerings, Grid Computing, Reliability of Cloud Model, Benefits of Cloud Model, Legal Issues, Key Characteristics of Cloud Computing, Challenges for the Cloud. The Evolution of Cloud Computing. Web Services Delivered from the Cloud: Communication-as-a-Service (CaaS), Infrastructure-as-a-Service, Monitoring-as-a-Service (MaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Building Cloud Networks. Virtualization. Federation, Presence, Identity, and Privacy in the Cloud. Security in the Cloud. Common Standards in Cloud Computing. End-User Access to Cloud Computing. Mobile Internet Devices and the Cloud.

Reference Materials:

1. *Cloud Computing Implementation, Management, and Security* by John W. Rittinghouse and James F. Ransome, Taylor & Francis Group, LLC (2010). ISBN 978-1-4398-0680-7.
2. *Cloud Computing Explained: Implementation Handbook for Enterprises* by John Rhoton, Recursive Press (2009). ISBN-10: 0956355609.
3. *Cloud Computing Bible* by Barrie Sosinsky, Wiley; 1st Edition (2011). ISBN-10: 0470903562.
4. *Securing the Cloud: Cloud Computer Security Techniques and Tactics* by Vic (J.R.) Winkler, Syngress; 1st Edition (2011). ISBN-10: 1597495921.

Course Name: **System Integration and Architecture**
Credit Hours: 3
Prerequisites: None

Course Outline:
Enterprise Architecture (EA) and Enterprise Engineering (EE). Balanced Scorecard and Strategy Maps (BSSM). Using Strategy Analysis (SA). Governance Analysis Using EA. Enterprise Architecture Methods. Using Business-Driven Data Mapping for Integrated Data. Strategic Modeling for Rapid Delivery of EA. Strategic Alignment, Activity and Workflow Modeling, and Business Rules. Using Business Normalization for Future Business Needs. Menu Design, Screen Design, Performance Analysis, and Process Modeling. Enterprise Application Integration Concepts. Enterprise Portal Technologies for Integration. Web Services for Real-Time Integration. Service-Oriented Architecture for Integration. Managing and Delivering EA. Future Directions in EA and Integration.

Reference Materials:

1. *Enterprise Architecture for Integration: Rapid Delivery Methods and Technologies* by Clive Finkelstein, Artech House Print on Demand; 1st Edition (March 31, 2006). ISBN-10: 1580537138
2. *Systems Integration (Systems Engineering)* by Jeffrey Grady, CRC-Press; 1st Edition (September 30, 1994). ISBN-10: 0849378311
3. *The Business of Systems Integration* by Andrea Prencipe, Andrew Davies, Mike Hobday. Oxford University Press, USA (June 30, 2005). ISBN-10: 019926323X
4. *Enterprise Integration: An Architecture for Enterprise Application and Systems Integration* by Fred A. Cummins, Wiley; 1st Edition (February 14, 2002). ISBN-10: 0471400106.

Course Title: **Technology Management**
Credit Hours: 3
Prerequisites: None

Course Outline:

Introduction to Technology Management, TM activities and tools, The TM framework, TM activities behind technological capabilities. TM Activities: Identification, Selection, Acquisition, Exploitation, Protection, Learning. TM Tools. TM Tools-Patent Analysis. TM Tools-Portfolio Management. TM Tools-Roadmapping. TM Tools-Value Analysis/Value Innovation. TM-Functions: Planning and Forecasting, Decision Making, Organizing, Leading Technical People.

Reference Materials:

1. *Technology Management: Activities and Tools* by Dilek Cetindamar, Rob Phaal, and David Probert, Palgrave Macmillan (April 27, 2010). ISBN-10: 0230233341 (TB1)
2. *Managing Engineering and Technology* by Lucy C. Morse And Daniel L. Babcock, Prentice Hall; 5th Edition (August 20, 2009). ISBN-10: 0136098096 (TB2)
3. *Management of Technology: Managing Effectively in Technology-Intensive Organizations* by Hans J. Thamhain, Wiley; 2nd Edition (May 25, 2005). ISBN-10: 0471415510
4. *Managing Information Technology* by Carol V. Brown, Daniel W. DeHayes, Jeffrey A. Hoffer, Wainright E. Martin, and William C. Perkins, Prentice Hall; 7th Edition (March 18, 2011). ISBN-10: 0132146320
5. *Technology Management: Activities and Tools* by Dilek Cetindamar, Rob Phaal, and David Probert, Palgrave Macmillan (April 27, 2010). ISBN-10: 0230233341

Contents of Information Technology Supporting Courses

Course Name: **Information Systems**
Credit Hours: 3
Prerequisites: None

Course Outline:

Information Systems Concepts, Types, Advantages, and Global Challenges. System Development Life Cycle. System Investigation, Systems Analysis, Systems Design, Environmental Design Considerations, System Implementations, Ethical and Social Issues, Systems Operations and Maintenance. Themes in information systems development. System Development Techniques. Information Systems Development Tools and toolsets. Information Systems Development Methodologies.

Reference Materials:

1. *Fundamentals of Information Systems* by Ralph Stair and George Reynolds, Course Technology; 6th Edition (January 1, 2011). ISBN-10: 0840062184
2. *Information Systems Development: Methodologies, Techniques & Tools* by David Avison and Guy Fitzgerald, McGraw-Hill; 4th Edition (May 1, 2006). ISBN-10: 0077114175
3. *Introduction to Information Systems: Supporting and Transforming Business* by R. Kelly Rainer and Casey G. Cegielski, Wiley; 3rd Edition (June 16, 2010). ISBN-10: 0470473525
4. *Information Systems* by Richard T. Watson, Create Space Independent Publishing Platform (March 20, 2012). ISBN-10: 1475074921

Course Name: **Information Technology Project Management**
Credit Hours: 3
Prerequisites: **Software Engineering, Technology Management**

Course Outline:

Introduction to Project Management. The Project Management and Information Technology Context. The Project Management Process Groups. Project Integration Management. Project Scope Management. Project Time Management. Project Cost Management. Project Quality Management. Project Human Resource Management. Project Communications Management. Project Risk Management. Project Procurement Management. Project Management Tools.

Reference Materials:

1. *Information Technology Project Management* by Kathy Schwalbe, Course Technology; 6th Edition (July 22, 2010). ISBN-10: 1111221758

2. *A Guide to the Project Management Body of Knowledge*, 3rd Edition (PMBOK Guides), ISBN-13: 978-1930699458
3. *IT Project Management: On Track from Start to Finish* by Joseph Phillips, McGraw-Hill Osborne Media; 3rd Edition (February 25, 2010). ISBN-10: 0071700439
4. *Information Technology Project Management* by Jack T. Marche, Wiley; 3rd Edition (January 6, 2009). ISBN-10: 0470371935
5. *Effective Project Management: Traditional, Agile, Extreme* by Robert K. Wysocki, Wiley; 6th Edition (2011). ISBN-10: 111801619X

Course Name: **Internet Architecture and Protocols**
Credit Hours: 3
Prerequisites: **Computer Communications and Networks**

Course Outline:

Terms and Concepts. Functioning of the Internet. Review of the TCP/IP Model. Network Layer Addresses (IP Addresses). DHCP. DNS Servers& Configuration. Error Recovery Operations. Internet Local Area Networks (LANs). IEEE Standards. (CSMA/CD), (CSMA/CA) LANs. CSMA/CD Protocol Stacks. Review of Ethernet. CSMA/CD Frames. Subnetwork Access Protocol (SNAP). CSMA/CD. Ethernet Layers. CSMA/CD Standards. The Token Ring Network. The Ring Configuration. FDDI. FDDI Configuration. The FDDI Layers. FDDI Backbones. Switched LANs. Fast Ethernet. Fast Ethernet and the Layered Model. Auto-Negotiation. Gigabit Ethernet. Internet Wide Area Networks (WANs). Message Switching and Packet Switching. Frame Relay. Cell Relay. Comparing WAN Technologies. X.25, Frame Relay, and ATM Virtual Circuits. Mapping IP Addresses to "Labels": Label or Tag Switching. IP and ICMP. Time-to-Live. Destination Unreachable. Redirect. Router Discovery. Pings. IPv6. TCP and UDP. Round Trip Time (RTT). Nagle's Algorithm. The Slow Start. Congestion Window and Threshold Size. The User Datagram Protocol (UDP). The Point-to-Point Protocol (PPP) and The Layer 2 Tunneling Protocol (L2TP). Routing Protocols. Autonomous Systems. Multiple Routing Protocols. Operation of Internet Operates with the Routing Protocols. Levels of Access. Peering through the Routing Protocols.

Reference Materials:

1. *Internet Architecture: An Introduction to IP Protocols* by Uyless D. Black, Prentice Hall PTR; 1st Edition (2000). ISBN-10: 0130199060
2. *Internet Routing Architectures* by Sam Halabi, Cisco Press; 2nd Edition (2000). ISBN-10: 157870233X
3. *TCP/IP Protocol Suite* by Behrouz A. Forouzan, McGraw-Hill Science/Engineering/Math; 4th Edition (2009). ISBN-10: 0073376043
4. *Next-Generation Internet: Architectures and Protocols* by Andrei Gurtov, Cambridge University Press (2011). ISBN-10: 0521113687

Course Name: **Object-Oriented Analysis and Design**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Principles of Object Technology. OOP Review. Principles of Modeling. OOA&D Overview. OO Development Process. Requirements Engineering, Analysis, and Specification: Requirements Engineering, Use Cases, Prototyping, Class Models. Interaction Diagrams. Verification and Validation. Architectural and Detailed Design. Class Diagrams. Interaction Diagrams. State Machines and Diagrams. Implementation, Package Diagrams. Activity Diagrams. OO Patterns, Verification and Validation. Note: Students may also be introduced to Object Diagram, Component Diagram, Package Diagram, Deployment Diagram, Network Diagram.

Reference Materials:

1. *Applying UML and patterns: An introduction to Object-Oriented Analysis and Design and Iterative Development* by Craig Larman, Prentice Hall; 3rd Edition (October 30, 2004). ISBN-10: 0131489062
2. *Using UML: Software Engineering with Objects and Components* by Perdita Stevens, Addison-Wesley; 2nd Edition (February 13, 2006). ISBN-10: 0321269675
3. *Fundamental of Object-Oriented Design in UML* by Meiler Page-Jones, Addison Wesley, 2000. ISBN: 020169946X.
4. *The Unified Modeling Language User Guide* by G. Booch, J. Rambaugh and I. Jakobson, Addison-Wesley Professional; 2nd Edition (2005). ISBN-10: 0321267974.
5. *The Unified Modeling Language Reference Manual* by James Rumbaugh, Ivar Jacobson and Grady Booch, Addison-Wesley Professional; 2nd Edition (2004). ISBN-10: 032171895X.

Course Name: **Database Administration & Management**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Installation of DBMS; SQL* Plus; DBA Tools. DBMS Physical Structure & Architectural Components: Server, Instance, SGA, Shared Pool, Library Cache, Data Dictionary Cache, Large Pool, Processes. Startup and Shutdown Database. Managing Instances. Managing Files. Creating Database and Data dictionary. Managing Tablespaces. Operations with Tablespaces. Data File Management, Segments, Block. Managing Undo Data, Undo Data Statistics: Managing Tables and Users. Indexes Management, Maintaining Data Integrity, Constraints. Managing Privileges. Server Side Configuration. Client Side Configuration. Usage and Configuration of Oracle Shared Server. Backup and Recovery. Sizing Shared

Pool, Sizing Buffer Cache, I/O Issues. Tuning Rollback Segments. Tuning Shared Servers, Types of Locks, Block Efficiency, Storage hierarchy, Avoiding Dynamic allocation, Statistics, PCTFREE and PCTUSED, Monitoring Index Usage.

Reference Materials:

1. *Database Administration: The Complete Guide to DBA Practices and Procedures* by Craig S. Mullins, Addison-Wesley Professional; 2nd Edition (October 21, 2012). ISBN-10: 0321822943
2. *Database Systems: A Practical Approach to Design, Implementation and Management* by Thomas M. Connolly and Carolyn E. Begg, Addison-Wesley; 5th Edition (2009). ISBN-10: 0321523067
3. *Online Material* URL http://www.oracle.com/technetwork/index.html (this should be avoided)

Contents of Information Technology Elective Courses

Course Name: **Telecommunication Systems**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Communication Channel and the Communication Network Technologies. Digital Telephony. Switching and Signaling Systems. Switching Fabric Interfaces and ICs, Optics and the Future. Cellular Systems. Fixed Wireless Access Technologies. Digital Subscriber Loop. Transmission Techniques. Telecommunication Systems Testing. Embedded Systems Design for Telecommunications.

Reference Materials:

1. *Essentials of Modern Telecommunications Systems* by Nihal Kularatna and Dileeka Dias, Artech House (May 2004). ISBN-10: 1580534910
2. *The Irwin Handbook of Telecommunications* by James Harry Green, McGraw-Hill; 5th Edition (October 26, 2005). ISBN-10: 0071452222
3. *Telecommunications Essentials: The Complete Global Source for Communications Fundamentals, Data Networking and the Internet, and Next-Generation Networks* by Lillian Goleniewski, Addison-Wesley Professional; 1st Edition (January 5, 2002). ISBN-10: 0201760320
4. *Fundamentals of Communications Systems* by Michael Fitz, McGraw-Hill Professional; 1st Edition (June 27, 2007). ISBN-10: 0071482806

Course Name: **Routing & Switching**
Credit Hours: 3
Prerequisites: **Internet Architecture & Protocols**

Course Outline:

Ethernet Basic: Ethernet Layer 1, Ethernet Layer 2, Switching and Bridging Logic, SPAN and RSPAN.: VLANs, VLAN Trunking Protocols, VLAN Trunking: ISL and 802.1Q, Configuring PPPoE. Spanning Tree Protocol: 802.1d Spanning Tree Protocol, Optimizing Spanning Tree, Protecting STP, Troubleshooting Complex Layer 2 Issues. IP Addressing. IP Services. IP Forwarding (Routing). EIGRP. OSPF. IGP Routing. Fundamentals of BGP Operations. BGP Routing Policies. Wide Area Network. IP Multicasting. IP Multicast Routing.

Reference Materials:

1. *CCIE Routing and Switching Certification Guide* by Wendell Odom, Rus Healy and Denise Donohue, Cisco Press; 4th Edition (December 18, 2009). ISBN-10: 1587059800
2. *Packet Guide to Routing and Switching* by Bruce Hartpence, O'Reilly Media (September 3, 2011). ISBN-10: 1449306551
3. *CCIE Routing and Switching v4.0 Quick Reference* by Brad Ellis, Jacob Uecker and Steven Means, Cisco Press (October 4, 2010). ASIN: B00452V45O

Course Name: **Network Design and Management**
Credit Hours: 3 (Lab may be assigned or adjusted by the University)
Prerequisites: **Computer Communication and Networks**

Course Outline:

Analyzing Business Goals and Constraints. Top-Down Network Design Methodology. Characterizing the Existing Internetwork. Designing a Network Topology. Designing Models for Addressing and Numbering. Selecting Switching and Routing Protocols. Developing Network Security Strategies. Developing Network Management Strategies. Physical Network Design. Selecting Technologies and Devices for Enterprise Networks. Testing Network Design. Optimizing Network Design. Documenting Network Design. Network Management Standards & Models. SNMP Management. SNMP Management. Broadband Network Management.

Reference Materials:

1. *Top-Down Network Design* by Priscilla Oppenheimer, Cisco Press; 3rd Edition (September 3, 2010). ISBN-10: 1587202832 (TB1)
2. *Network Management: Principles and Practice* by Mani Subramanian; Timothy A. Gonsalves; N. Usha Rani, Pearson Education India (2010). ISBN-10: 81-3172-759-9

3. *Networking Systems Design and Development* by Lee Chao, CRC Press; 1st Edition (December 21, 2009). ISBN-10: 142009159X (TB2)
4. *Networks: Design and Management* by Steven Karris, Orchard Publications (August 2002). ISBN-10: 0970951140
5. *Network Warrior* by Gary A. Donahue, O'Reilly Media; 2nd Edition (May 13, 2011). ASIN: B004W8ZL3W.

Course Name: **Network Programming**
Credit Hours: 3
Prerequisites: **Operating Systems**

Course Outline:

The Network Programming course is aimed at developing Network programming concepts and skills in general. Unix Programming Environment, TCP Protocol suite, Socket Programming , UDP and TCP Sockets, I/O Multiplexing including Non-blocking I/O, Advanced Socket Options, Name and Address Conversions, IPv4 and IPv6 Interoperability, Unix Domain Protocols, Broadcasting and Multicasting, Routing and Communication, Pipes and FIFO's Message Queues, Mutexes and Locks, Semaphores, POSIX Shared Memory, Doors and RPC (Remote Procedure Calls).

Reference Materials:

1. *UNIX Network Programming Volume I* by Richard Steven, Prentice Hall; 2nd Edition (September 4, 1998). ISBN-10: 0130810819
2. *Windows System Programming* by Johnson M. Hart, Addison-Wesley Professional; 4 Edition (February 26, 2010). ISBN-10: 0321657748
3. *The Linux Programming Interface: A Linux and UNIX System Programming Handbook* by Michael Kerrisk, No Starch Press; 1st Edition (October 28, 2010). ISBN-10: 1593272200
4. *Linux Kernel Development* by Robert Love, Addison-Wesley Professional; 3rd Edition (July 2, 2010). ISBN-10: 0672329468
5. *System Software: An Introduction to Systems Programming (3rd Edition)* by Leland L. Beck, Addison Wesley (1996). ASIN: B0084YEEWO.

Course Name: **Computer Game Development**
Credit Hours: 3
Prerequisites: **Data Structures & Algorithms**

Course Outline:

Introduction to Game Development, Platform and Player Modes, What Is The Framework? Goals And Genres? What Are The Possibilities? Player Elements, Player Motivation, Geographic, Psychographics. Demographics, Gender, Generation, Rating, Applying Player Market to Platform. Story and Character Development: Classic Charters, Traditional Story Structure, Story Element. Plot, Game Story Devices, Game Characters. Character Development Element, Point-of-view, Visual Character Development, Verbal Character Development, Movement. Visual Character Development, Verbal Character Development, Movements, Character Description, Game Storytelling and Documentation. Gameplay: Rules to Play, Interactivity Modes, Game theory, Challenges, Balance. Levels: Level Design, Structure, Time, Space. Interface: Playe-Centerd Design, Interface & Game Feature, Interface Types, Usability. Audio: Importance of Game Audio, Sound Effect, Voiceover, Music. Company Role, Team Roles, Tools, Business Side of Game Development. Production and Management, Development Phases, Game Documentation.

Reference Materials:

1. *Game Development Essentials* by Jeannie Novak, Delmar Cengage Learning; 3rd Edition (August 17, 2011). ISBN-10: 1111307652
2. *Game Development Essentials: An Introduction* by Jeannie Novak, Delmar Cengage Learning; 3rd Edition (2011). ISBN-10: 1111307652
3. *Game Development Essentials: Mobile Game Development* by Kimberly Unger and Jeannie Novak, Delmar Cengage Learning; 1st Edition (2011). ISBN-10: 1418052655
4. *Game Development Essentials: Game Interface Design* by Kevin Saunders and Jeannie Novak, Delmar Cengage Learning; 2nd Edition (2012). ISBN-10: 1111642885
5. *Game Development Essentials: Online Game Development* by Rick Hall and Jeannie Novak, Delmar Cengage Learning; 1st Edition (2008). ISBN-10: 1418052671

Course Title: **Multimedia Technologies**
Credit Hours: 3
Prerequisites:

Course Outline:

What is Multimedia? Text, Multimedia Authoring and Tools, Multimedia Authoring, Multimedia Production, Multimedia Presentation, Automatic Authoring; Editing and Authoring Tools- (Adobe Premiere, Macromedia Director, Macromedia Flash, Dreamweaver), VRML, Handling Images,

Sound, Making Animation and Video, Making Multimedia, Multimedia Skills, Planning and Costing, Designing and Producing, Content and Talent, The Internet and Multimedia, Designing for the World Wide Web, Delivering Multimedia Product. Instructors need to devise a content delivery and Lab work plan using a multimedia Authoring tool in line with the contents of the textbook.

Reference Materials:

1. *Multimedia Making It Work 8th Edition* by Tay Vaughan, McGraw-Hill Osborne Media; 8th Edition (October 29, 2010). ISBN-10: 0071748466
2. *Fundamentals of Multimedia* by Z. M. Li and M. S. Drew, Prentice Hall (2004), ISBN: 0-13-127256-X
3. *Digital Multimedia* by N. Chapman and J. Chapman. 2nd Edition, Wiley 2004, ISBN: 0-470-85890-7
4. *The Technology of Video and Audio Streaming* by David Austerberry, Focal Press; 2nd Edition (2004). ISBN-10: 0240805801
5. *Multimedia Security: WaTermarking, Steganography, and Forensics* by Frank Y. Shih, CRC Press; 1st Edition (2012), ISBN-10: 1439873313

Course Name: **3D Modeling & Animation**
Credit Hours: 3*
Prerequisites: **Multimedia Systems and Design**

Course Outline:
Introduction to 3D Modeling & Animation, History of Computer Graphics and Special Effects. Polygons, Polygon Meshes, Extruding, Controlling Edges and Edges Loop, Subdividing and Simplifying, Combining Meshes, Polygon Count, Normals, UV Coordinates. NURBS, Advantages and Disadvantages of NURBS. Subdivision Surfaces. Deforming, Sculpting and Special Selections, Morph Targets, Lattices and Curves, Specialized Deformers, Managing Soft and Rigid Bodies. Managing Animation. Coloring, Shaders, Ray Tracing, Photon Mapping. Working with Textures, Shading, UV Mapping, Paining in 3D, Changing Geometry, Seamless Reporting Pattern, Multiple Maps. Light Effect. Virtual Camera, Faking Camera Effects, Matching Virtual Cameras to Real One, Cameras and Image Planes, Animating the Camera, Camera Views, Camera Movements. Environments, Rendering. Procedures and Graphs. Scripting. Animation Tools.

Reference Materials:

1. *3D Art Essentials: The Fundamentals of 3D Modeling, Texturing, and Animation* by Ami Chopine, Focal Press; 1st Edition (March 23, 2011). ISBN-10: 0240814711
2. *3D Modeling, Animation, and Rendering: An Illustrated Lexicon, Colour Edition* by Michael E. Mortenson, Create Space Independent Publishing Platform (2010). ISBN-10: 1453728481

3. *The Complete Guide to Blender Graphics: Computer Modeling and Animation* by John M. Blain, A K Peters/CRC Press; 1st Edition (2012). ISBN-10: 1466517034
4. *Digital Modeling* by William Vaughan, New Riders; 1st Edition (2012). ISBN-10: 0321700899
5. *Blender Game Engine: Beginner's Guide* by bacone Victor kuller, Packt Publishing (2012). ISBN-10: 1849517029

Course Name: **Mobile Computing**
Credit Hours: 3
Prerequisites: **Internet Architecture & Protocols, Web Systems and Technologies**

Course Outline:

Introduction to Mobile Computing, Architecture of Mobile Software Applications, Mobile Development Frameworks and Tools. Creating Consumable Web Services for Mobile Devices. Memory Management. Mobile Applications. Mobile User-Interface Design. Dynamic Linking. Concurrency. Managing Resources. Introduction to Mobile Application Development with Android. Introduction to Mobile Application Development with IOS. Introduction to Mobile Application Development with Windows Phone. Introduction to Mobile Application Development with Blackberry.

Reference Materials:

1. *Programming Mobile Devices: An Introduction for Practitioners* by Tommi Mikkonen, Wiley; 1st Edition (March 19, 2007). ISBN-10: 0470057386.
2. *Professional Mobile Application Development* by Jeff McWherter & Scott Gowell, Wrox; 1st Edition (September 4, 2012). ISBN-10: 1118203909
3. *Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML* by Reza B'Far and Roy T. Fielding, Cambridge University Press (2004). ISBN-10: 0521817331.
4. *Fundamentals of Mobile and Pervasive Computing* by Frank Adelstein, Sandeep KS Gupta, Golden Richard III and Loren Schwiebert, McGraw-Hill Professional; 1st Edition (2004). ISBN-10: 0071412379.

Course Name: **Software Agents Technology**
Credit Hours: 3
Prerequisites: **Web Systems and Technologies**

Course Outline:

Basics of Intelligent Agents. Intelligent Agents Application. Desktop Agents. Internet Agents. Web search Agents, Information Filtering Agents, Personalized Newspaper, Offline Delivery Agents, URL-minder, Bargain Finder. Intranet Agents. Mobile Agents. Technology of Intelligent Agents. Agent Machinery. Agent Content. Agent Access. Agent Security. Developing Agent Applications.

Reference Materials:

1. *Intelligent Agent Source book* by Caglayan, Alper, John Wiley and Sons Ltd (1997). ISBN: 9780471153276
2. *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence* by Gerhard Weiss, The MIT Press (July 31, 2000). ISBN-10: 0262731312
3. *Design of Agent-Based Models* by Tomas Salamon, Tomas Bruckner (September 1, 2011). ISBN-10: 8090466117
4. *Intelligent Software Agents: Foundations and Applications* by Walter Brenner, Rüdiger Zarnekow, Hartmut Wittig and A.S. Rudd, Springer, (July 31, 2012). ISBN-10: 3642804861
5. *Agent Technology for E-Commerce* by Maria Fasli, Wiley; 1st Edition (March 6, 2007). ISBN-10: 0470030305.

Course Name: **E-Commerce Applications Development**
Credit Hours: 3
Prerequisites: **Web Technologies**

Course Outline:

An overview of e-Commerce & Models, Planning an e-Commerce Framework, Managing Products and Categories, Product Variations and User Uploads, Enhancing the User Experience, The Shopping Basket, The Checkout and Order Process, Shipping and Tax, Discounts, Vouchers, and Referrals, Checkout, Taking Payment for Orders, User Account Management, Administration: Dashboard, Managing Products and Categories, Managing Orders, Customers, Refunds, Voucher Codes, Shipping, Deploying, Security, and Maintenance, SEO.

Reference Materials:

1. *PHP 5 E-commerce Development* by Michael Peacock, Packt Publishing (January 20, 2010). ISBN-10: 184719964X
2. *Introduction to E-Commerce* by Jeffrey F. Rayport, McGraw-Hill, 2nd Edition (2007). ISBN-10: 0071232664
3. *E-Commerce* by Kenneth Laudon and Carol Guercio Traver, Prentice Hall; 8th Edition (2011). ISBN-10: 0138018812
4. *e-Business and e-Commerce How to Program* by Harvey M. Deitel, Paul J. Deitel and Tem R. Nieto, Prentice Hall; 1st Edition (2000). ISBN-10: 013028419X
5. *The Complete E-Commerce Book: Design, Build & Maintain a Successful Web-based Business* by Janice Reynolds, Cmp Books (2000). ISBN-10: 157820061X

Course Name: **Enterprise Application Development**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Object-Oriented Programming Review, Software Architectures Overview, Challenges and Platform of Enterprise Application Development, J2EE Scenarios, J2EE Platform Technologies, The Client Tier, The Web Tier, The Enterprise JavaBeans Tier, Integrating with the Enterprise Information System Tier, Packaging and Deployment, Transaction Management, Security, J2EE Internationalization and Localization, Architecture of the Sample Application.

Reference Materials:

1. *Designing Enterprise Applications with the J2EE™ Platform* by Inderjeet Singh; Beth Stearns; Mark Johnson; 2nd Edition, Prentice Hall (March 25, 2002). Print ISBN-10: 0-201-78790-3
2. *Mastering Enterprise JavaBeans 3.0* by Sriganesh, R.P., Brose, G., And Silverman, M. Wiley Publishing, Indianapolis, (2006). ISBN 0-471-78541-5.
3. *Core J2EE Patterns: Best Practices and Design Strategies* by Deepak Alur, Dan Malks and John Crupi, Prentice Hall; 2nd Edition (May 10, 2003). ISBN-10: 0131422464
4. *Sun Certified Enterprise Architect for Java EE Study Guide* by Mark Cade and Humphrey Sheil, Prentice Hall; 2nd Edition (February 8, 2010). ISBN-10: 0131482033

Course Name: **Distributed Computing**
Credit Hours: 3
Prerequisites: **Web Systems and Technologies**

Course Outline:

Centralized and Decentralized Systems, Taxonomy Dependency Considerations. Discovery Protocols. Structured Document Types. Distributed Security Techniques. Hash Functions. Digital Signature, Secure Channels, Secure Mobile Code. The Web as Distributed Environment: URI Templates, HTTP and Security, Representational State Transfer, The Semantic Web. Peer-2-Peer Environments. Volunteer Computing. Web Services: Architecture and Development, Service-Oriented Architecture. Distributed Objects and Agent Technologies. Grid Computing. P2P Applications Protocols and Architectures. Freenet. Middleware Protocols and Architectures. Web Services Protocols. Distributed Object Deployment Using Jini. P2P Deployment Using Jxta. Web Services Deployment.

Reference Materials:

1. *From P2P and Grids to Services on the Web: Evolving Distributed Communities* by Ian J. Taylor Ian J. Taylor and Andrew Harrison, Springer; 2nd Edition (November 14, 2008). ISBN-10: 1848001223.
2. *Peer-to-Peer : Harnessing the Power of Disruptive Technologies* by Andy Oram, O'Reilly Media; 1st Edition (March 15, 2001)
3. *Structured Peer-to-Peer Systems: Fundamentals of Hierarchical Organization, Routing, Scaling, and Security* by Dmitry Korzun and Andrei Gurtov, Springer, (November 12, 2012).
4. *From P2P to Web Services and Grids* by Ian Taylor, Springer-Verlag, 2005, ISBN: 1-85233-869-5.

Course Title: **Mobile Application Development**
Credit Hours: 3
Prerequisites: **Web Technologies**

Course Outline:

What is Android? Installing and Configuring the Android SDK Manager, Creating Android Application, Anatomy of an Android Application. 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. Presisting Data. Sharing Data. Sending SMS Messages. Getting Feedback. Sending E-mail. Displaying Maps, Consuming Web Services Using HTTP, Accessing Web Services. Creating Services. Threading. Android games Development, Publishing Android Applications. Handling Telephone Calls, Fonts.

Reference Materials:

1. *Beginning Android 4 Application Development* by Wei-Menge Lee, John Wiley & Sons, 2012
2. *Beginning Android 4* by Grant Allen, Apress, (2011), ISBN: *1430239840.*
3. *Beginning Android games* by Mario Zechner, Apress, (2011), ISBN: 1430230428
4. *Pro Android 4* by Satya Komatineni and Dave MacLean, (2012), ISBN:1430239301 Apress
5. *Professional Android 4 Application Development* by Reto Meier, Wiley, (2012), ISBN:1118237226

Course Name: **Web Engineering**
Credit Hours: 3
Prerequisites: **Web Systems and Technologies**

Course Outline:

An Introduction to Web Engineering. Requirements Engineering for Web Applications. Web Applications Modeling. Web Application Architectures. Technology-away Web Application Design. Technologies for Web Applications. Testing Web Applications. Operation and Maintenance of Web Application. Web Project Management. Web Application Development Process. Usability of Web Applications. Performance of Web Applications. Security for Web Applications. The Semantic Web.

Reference Materials:

1. *Web Engineering: The Discipline of Systematic Development of Web Applications* by Gerti Kappel, Birgit Pr ¨ oll, Siegfried Reich, Werner Retschitzegger, Springer; Softcover reprint of hardcover 1st Edition. 2008 Edition (December 10, 2010). ISBN-10: 184996677X
2. *Web Engineering* by Emilia Mendes and Nile Mosley, Springer; Softcover reprint of hardcover 1st Edition. 2006 Edition (November 9, 2010). ISBN-10: 3642066453
3. *Web Engineering: A Practitioner's Approach* by Roger Pressman and David Lowe, McGraw-Hill Science/Engineering/Math; 1st Edition (January 22, 2008). ISBN-10: 0073523291
4. *Web Application Architecture: Principles, Protocols and Practices* by Leon Shklar and Rich Rosen, Wiley; 2nd Edition (May 5, 2009). ISBN-10: 047051860X
5. *Web Engineering* by Emilia Mendes and Nile Mosley, Springer; Softcover reprint of hardcover 1st Ed. 2006 Edition (November 9, 2010). ISBN-10: 3642066453
6. *W3C Online Resources.*

Course Name: **Data Warehousing**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Data Warehousing: History, Characteristics, Architecture, Data Staging and ETL, Multi-Dimensional Model, Meta-data, Accessing Data Warehouse. Data Warehouse System Lifecycle. Risk Factors, Data Mart Design Phases, Methodological Framework. Testing Data Marts. Analysis and Reconciliation of Data Sources. User Requirement Analysis. Conceptual Modeling. Conceptual Design. Workload and Data Volume. Logical Modeling: MOLAP and HOLAP Systems, ROLAP Systems, Views, Temporal Scenarios. Logical Design. Data-staging Design: Population Reconciled Databases, Cleansing Data, Populating Dimensional Tables, Populating Fact Tables, Populating

Materialized View. Indexes for the Data Warehouse: B*-Tree Indexes, Bitmap Indexes, Projection Indexes, Join & Star Indexes, Spatial Indexes, Join-Algorithm. Physical Design: Optimizers, Index Selection, Splitting a Database into Tablespaces, Allocating Data Files, Disk Block Size. Data Warehouse Project Documentation: Data Warehouse Levels, Data Mart Level, Fact Level. Case Studies and Tools for Data Warehousing.

Reference Materials:

1. *Data Warehouse Design: Modern Principles and Methodologies* by Matteo Golfarelli and Stefano Rizzi, McGraw-Hill Osborne Media; 1st Edition (May 26, 2009). ISBN-10: 0071610391
2. *Building the Data Warehouse* by William H. Inmon, Wiley; 4th Edition (2005). ISBN-10: 0764599445
3. *The Data Warehouse Lifecycle Toolkit : Expert Methods for Designing, Developing, and Deploying Data Warehouses* by Ralph Kimball, Laura Reeves, Margy Ross and Warren Thornthwaite, Wiley (August 13, 1998). ISBN-10: 0471255475
4. *Data Warehousing Fundamentals for IT Professionals* by Paulraj Ponniah, Wiley; 2nd Edition (2010). ISBN-10: 0470462078

Course Name: **Data Mining**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Data-Mining Concepts, Preparing the Data, Data Reduction, Learning From Data, Statistical Methods, Decision Trees and Decision Rules, Artificial Neural Networks, Ensemble Learning, Cluster Analysis, Association Rules, Web Mining and Text Mining, Genetic Algorithms, Fuzzy Sets and Fuzzy Logic, Visualization Methods, Data Mining Tools: Weka, CBA and Yale, etc.

Reference Materials:

1. *Data Mining: Concepts, Models, Methods, and Algorithms* by Mehmed Kantardzic, Wiley-IEEE Press; 2nd Edition (August 16, 2011). ISBN-10: 0470890452
2. *Data Mining: Concepts and Techniques, Third Edition (The Morgan Kaufmann Series in Data Management Systems)* by Jiawei Han, Micheline Kamber and Jian Pei, Morgan Kaufmann; 3rd Edition (2011). ISBN-10: 0123814790
3. *Principles of Data Mining (Adaptive Computation and Machine Learning)* by David J. Hand, Heikki Mannila and Padhraic Smyth, A Bradford Book (August 1, 2001). ISBN-10: 026208290X

Course Name: **Business Intelligence and Analytics**
Credit Hours: 3
Prerequisites: **Data Warehousing, Data Mining**

Course Outline:

Business Intelligence Introduction, BI Environment, Business Process and Information Flow, Data Requirements Analysis, Data Warehouses and the Technical BI Architecture, Data Profiling, Business Rules, Data Quality, Data Integration, Deriving Insight from Data, Knowledge Discovery & Delivery, BI User Types and Reports, Installations, Configuring and Maintaining the BI Server, Creating Repositories from Relational Sources, Creating Repositories from OLAP Data Sources, Creating Reports Using Answers and Dashboards.

Reference Materials:

1. *Business Intelligence by David Loshi, Morgan Kaufmann; 2nd Edition (October 31, 2012). ISBN-10: 0123858895*
2. *Delivering Business Intelligence with Microsoft SQL Server 2012 3/E by Brian Larson, McGraw-Hill Osborne Media; 3rd Edition (March 16, 2012). ISBN-10: 0071759387*
3. *The Data Warehouse Mentor: Practical Data Warehouse and Business Intelligence Insights, by Robert Laberge, 1st Edition, McGraw-Hill Companies, (2012). ASIN: B008UYJJ8C*
4. *Business Intelligence: A Managerial Approach by Turban, Sharda, Delen, King, 2nd Edition, Prentice Hall (2011). ISBN: 13-978-0-136-10066-9*
5. *Business Intelligence in Plain Language: A practical guide to Data Mining and Business Analytics by Jeremy Kolb, Applied Data Labs Inc. (2012). ASIN: B009K7INOY*

Course Title: **Distributed Database Systems**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Distributed Data Processing, Distributed Database Systems, Design Issues, Distributed DBMS Architecture. Distributed Database Design. Database Integration. Data and Access Control. Query Processing. Query Decomposition and Data Localization. Optimization of Distributed Queries. Multidatabase Query Processing. Transaction Management. Distributed Concurrency Control. Distributed DBMS Reliability. Data Replication.

Reference Materials:

1. *Principles of Distributed Database Systems* by M. Tamer Özsu and Patrick Valduriez, Springer, 3rd Edition, (March 2, 2011). ISBN-10: 1441988335

2. *Distributed Database Management Systems: A Practical Approach* by Saeed K. Rahimi, and Frank S. Haug, Wiley-IEEE Computer Society Pr; 1st Edition (May 23, 2011). ASIN: B005CDYQSC
3. *Distributed Systems: Principles and Paradigms* by Andrew S. Tanenbaum and Maarten van Steen, Prentice Hall; US Edition (January 15, 2002). ISBN-10: 0130888931
4. *Distributed Systems: Concepts and Design* by Jean Dollimore, Tim Kindberg and George Coulouris, Addison Wesley; 4th Edition (May 20, 2005). ISBN-10: 0321263545
5. *Distributed Database Systems* by Chhanda Ray, Pearson (October 3, 2012). ASIN: B009NEMZ0W

Course Name: **Enterprise Resource Planning Systems**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Introduction to Enterprise Resource Planning Systems. ERP Technology. ERP and Business Process Reengineering. Systems Diagramming and the Process Map. ERP Life Cycle: Planning and Package Selection. ERP Life Cycle: Implementation and Operation and Maintenance. ERP Sales, CRM and Knowledge Management. ERP Financials. Human Capital Management, Self-Service and Outsourcing. Manufacturing Systems and Supply Chain. Auditing ERP. Business Intelligence and Performance Management.

Reference Materials:

1. *Modern ERP: Select, Implement & Use Today's Advanced Business Systems* by Marianne Bradford, lulu.com (October 19, 2009). ISBN-10: 0557012910.
2. *Managerial Issues of Enterprise Resource Planning Systems* by David Olson, McGraw-Hill/Irwin; 1st Edition (September 10, 2003). ISBN-10: 0072861126
3. *Enterprise Resource Planning* by Bret Wagner by Ellen Monk, Course Technology; 3rd Edition (February 4, 2008). ISBN-10: 1423901797
4. *ERP Systems* by Dimpi Srivastava and Aarti Batra, I K International Publishing House (February 15, 2010). ISBN-10: 9380578148

Course Name: **Information Systems Auditing and Assurance**
Credit Hours: 3
Prerequisites: **Information Systems**

Course Outline:

Introduction to Auditing, Assurance and Internal Control, IT Governance and Management, Organization Structure and Responsibilities, Business Continuity Planning, Auditing IT Governance, The Audit Process, Internal Controls, IT Life Cycle Management, Infrastructure Development and

Implementation, Maintaining Information Systems, Business Processes, Application Controls, Auditing the Software Development Life Cycle, Auditing Business Controls, Auditing Application Controls, IT Service Delivery and Infrastructure, Disaster Recovery Planning, Information Asset Protection, Network Security Controls, Over view of Popular Methodologies, Framework and Guidelines, Overview of Computer-Assisted Audit Tools and Techniques.

Reference Materials:

1. *Information Systems Auditing and Assurance* by James A. Hall and Tommie Singleton, South-Western College Pub; 2nd Edition (July 27, 2004). ISBN-10: 0324191995
2. *CISA® Certified Information Systems Auditor All-in-One Exam Guide* By: Peter Gregory, McGraw-Hill Osborne Media; 2nd Edition (August 9, 2011). ISBN-10: 0071769102
3. *Information Technology Control and Audit, 3rd Edition* by Sandra Senft and Frederick Gallegos, Auerbach Publications; 3rd Edition (2008). ISBN-10: 1420065505
4. *Managing the Audit Function: A Corporate Audit Department Procedures Guide* by Michael P. Cangemi and Tommie W. Singleton, Wiley; 3rd Edition (2003). ISBN-10: 0471281190

Course Name: **Business Process Management**
Credit Hours: 3
Prerequisites: **Object Oriented Analysis and Design**

Course Outline:

Introduction d BPM, Motivation and Definitions, Business Process Lifecycle, Classification of Business Processes, Goals, Structure, and Organization. Evolution of Enterprise Systems Architectures. Business Process Modeling. Process Orchestrations. Process Choreographies. .Modeling in BPMN. Properties of Business Processes. Workflow Management Architectures, Flexible Workflow Management, Web Services and their Composition, Advanced Service Composition, Data-Driven Processes. Business Process Management Methodology.

Reference Materials:

1. *Business Process Management: Concepts, Languages, Architectures* by Mathias Weske, Springer; 2nd Edition (May 3, 2012). ISBN-10: 3642286151.
2. *Business Process Management Common Body of Knowledge* by Yvonne Lederer Antonucci, et. al., CreateSpace Independent Publishing Platform (March 8, 2009). ISBN-10: 1442105666
3. *Process Management: A Guide for the Design of Business Processes* by Jörg Becker, Martin Kugeler and Michael Rosemann, Springer; 2nd Edition (January 21, 2011). ISBN-10: 3642151892

4. *Business Process Management, 2nd Edition: Practical Guidelines to Successful Implementations* by John Jeston and Johan Nelis, Butterworth-Heinemann; 2nd Edition (March 24, 2008). ISBN-10: 0750686561

Course Name: **Knowledge Management**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

History and paradigms of knowledge management. Types of knowledge. Knowledge Revolution, Globalization, Knowledge Economy, Knowledge Workers, Knowledge Artifacts, Knowledge Agents. Knowledge Management: Definitions, Knowledge management Cycles, Benefits of KM, Implications for KM, KM Core Competencies. KM Processes: Discovery/Detection, Capture and Codification, Organization, Sharing, transfer, Acquisition, Verification, Utilization, Creation, Reuse. KM Frameworks and Models. KM Frameworks and Models. Knowledge Capture and Codification. Knowledge Codification. Knowledge Taxonomies. Relationships among Knowledge Management, Competitive Intelligence, Business Intelligence, and Strategic Intelligence. Strategic and Practical Implications of Knowledge Capture and Codification. Knowledge Sharing and Communities of Practice. Knowledge Application. The Role of Organizational Culture. Knowledge Management Tools. Knowledge Management Strategy. The Value of Knowledge Management. Organizational Learning and Organizational Memory. The KM Team. The KM Profession, the Ethics of KM**.**

Reference Materials:

1. *Essentials of Knowledge Management: Concepts, Theories and Practices* by M. A. Pasha & S. Pasha, Innovators Knowledge Services (2012). ISBN:978-969-9791-04-8
2. *Knowledge Management In Theory And Practice* by Kimiz Dalkir, The MIT Press; 3rd Edition (March 4, 2011). ISBN-10: 0262015080
3. *The Knowledge Management Toolkit: Orchestrating IT, Strategy, and Knowledge Platforms* by Amrit Tiwana, Prentice Hall; 2nd Edition (August 29, 2002). ISBN-10: 013009224X
4. *Principles of Knowledge Management: Theory, Practice and Cases* by Elie Geisler and Nilmini Wickramasinghe, M. E. Sharpe (January 15, 2009). ISBN-10: 0765613220
5. *Knowledge Management: Concepts, Methodologies, Tools and Applications* (6-volume set) by Murray E. Jennex, IGI Global; Reprint Edition (August 10, 2007). ISBN-10: 1599049333

Course Name: **Artificial Intelligence**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

Introduction to AI, Turing Test, Strong AI vs Weak AI, Heuristics, Applications and Methods, History of AI. Uninformed Search: Search in IS, Generate-and-Test Paradigm, Blind Search Algorithm. Informed Search: Heuristics, The Best-First Search, The Beam Search, The A* Search, The Bidirectional Search. Search Using Game: Game Trees and Minimum, Game Theory. Logic in AI: Logic and Representation, Propositional Logic, Predicate Logic, Other Logics. Knowledge Representation: Search Tree, Production System, Objects, Frames, Scripts & the Conceptual Dependency System, Semantic Networks, Recent Approaches, Agents. Prolog Programming. Production Systems: Strong Methods vs. Weak Methods, Production System and Inference Methods, Stochastic Processes and Markov Chain. [Uncertainty in AI: Fuzzy Sets, Fuzzy Logic, Fuzzy Inference, Probability Theory and Uncertainty. [Expert Systems: Characteristics of ES, Knowledge Engineering, Knowledge Acquisition, Classical ES, Case-Based Reasoning. Neural Networks: Introduction, The Perceptron Learning Rule, Back propagation, Discrete Hopfield Networks, Application Areas. Evolutionary Computation: Simulated Annealing, Genetic Algorithms, Genetic, Genetic Programming. Natural Language Processing: History of NLP, Syntax and Formal Grammars, Syntax and Formal Grammar, Statistical Parsing, Hidden Markov Model, Wordnet, Question Answering System. Automated Planning: Planning Terminology, Planning as Search, Hierarchical Planning, Case-Based Planning, Planning Approaches to Learning System. Advanced Computer Games: Rote Learning and Generalization, Signature Table and Book Learning, Programing Methods, Search in Machines.

Reference Materials:

1. *Artificial Intelligence in the 21st Century by Stephen Lucci* by Danny Kopec, Mercury Learning and Information (May 18, 2012). ISBN-10: 1936420236
2. Artificial Intelligence: A Modern Approach, 2nd Edition, by Russell and Norvig, Prentice Hall
3. *Artificial Intelligence: A Systems Approach* by M. Tim Jones, Jones and Bartlett Publishers, Inc; 1st Edition (December 26, 2008). ISBN-10: 0763773379.

Course Name: **Formal Methods in Software Engineering**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

Introduction to Formal methods, Introducing Z, Elements of Z, Logic, Using Predicates in Z, Schemas and Schema Calculus, Formal Reasoning, Case Studies in Z, Computer Graphics and Computational Geometry. Rule-Based Programming, Graphical User Interface, Safety-Critical Protection System, Modeling Large Systems, Object-Oriented Programming Model and Z, Concurrency and Real-time, Refinement, Program Derivation and Formal Verification, Converting Z into Code.

Reference Materials:

1. *The Way of Z: Practical Programming with Formal Methods* by Jonathan Jacky, Cambridge University Press (November 28, 1996). ISBN-10: 0521559766
2. *Z: An Introduction to Formal Methods* by Antoni Diller, Wiley; 2nd Edition (July 27, 1994). ISBN-10: 0471939730
3. *Model Checking* by Edmund M. Clarke Jr., Orna Grumberg, Doron A. Peled , MIT Press, 1st Edition (1999). ISBN-13: 978-0262032704.
4. *Reactive Systems: Modelling, Specification and Verification* by Luca Aceto, Anna Ingólfsdóttir, Kim Guldstrand Larsen and Jiri Srba, Cambridge University Press (August 13, 2007). ISBN-10: 0521875463
5. *Fundamentals of Algebraic Specifications: Equations and Initial Semantics*, H. Ehrig & B. Mahr, Springer-Verlag (1985), ISBN 0-387-13718-1.
6. *Systems and Software Verification: Model-Checking Techniques and Tools*. By B. Berard, M. Bidoit, A. Finkel, F. Laroussinie, A. Petit, L. Petrucci, and P. Schnoebelen, Springer, 1st Edition , 2001. ISBN-10: 3642074782
7. *Algebraic Specifications in Software Engineering* by I. Van Horebeek & J. Lewi, Springer; 1st Edition (December 19, 1989). ISBN-10: 3540516263

Course Name: **Software Requirements Engineering**
Credit Hours: 3
Prerequisites: **Intro. to Software Engineering**

Course Outline:

Basics of Requirements Engineering. RE Processes. Requirements Analyst Role, Tasks, Essential Skills & Knowledge. Dealing with Customers. Prototype Categories. Evaluation, Risks, Validating the Requirements. Documenting the Requirements. Non Functional Requirements. Software Quality Attributes. Setting Requirements Priorities. Special Requirements Challenges. Requirements Development Plans. Requirements Management Principles and Practices. Requirements Creeping. Tracing Requirements.

Tools for Requirements Management. Software Requirements Risk Management.

Reference Materials:

1. *Requirements Engineering: Processes and Techniques, Kotonya and Sommerville*, John Wiley Sons, 1998. ISBN-10: 0471972088
2. *Software Requirements Engineering, 2nd Edition* by Richard H. Thayer and Merlin Dorfman, Wiley-IEEE Computer Society Pr; 2nd Edition (1997). ISBN-10: 0818677384
3. *Requirements Engineering: From System Goals to UML Models to Software Specifications* by A. van Lamsweerde, Wiley; 1st Edition (2009). ISBN-10: 0470012706.
4. *Requirements Engineering: Fundamentals, Principles, and Techniques* by Klaus Pohl, Springer; 1st Edition (July 23, 2010). ISBN-10: 3642125778
5. *Requirements Engineering* by Hull, Jackson, and Dick, Springer; 3rd Edition (October 11, 2010). ISBN-10: 1849964041
6. *Software Requirements 2* by Karl Wiegers, 2nd Edition (2003). Microsoft Press; ISBN-10: 0735618798

Course Name: **Software Design and Architecture**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Basics of Software Architecture (SA). Characteristics of SA, Importance of SA, SA Business Cycle and Software Processes, Architectural Patterns. SA Case Study. Creating Architecture, Quality Attributes, Business Qualities, Architecture Qualities. Achieving Qualities. Global Analysis. Conceptual Architecture View. Module Architecture View. Execution Architecture View. Code Architecture View. Designing & Documenting the Architecture. Analyzing Architectures. The CBAM. Reconstructing Software Architectures.

Reference Materials:

1. *Applied Software Architecture* by Christine Hofmeister, Robert Nord and DilipSoni, Addison-Wesley Professional (1999). ISBN-10: 0201325713.
2. *Software Architecture in Practice* by Len Bass, Paul Clements and Rick Kazman, Addison-Wesley Professional; 2nd Edition (April 19, 2003). ISBN-10: 0321154959
3. *Software Architecture in Practice* by Len Bass, Paul Clements and Rick Kazman, Addison-Wesley Professional; 3rd Edition (2012). ISBN-10: 0321815734
4. *Software Architecture and Design Illuminated* by Kai Qian, Xiang Fu, Lixin Tao and Chong-weiXu, Jones & Bartlett Publishers; 1st Edition (2009). ISBN-10: 076375420X

5. *Software Architecture: Foundations, Theory, and Practice* by R. N. Taylor, N. Medvidovic and E. M. Dashofy, Wiley; 1st Edition (2009). ISBN-10: 0470167742.

Course Name: **Software Quality Engineering**
Credit Hours: 3
Prerequisites: **Intro. to Software Engineering**

Course Outline:

A Quality Principles, Benefits of Quality, Organization and Process Benchmarking. Ethical and Legal Compliance. Standards and Models. Leadership Skills. Quality Management System. Methodologies for Quality Management. Audit Types, Audit Roles and Responsibilities, Audit Process. Project Tracking and Control, Tracking Methods, Project Reviews and Program Reviews. Software Verification and Validation Method, Software Product Evaluation. Testing Planning and Design. Reviews and Inspection. Test Execution Documentation. Customer Deliverables. Configuration Control and Status Accounting.

Reference Materials:

1. *The Certified Software Quality Engineer* by Linda Westfall, Quality Press; (September 28, 2009), ISBN-10: 0873897307
2. *Software Quality Assurance: Principles and Practice* by Nina S. Godbole, published by Alpha Science (2004). ISBN-10: 1842651765.
3. *Software Testing: Fundamental Principles and Essential Knowledge* by James D. McCaffrey, Book Surge Publishing (2009). ISBN-10: 1439229074.
4. *Perfect Software: And other illusions about testing* by Gerald M. Weinberg, published Dorest House (2008). ISBN-10: 0932633692.
5. *Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement* by Jeff Tian, published by John Wiley & sons, (2005). ISBN-10: 0471713457
6. *Mastering Software Quality Assurance: Best Practices, Tools and Techniques for Software Developers* by Murali Chemuturi, J. Ross Publishing (2010). ISBN-10: 1604270322.

Course Name: **Software CASE Tools & Applications**
Credit Hours: 3
Prerequisites: **Intro. to Software Engineering**

Course Outline:

Introduction to CASE, Types of CASE Tools. Approaches CASE Tool Integration. Integration as a Design Activity. Service Based Model of a CASE Environment. Properties and Types of Integration Mechanism. The Role of Process in Integrated CASE Environments. Examples of Process and CASE Tool Interactions. Replacing the Message Service in a CASE Integration

Framework. Integration of CASE Tools with CM Systems. Case Environments in Practice. Object-Oriented Analysis & Design Modeling. Design Reuse, E-Commerce, ISO. Comparison of Popular CASE Tools. Practice Real Life Problem for Development Through CASE Tools.

Reference Materials:

1. *Principles of CASE Tool Integration* by Alan W. Brown, Oxford University Press, USA; 1st Edition, (September 1, 1994)ISBN-10: 0195094786
2. *Computer Aided Software Engineering* by Hausi A. Muller, Ronald J. Norman and Jacob Slonim, Springer; Softcover reprint of the original 1st Edition 1996 (September 27, 2011). ISBN-10: 1461286263.
3. Most popular software CASE tool documentation

Course Name: **Software Construction**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Introduction to Software Construction. Importance of Prerequisites of Target Software. Key Construction Decisions: Choice of Programming Language, Programming Conventions, Localization Aspects of Technology, Selection of Construction Practices. Design in Software Construction. Design Building Blocks. Defensive Programming. The Software-Quality Considerations. Collaborative Construction. Refactoring. Program Size & Software Construction. Managing Software Construction. Integration. Programming Tools. Layout and Style. Self-Documenting Code.

Reference Materials:

1. *Code Complete: A Practical Handbook of Software Construction* by Steve McConnell, Microsoft Press; 2nd Edition (July 7, 2004). ISBN-10: 0735619670
2. *Compiler Construction (International Computer Science Series)* by Niklaus Wirth, Addison-Wesley Pub (Sd); (1996). ISBN-10: 0201403536.
3. *Object-Oriented Software Construction (Book/CD-ROM) (2nd Edition)* by Bertrand Meyer, Prentice Hall; 2nd Edition (2000). ISBN-10: 0136291554.
4. *The Design of Well-Structured and Correct Programs*, S. Alagic & M. A. Arbib, Springer-Verlag (1978), ISBN 0-387-90299-6.
5. *Object-Oriented Software Construction*, by Bertrand Meyer, 2nd Edition, Published by, Prentice Hall in 1997. Prentice Hall; 2nd Edition (March 21, 2000). ISBN-10: 0136291554

Course Name: **Software Engineering Economics**
Credit Hours: 3
Prerequisites: **Intro. to Software Engineering/Software Construction**

Course Outline:

The Software Life-Cycle. The Waterfall Model. The Software Work Breakdown Structure (WBS) Software Maintenance. The Basic COCOMO

Model. Development Modes. Model-Product Level Estimates. Performance Models & Cost Effectiveness Models. Decision Criteria. Present vs. Future Expenditure & Income - Cost Analysis. Goals as Constraints. Coping with Un-reconcilable & Un-quantified Goals. Statistical Decision Theory-The Value of Information. Alternative Software Cost Estimation Methods. Detailed COCOMO. Detailed COCOMO Cost Drivers. Detailed COCOMO Cost Drivers-Personal Attributes: ACAP, AEXP, PCAP, VEXP, LEXP. Detailed COCOMO Cost Drivers: Project Attributes–Modern Programming Practices, Use of Software Tools, Schedule Constraint.

Reference Materials:

1. *Software Engineering Economics* by Boehm, Prentice Hall, 1981.ISBN-10: 0138221227
2. *Estimating Software Costs: Bringing Realism to Estimating* by Capers Jones, McGraw-Hill Osborne Media; 2nd Edition (April 19, 2007).ISBN-10: 0071483004
3. *Software Cost Estimation with COCOMO II* by Barry W. Boehm, Chris Abts, A. Winsor Brown and Sunita Chulani, Prentice Hall (August 11, 2000). ISBN-10: 0130266922.
4. *Software Cost Estimation and Sizing Methods, Issues, and Guidelines* by Shari Lawrence Pfleeger, Rand Publishing (September 13, 2005). ISBN-10: 0833037137.
5. *Software Engineering Economics and Declining Budgets* by Pamela T. Geriner, Thomas R. Gulledge, William P. Hutzler, Springer London, Limited, 31-Jul-2012

Course Name: **Design Patterns**
Credit Hours: 3
Prerequisites: **Programming Fundamental**

Course Outline:

Overview of Object-oriented design, Overview of UML & OCL. Introduction to design patterns. Coupling and Cohesion. Why design patterns? Creational patterns: Singleton, Abstract Factory, Builder, Prototype. Structural patterns: Facade, Composite, Bridge, Proxy, Adapter, Decorator. Behavioural patterns: Chain of responsibility, Visitor, Observer, Iterator, Command, Mediator, Strategy, Interpreter, Memento. Patterns for concurrent and distributed systems: Event handling patterns. Synchronization and Concurrency patterns. Concurrency Controller pattern. Antipatterns: Common pitfalls and antipattern examples, Recovering from bad designs, **Refactoring to patterns. Introduction to Aspect-Oriented design: Aspects, themes, concerns**.

Reference Materials:

1. *Design Patterns: Elements of Reusable Object Oriented Software*, E. Gamma, R. Helm, R. Johnson, and J. Vlissides, Addison -Wesley Professional, 1995
2. *Java Design Pattern Essentials* by Tony Bevis, Ability First Limited; 2nd Edition (October 11, 2012). ISBN-10: 0956575846

3. *Patterns in Java: A Catalog of Reusable Design Patterns Illustrated with UML* by Mark Grand, 2nd Edition, Volume 1, Wiley, 2002. ISBN-10: 0471227293
4. *Object-Oriented Software Engineering: Using UML, Patterns, and Java* by B. Bruegge and A. H. Dutoit, 2nd Edition , Prentice Hall, 2003. ISBN-10: 0136061257.
5. *Refactoring to Patterns* by J. Kerievsky, Addison-Wesley, 2004. ISBN-10: 0321213351.

Course Title: **Service-Oriented Architecture**
Credit Hours: 3
Prerequisites: **Programming Fundamentals**

Course Outline:

Introducing SOA. Web Services & Primitive SOA. Web Services & Contemporary SOA (Activity Management & Composition). Web Services & Contemporary SOA *(Advanced Messaging, Metadata & Security).* Principles of Service-Orientation. Service Orientation & Contemporary SOA. SOA Delivery Strategies. Service Oriented Analysis. Service Modelling (Process). Service Oriented Design. WSDL-Related XML Schema Language. SOAP Language Basic, Service Interface Design Tools. Service Oriented Design Steps to Composing SOA. Considerations for Choosing Service Layers, Considerations for Positioning Core SOA Standards (Industry Standards, & SOA, XML & SOA, The WS-I Baisc Profile, WDSL & SOA, XML Schema & SOA, SOAP & SOA, Namespaces & SOA, UDDI & SOA) Considerations for Choosing SOA Extensions (Choosing SOA Characteristics, Choosing WS* Specifications, WS-BPEL & SOA). Entity Centric Business Service Design, Application Service Design, Service Design Guidelines.

Reference Materials:

1. *Service-Oriented Architecture (SOA): Concepts, Technology, and Design* by Thomas Erl, Prentice Hall (August 12, 2005). ISBN-10: 0131858580
2. *Service-Oriented Architecture (SOA): Concepts, Technology, and Design* by Thomas Erl, Prentice Hall (August 12, 2005). ISBN-10: 0131858580
3. *SOA Design Patterns* by Thomas Erl, Prentice Hall PTR; 1st Edition (January 9, 2009)
4. *Service-Oriented Architecture (SOA): A Planning and Implementation Guide for Business and Technology* by Eric A. Marks and Michael Bell, Wiley; 1st Edition (April 28, 2006). ISBN-10: 0471768944
5. *Applied SOA: Service-Oriented Architecture and Design Strategies* by Michael Rosen, Boris Lublinsky, Kevin T. Smith and Marc J. Balcer, Wiley; 1st Edition (June 16, 2008). ISBN-10: 0470223650.

Course Name: **Computer Graphics**
Credit Hours: 3
Prerequisites: **Discrete Structures**

Course Outline:

Computer Graphics Introduction, Data, Images, and Computer Graphics, Application of computer Graphics. Geometry, Transformations and Computer Graphics. Plane Rotations. Colour in the Physical Universe. Colour Systems and Computer Graphics. Image Abstraction Paradigms. Graphics and Planar Graphics Objects. Digital Geometry Processing. Objects Hierarchy. Modeling and Representation. Classification, Partitioning, and Clipping. Visibility and Algorithms. The Nature of light. Illumination. Sampling and Ray Tracing. Mapping Graphics Objects.

Reference Materials:

1. *Computer Graphics: Theory and Practice* by Jones Gomes, CRC Press, 2012, ISBN-10: 1568815808
2. *Computer Graphics with Open GL (4th Edition)* by Donald D. Hearn, Prentice Hall, 4th Edition, 2010, ISBN-10: 0136053580
3. *Introduction to Computer Graphics: Using Java 2D and 3D*, Springer, 2nd Edition, 2012, ISBN-10: 1447127323.

Curriculum for MS Information Technology MS (IT)

Program's Rationale:

A high pace of innovations in technologies for communication, computation, interactivity, and delivery of information introduced invention like *the Internet, the World Wide Web, email, bulletin board system, virtual communities, E-commerce*, and other online technologies. These inventions brought a paradigm shift in business world - from data processing to information processing - converting industrial society to an "information society." This paradigm shift not only affected the way scientists conduct their research but also expedite the pace of inventions. As a result Computing becomes a rapidly progressing domain. In recent years, many significant developments have been made and many new concepts have been introduced. For example, "Computational Lens" which articulates a new relationship between computer science and other sciences, "Ternary Computing" dealing with computing for the masses, "e-Science" managing massive experimental data and collaborating via the Net, "Computational Thinking", "Cloud Computing", "Biological Computing", etc. In parallel, the integration of computing in other disciplines introduces new disciplines such as "Computational - x" (e.g., computational mathematics, computational physics, computational finance, etc.) and "x - Informatics" (e.g., bio-informatics, dental-informatics, clinical-informatics, health-informatics, etc.). Many such developments compel IT graduates to update their knowledge to meet the needs of the time. One of the key rationales behind MS(IT) program is the development of a dynamic curricula structure that allows IT graduates to gain a broad technical understanding of current and evolving technologies in the IT field with an emphasis on moving technology from the laboratory to the realm of business development through offering Breadth-Based, Depth-Based, and Integrated Breadth & Depth-Based courses. Students may choose a particular option, which is the most appropriate to their planned future career. Through offering these options, the program develops technically competent, highly productive, and self-motivated professionals in tune with the demands of an ever changing market. The program will groom not only IT professionals, but also experts from other domains offering a unique and comprehensive body of knowledge that exposes the learners to a practical application of information technology within an area of specialization.

Programme Aim:

MS (IT) Programme is aimed to create, expand, disseminate and teach the information technology body of knowledge through academics, applications and research which positively impact society locally, nationally, and internationally.

Programme Objectives:

One of the key objectives of the programme is to produce well rounded individuals who are productive and responsible members of society familiar with the technical concepts and practices in the computing & information technology domains. The program provides graduates with competency and knowledge to take on appropriate professional roles in information technology industry or to pursue further education. Following are the key objectives of the program:

1. Use and apply current technical concepts and practices in the core information technologies.
2. Analyze, identify and define the requirements that must be satisfied to address problems or opportunities faced by individuals or organizations.
3. Identify and evaluate current and emerging technologies and assess their impact on individuals, organizations and society; including ethical, legal and policy issues.
4. Demonstrate independent critical thinking and problem solving skills.
5. Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation.
6. Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology.
7. Recognize the need for continued learning throughout career.

Program Structure:

The Program is designed for full-time students. The program comprises of 33 Cr. Hrs. with 4 core courses, 4 elective courses, and a research thesis of 9 Cr. Hrs. The dynamic structure of the program allows students to choose a particular option, which is the most appropriate for planned future career. Followings are the program details:

Eligibility Criteria:

1. BS (IT/CS/SE) 4 years degree program or equivalent (minimum 130 Cr. Hrs. with minimum 2.5 CGPA on scale 4.0 or 60% marks);
   OR
2. Computer Science conversion course two years degree program referred to as MCS or M.Sc. (CS) or M. Sc. (IT), (minimum 2.5 CGPA of scale 4.0 or 60% marks);
   OR
3. BCS 3-year program degree applicants may be provisionally admitted in the MS (IT) program. Candidates will be required to take additional courses to complete credit hours requirement of minimum 130 Cr. Hrs. before being formally enrolled in the MS (IT) program.
   Under eligibility criteria 1-3, the university/department may recommend

additional deficiency courses/ transition courses[8], from the BS (IT) curriculum, considering the deficiency of the candidates.
OR

4. 16-years education engineering degrees (minimum 2.5 CGPA of scale 4.0 or 60% marks).
   Under eligibility criterion 4, candidates will be required to complete the deficiency coursework prior to the MS (IT) coursework to ensure the pre-requisite competency in IT. The deficiency/transition coursework will be determined on the basis of the core IT courses of the BS (IT) degree.
5. Test (University/Institution rules shall be observed).

Duration:

Four (4) semesters/terms spread over two (2) calendar years with two semesters/terms a year.

Degree Requirements:

Minimum credit hours shall be 30 Cr. Hrs. for MS (Information Technology) program including course work and research thesis/project. In order to obtain MS (IT) degree a student must pass a minimum of:

i. Four (4) core courses (12 credit hours).
AND
ii. Four (4) courses (12 credit hours) from graduate elective courses.
AND
iii. Satisfactorily complete a Research Thesis of 6 credit hours.

Distribution of Courses:

Followings are the distribution of total credit hours:

Category or Area	Credit Hours
Core	12
Elective	12
Thesis	6
Total Credit Hours	30

[8]Transition courses cover essentially undergraduate material mastery of which is crucial for student success in the program. Transition courses are assigned based on an applicant's credentials and will not be counted towards the MS degree program.

List of Core Courses:

S. No	Code	Pre-Req.	Course Title	Credit Hours
1	IT	*	Advanced Database Management Systems	3
2	IT	*	Information Security and Assurance	3

List of Elective Courses:

Universities/Institutions may add courses in this list.

#	Code	Pre-Req.	Course	Cr. Hrs.
	IT	*	Mobile and Wireless Networks	3
	IT	*	Information Technology Infrastructure	3
	IT	*	Telecom Management	3
	IT	*	Data Warehousing Trends & Issues	3
	IT	*	Data Mining Trends & Issues	3
	IT	*	Advanced Business Intelligence and Analytics	3
	IT	*	Multimedia Databases	3
	IT	*	Information Retrieval	3
	IT	*	Cloud Computing	3
	IT	*	Mobile & Pervasive Computing	3
	IT	*	Enterprise Data Center Design and Methodology	3
	IT	*	Data Center Network Design, Implementation, and Security	3
	IT	*	Virtualized Data Center	3
	IT	*	Advanced Computer Networks	3
	IT	*	Network Performance Modeling and Evaluation	3
	IT	*	Integrated Services over Packet Networks	3
	IT	*	Stochastic Systems	3
	IT	*	Stochastic Processes	3
	IT	*	Knowledge-Based Systems	3
	IT	*	Distributed Databases	3
	IT	*	Advanced Telecommunication Networks	3
	IT	*	Multimedia Databases	3
	IT	*	Telecommunication Systems	3
	IT	*	Advanced Network Security	3
	IT	*	Principles of Multimedia Systems	3
	IT	*	Advanced Multimedia Systems	3
	IT	*	Distributed System	3

	IT	*	Computer Graphics	3
	IT	*	Computer Vision	3
	IT	*	Image Processing	3
2	IT	*		

Sample Scheme of Study for MS (IT) Programme
2–year Programme (4 Semesters/Terms)
(30 Credit Hours)

Semester/Term 1 (9 Credit Hours)			
#	**Code**	**Course Title**	**Cr. Hrs.**
1	IT	Advanced Database Management Systems	3
2	IT	Information Security and Assurance	3
4	IT	Research Methods (University Elective-I)	3
		Semester Credit Hrs.	9

Semester/Term 2 (9 Credit Hours)			
#	**Code**	**Course Title**	**Cr. Hrs.**
1	IT	Elective II	3
2	IT	Elective III	3
3	IT	Elective IV	3
		Semester Credit Hrs.	9

Semester/Term 3 (6 Credit Hours)			
#	**Code**	**Course Title**	**Cr. Hrs.**
1	IT	Thesis (Partial Registration)	3
3	IT	Elective V	3
		Semester Credit Hrs.	6

Semester/Term 4 (6 Credit Hours)			
#	**Code**	**Course Title**	**Cr. Hrs.**
1	IT	Elective VI	3
2	IT	Thesis (Full Registration)	3
		Semester Credit Hrs.	6
Total Credit Hours			30

Course Outline for MS (IT) Programme (Core)

Course Name: **Advanced Database Management Systems**
Credit Hours: 3
Pre-requisites: **Database Management System/Equivalent**

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.

Reference Materials:

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. *Advanced Database Systems* by Carlo Zaniolo, Stefano Ceri (Chapter 5, 6)
5. *Foundations of Semantic Web Technologies* by Pascal Hitzler. ISBN: 142009050X.

Course Name: **Information Security and Assurance**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Basics of Information Security, Computer Security, Security Attacks, Computer Criminals, Methods of Defence. Cryptography: Substitution Ciphers, Transpositions (Permutations), Encryption Algorithms, The Data Encryption Standard, The AES Encryption Algorithm, Public Key Encryption, The Uses of Encryption. Crypto Basics. Symmetric Key Crypto: Stream Ciphers, Block Ciphers, Integrity. Public Key Crypto: Knapsack, RSA, Diffie-Hellman, Elliptic Curve Cryptography, Public Key Notation, Uses for Public Key Crypto, Public Key Infrastructure. Hash Functions++: Cryptographic Hash Function, Non-Cryptographic Hashes, Tiger Hash, HMAC, Uses for Hash Functions. Advanced Cryptanalysis: Enigma, RC4 as Used in WEP, Linear and Differential Cryptanalysis, Lattice Reduction and the Knapsack, RSA Timing Attack. Authentications. Authorization. Access Control Matrix,

Multilevel Security Models, Compartments, Covert Channel, CAPTCHA, Firewalls, Intrusion Detection Systems. Authentication Protocols: Security Protocols, Authentication Protocols, Authentication and TCP, Zero Knowledge Proofs, The Best Authentication Protocol. Real-World Security Protocols: SSH, SSL, IPSec, Kerberos, WEP, GSM. Software Flaws and Malware: Software Flaws, Malware, Botnets, Miscellaneous Software-Based Attacks. Insecurity in Software. Research Trends in information security.

Reference Materials:

1. *Security in Computing, 4th Edition* by Charles P. Pfleeger and Shari Lawrence Pfleeger, Prentice Hall; 4th Edition (2006). ISBN-10: 0132390779
2. *Information Security: Principles and Practice* by Mark Stamp, Wiley; 2nd Edition (2011). ISBN-10: 0470626399
3. *Computer Security: Art and Science* by Matthew Bishop, Addison-Wesley Professional; 1st Edition (2002). ISBN-10: 0201440997
4. *Software Security: Building Security In* by Gary McGraw, Addison-Wesley Professional; PAP/CDR Edition (2006). ISBN-10: 0321356705
5. *Network Security: The Complete Reference* by Mark Rhodes-Ousley, Roberta Bragg and Keith Strassberg, McGraw-Hill Osborne Media; 1st Edition (2003). ISBN-10: 0072226978
6. *Information Security Intelligence: Cryptographic Principles & Applications* by Thomas Calabrese, ISBN-10: 1401837271.

Elective Courses for IT

Course Name: **Mobile and Wireless Networks**
Credit Hours: 3
Prerequisites: **Internet Architecture and Protocols**

Course Outline:

Basics of Wireless Local Area Networks. Radio Transmitters and Receivers, Multiple Access Methods: FDMA, TDMA, CDMA, Random Access, ALOHA, Slotted ALOHA, Reservation-based ALOHA. Radio Propagation. Antennas and Transmission Lines. Communication Protocols and Modulation. High-Speed Wireless Data. GSM/Cellular Networks. Indoor Networks. Security in Wireless Local Area Networks. Voice Over Wi-Fi and Other Wireless Technologies. Mobile Ad Hoc Networks. Wireless Sensor Networks. Reliable Wireless Networks for Industrial Applications. Applications and Technologies. Conflict and Compatibility, Ultra-wideband Technology.

Reference Materials:

1. Wireless Networking: Know It All by Praphul Chandra, Daniel M. Dobkin, Dan Bensky, Ron Olexa, David Lide, and Farid Dowla, Newnes (September 28, 2007). ISBN-10: 0750685824 (TB1)
2. Wireless Communications & Networks by William Stallings, Prentice Hall;

2nd Edition (November 22, 2004). ISBN: 0131918354.
3. CCNA Wireless Official Exam Certification Guide by Brandon James Carroll, Cisco Press; 1st Edition (November 2, 2008). ISBN-10: 1587202115
4. Wireless Crash Course by Paul Bedell, McGraw-Hill Professional; 3rd Edition (September 5, 2012). ISBN-10: 0071797890
5. Wireless and Mobile Data Networks by Aftab Ahmad, Wiley-Interscience; 1st Edition (July 20, 2005). ISBN-10: 0471670758

Course Name: **Advanced Web Systems & Technologies**
Credit Hours: 3
Prerequisites: **Web Engineering**

Course Outline:

The Need for Web Engineering. Web Effort Estimation. Web Productivity Measurement and Benchmarking. Web Quality. Web Usability. Web System Reliability and Performance. Web Application Testing. Process Improvement in Small Settings. Conceptual Modeling of Web Applications. Model-Based Web Application Development. W2000: A Modeling Notation for Complex Web Applications. Statistics Analysis. W3C Web Content Accessibility Guidelines. Internationalization. Classroom Group Assignments: Instructors are advised to ask students to review the Current Status of W3C Specifications: HTML5, CSS3, Best Practices for Authoring HTML5, Web Fonts, SMIL, Media Access, Timed Text, SVG, Web Real Time Communication, Audio, Mobile Web Authoring, Device Independence Authoring, CSS Mobile, SVG Tiny, XHTML For Mobile, Mobile Web Applications, Mobile Web for Social Development, Geospatial, Accessible Rich Internet Applications (WAI-ARIA), DOM, DOM events, Declarative Web Applications, JavaScript APIs, Mobile Web Applications, WICD, Widgets, XBL, Web Components, Web Performance. Google Technologies. Web 2.0 & Associated Technologies.

Classroom Group Assignments: Instructors are advised to ask students to review the Current Status of W3C Specifications: HTML, CSS, Best Practices for Authoring HTML, Web Fonts, SMIL, Media Access, Timed Text, SVG, Web Real Time Communication, Audio, Mobile Web Authoring, Device Independence Authoring, CSS Mobile, SVG Tiny, XHTML For Mobile, Mobile Web Applications, Mobile Web for Social Development, Geospatial, Accessible Rich Internet Applications (WAI-ARIA), DOM, DOM events, Declarative Web Applications, JavaScript APIs, Mobile Web Applications, WICD, Widgets, XBL, Web Components, Web Performance. [W3C website]

Reference Materials:

1. *Web Engineering by Emilia Mendes and Nile Mosley, Springer*; Softcover reprint of hardcover 1st Edition. 2006 edition (November 9, 2010). ISBN-10: 3642066453

2. W3C Online Resources
3. *Web Engineering: A Practitioner's Approach* by Roger Pressman and David Lowe, McGraw-Hill Science/Engineering/Math; 1st Edition (January 22, 2008). ISBN-10: 0073523291

Course Name: **Information Technology Infrastructure**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Definition of IT Infrastructure, Non-functional Attributes, Availability Concepts, Sources of Unavailability, Availability Patterns. Performance. Security Concepts. Data centres. Servers: Availability, Performance, Security. Networking: Building Blocks, Availability, Performance, Security. Storage: Availability, Performance, Security. Virtualization: Availability, Performance, Security. Operating Systems: Building Blocks, Implementing Various OSs, OS availability, OS Performance, OS Security. End User Devises: Building Blocks, Device Availability, Performance, Security. IT Infrastructure Management. Service Delivery Processes. Service Support Processes. Ethics, Trends, organizational and technical issues related to IT infrastructure.

Reference Materials:

1. *IT Infrastructure Architecture: Infrastructure building blocks and concepts* by Sjaak Laan, Lulu.com (November 5, 2011). ISBN-10: 1447881281
2. *IT Infrastructure and its Management* by Prof Phalguni Gupta, Tata McGraw Hill Education Private Limited (October 6, 2009). ISBN-10: 0070699798
3. *IT Architecture For Dummies* by Kalani Kirk Hausman and Susan Cook, For Dummies; 1st Edition (November 9, 2010). ISBN-10: 0470554231
4. *Standards Policy for Information Infrastructure* by Brian Kahin and, Janet Abbate, The MIT Press (August 14, 1995). ISBN-10: 026211206X
5. *IT Architectures and Middleware: Strategies for Building Large, Integrated Systems* by Chris Britton and Peter Bye, Addison-Wesley Professional; 2nd Edition (June 3, 2004). ISBN-10: 0321246942

Course Name: **Telecom Management**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Introduction to Telecommunication Management and Planning. Telecommunication Strategic Planning. Developing Requirements and Specifications. Managing Long-Distance Services. Managing Internet Services. Managing PBX and Key Telephone Equipment. Managing Automatic Call Distributors. Managing Voice Processing Equipment.

Managing Local Area Network and Internets. Managing Wide Area Networks. Managing Video and Audio Conferencing Equipment. Managing Convergence. Developing a Telecommunication Operations Plan. Disaster Prevention and Recovery. Telecommunications Project Management. Managing Telecommunications Security. Current Trends and Practices of Telecom Management.

Reference Materials:

1. *The Irwin Handbook of Telecommunications Management* by James Harry Green, McGraw-Hill; 3rd Edition (March 22, 2001). ISBN-10: 0071370587
2. *Telecom Management Crash Course: A Telecom Company Survival Guide* by P. J. Louis, McGraw-Hill Professional; 1st Edition (June 1, 2002). ISBN-10: 0071386203
3. *The Essentials of Telecommunications Management: A Simple Guide to Understanding a Complex Industry* by Jayraj Ugarkar, Author House (March 29, 2010). ISBN-10: 1434397254

Course Name: **Data Warehousing Trends & Issues**
Credit Hours: 3
Prerequisites: *

Course Outline:

Overview of Databases and Data Warehouses: Database Concepts, The Entity-Relationship Model, Database Design, Conventional Data Warehouses, Spatial Databases and Spatial Data Warehouses, Temporal Databases and Temporal Data Warehouses, Conceptual Modeling for Databases and Data Warehouses, Data Warehouses, Logical Data Warehouse Design, Physical Data Warehouse Design, Data Warehouse Architecture, Variations of the Architecture, Analysis Services 2005, Oracle 10g with the OLAP Option. Conventional Data Warehouses: Multidimensional Model, Data Warehouse Hierarchies, Advanced Modeling Aspects, Metamodel of the Multi Dim Model, Mapping to the Relational and Object-Relational Models, Logical Representation of Hierarchies, Implementing Hierarchies Spatial Databases General Concepts, Spatial Data Warehouses: Spatial Extension of the Multi Dim Model, Spatial Levels, Spatial Hierarchies, Spatial Fact Relationships, Spatiality and Measures, Metamodel of the Spatially Extended MultiDim Model, Rationale of the Logical-Level Representation Object-Relational Representation of Spatial Data Warehouses. Temporal Data Warehouses: Temporal Databases, Temporal Extension of the MultiDim Model, Temporal Support for Levels, Temporal Hierarchies, Temporal Fact Relationships, Temporal Measures, Managing Different Temporal Granularities, Metamodel of the Temporally Extended MultiDim Model, Rationale of the Logical-Level Representation, Logical Representation of Temporal Data Warehouses. Designing Conventional Data Warehouses: Current Approaches to Data Warehouse Design, Data Warehouse Design, Requirements Specification, Conceptual Design,

Characterization of the Various Approaches, Logical Design, Physical Design, Methods. 7 Designing Spatial and Temporal Data Warehouses: Current Approaches to the Design of Spatial and Temporal Databases, Spatial-Data-Warehouse Design. Research trends in Conventional Data Warehouses, Spatial Data Warehouses, Temporal Data Warehouses, Spatiotemporal Data Warehouses, Design Methods.

Reference Materials:

1. *Advanced Data Warehouse Design: From Conventional to Spatial and Temporal Applications (Data-Centric Systems and Applications)* Elzbieta Malinowski and Esteban Zimányi, Springer; 2nd printing 2008 edition (April 6, 2011). ISBN-10: 3540744045
2. *Data Warehouse Design: Modern Principles and Methodologies* by Matteo Golfarelli and Stefano Rizzi, McGraw-Hill Osborne Media; 1st Edition (May 26, 2009). ISBN-10: 0071610391
3. WWW Resources
4. *Building the Data Warehouse* by William H. Inmon, Wiley; 4th Edition (2005). ISBN-10: 0764599445
5. *The Data Warehouse Lifecycle Toolkit: Expert Methods for Designing, Developing, and Deploying Data Warehouses* by Ralph Kimball, Laura Reeves, Margy Ross and Warren Thornthwaite, Wiley (August 13, 1998). ISBN-10: 0471255475.

Course Name: **Data Mining Trends & Issues**
Credit Hours: 3
Prerequisites: **Database Management System**

Course Outline:

Combining Data Warehousing and Data Mining Techniques for Web Log Analysis Computing Dense Cubes Embedded in Sparse Data. Exploring Similarities Across High-Dimensional Datasets. Pattern Comparison in Data Mining. Mining Frequent Patterns Using Self-Organizing Map. Compression Technique for Vertical Mining Methods. Data Mining Techniques via Multiple Criteria Optimization. Graph-Based Data Mining. Facilitating and Improving the Use of Web Services with Data Mining.

Reference Materials:

1. *Research and Trends in Data Mining Technologies and Applications (Advanced Topics in Data Warehousing and Mining)* by David Taniar, IGI Global (February 5, 2007). ISBN-10: 1599042711
2. *Principles of Data Mining* by Max Bramer, Springer; 2nd Ed. (2013). ISBN-10: 1447148835
3. *Data Mining: Concepts, Models, Methods, and Algorithms* by MehmedKantardzic, Wiley-IEEE Press; 2nd Edition (August 16, 2011). ISBN-10: 0470890452
4. *Data Mining: Concepts and Techniques, 3rd Edition (The Morgan*

Kaufmann Series in Data Management Systems) by Jiawei Han, Micheline Kamber and Jian Pei, Morgan Kaufmann; 3rd Edition (2011). ISBN-10: 0123814790

5. *Principles of Data Mining (Adaptive Computation and Machine Learning)* by David J. Hand, Heikki Mannila and Padhraic Smyth, A Bradford Book (August 1, 2001). ISBN-10: 026208290X.

Course Name: **Advanced Business Intelligence and Analytics**
Credit Hours: 3
Prerequisites: **Data Mining**

Course Outline:

Basic principles of Business Intelligence, Development in BI Area, Position in IS/ICT Architecture, Links to other Applications, Core OLAP (On Line Analytical Processing) Technologies, Demonstration of Principles on Examples, BI Application Areas, Specification of these Areas, BI in the Company Management, Effects of BI Applications, Database Environment, Data Warehouse in MS SQL Server-- Principles, Architecture, Components, Management Basics, BI Tasks Management, Effect and Critical Success Factors of BI, Planning and Analysis Design and Modeling -- Principles of Dimensional Modeling, Relationship Between Measures And Relevant Dimensions, Physical Design And Modeling, Data Quality Management, Data Granularity Problems Management, BI Implementation Principles, Data Pumps, ETL -- Principle, Documentation In MS -- DTS, Activex Script, Data Pumps Parameters and Logging, Server Applications Solution, Basic Principles Of MS Analysis Services, Functions and Options Client Applications Solution, Proclarity, MS Office - Excel, Access, Export Of OLAP Cube - Off-Line Solution, Query Tools In Multidimensional Databases, Data Mining -- Core Principles and Application Options, Relations To BI And Other Applications, Relationship Between CRM And BI - Customer Intelligence. BI Market Segment, BI Trends, BI Tools - SAP, Oracle, Sharepoint.

Reference Materials:

1. *Business Intelligence* by David Loshi, Morgan Kaufmann; 2nd Edition (October 31, 2012). ISBN-10: 0123858895
2. *Oracle Business Intelligence* 11g Developers Guide by Mark Rittman, McGraw-Hill Osborne Media; 1st Edition (September 18, 2012). ISBN-10: 0071798749
3. Delivering Business Intelligence with Microsoft SQL Server 2012 3/E by Brian Larson, McGraw-Hill Osborne Media; 3rd Edition (March 16, 2012). ISBN-10: 0071759387
4. Business Intelligence by Elizabeth Vitt, Michael Luckevich, and Stacia Misner, Microsoft Press (December 22, 2008). ISBN-10: 073562660X

Course Name: **Multimedia Databases**
Credit Hours: 3
Prerequisites:

Course Outline:

Multimedia Data, The Human Sensory System and Multimedia, Database Approach for the Management of Multimedia Information, Multimedia Databases, Object-Oriented Multimedia DBMS, SQL and Multimedia, Multimedia Query Specification Language, Querying Multimedia Data, Modeling Multimedia Databases, Using Multimedia Metadata, Multimedia Database Architecture and Performance, Multimedia and the Internet, Quality-of-service Issues, Dealing with Text Databases, Content-dependent Metadata, Dealing with Image Databases, Dealing with Video Databases. Synchronization and User Interaction in Distributed Multimedia Presentation Systems, Model for Interactive Retrieval of Videos and Still Images, Latest Developments and Research Trends in Multimedia Database Systems.

Reference Materials:

1. *Multimedia Databases: An Object-Relational Approach* by Lynne Dunckley, Pearson Education (January 31, 2003). ISBN-10: 0201788993
2. *Multimedia Database Systems: Design and Implementation Strategies* by Kingsley C. Nwosu, B. Thuraisingham and P. Bruce Berra, Springer; (October 28, 2011). ISBN-10: 146138060X
3. *Principles of Multimedia Database Systems* by V.S. Subrahmanian, Morgan Kaufmann Publishing Company, San Francisco, CA. 1998. ISBN: 1558604669.
4. *Distributed Multimedia Database Technologies Supported* by MPEG-7 and MPEG-21 by HaraldKosch, CRC Press; 1st Edition (November 24, 2003). ISBN-10: 0849318548.

Course Name: **Information Retrieval**
Credit Hours: 3
Prerequisites: **None**

Course Outline:

Basic Concepts of IR, IR System Block, Diagram. Automatic Text Analysis, Indexing and Classification. Measures of Association. Clustering Algorithms. File Structures. IR Models. Search Strategies. Performance Evaluation. Online IR Systems & Interfaces Standards. Taxonomy and Ontology. Distributed and Parallel IR. Query Processing. Multimedia IR Models & Languages- Data Modeling Techniques to Represent Audio and Visual Document, Query Languages Indexing & Searching- Generic Multimedia Indexing Approach, Query Databases of Multimedia Documents, Display the Results of Multimedia Searches, One Dimensional Time Series, Two Dimensional Color Images, Automatic Feature Extraction. Searching the Web, Challenges, Characterizing the Web, Search Engines, Browsing, Mata

Searchers, Web Crawlers, Robot Exclusion, Web Data Mining, Metacrawler, Collaborative Filtering, Web Agents (Web Shopping, Bargain Finder,..), Latest Development and Economic, Ethical, Legal and Political Issues related to Information Retrieval.

Reference Materials:

1. *Modern Information Retrieval: The Concepts and Technology behind Search* by Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Addison-Wesley Professional; 2nd Edition (February 10, 2011). ISBN-10: 0321416910
2. *The Geometry of Information Retrieval* by C. J. van Rijsbergen, Cambridge University Press (September 13, 2004). ISBN-10: 0521838053
3. *Managing Gigabytes: Compressing and Indexing Documents and Images* by Ian H. Witten, Alistair Moffat, & Timothy C. Bell, Morgan Kaufmann; 1st Edition (May 17, 1999)
4. *Information Retrieval: Algorithms and Heuristics* by D. Grossman and O. Frieder, Springer; 2nd Edition (December 20, 2004). ISBN-10: 1402030045
5. *An Introduction to Search Engines and Web Navigation* by Mark Levene, Wiley; 2nd Edition (October 18, 2010). ISBN-10: 047052684X
6. *Information Retrieval: Data Structures and Algorithms* by William B. Frakes and Ricardo Baeza-Yates, Prentice Hall; 1st Edition (June 22, 1992). ISBN-10: 0134638379

Course Name: **Cloud Computing**
Credit Hours: 3
Prerequisites: *

Course Outline:

Datacenter Architectures, Cloud Stack , Technology Trends, Consistency, Availability, Partitions, Cluster File Systems, Data-flow Computation Frameworks, Key-Value Store and Interactive Query Systems, Big Data in the Clouds , Geographic distributed Storage, Programming Languages for the Cloud, DBases in the Cloud, In-Memory Frameworks, Google file system , Hadoop file system, MapReduce, OSes and Clouds Networking: topologies, Networking: Traffic Management, Networking: Transport Protocol Improvements, Security, Scheduling and Resource Management in clouds, Software Level Agreements. Cloud Computing Trends &Issues

Reference Materials:

1. *Cloud Computing Implementation, Management, and Security* by John W. Rittinghouse and James F. Ransome, Taylor and Francis Group, LLC (2010). ISBN 978-1-4398-0680-7 WWW resources
2. *Cloud Computing Explained: Implementation Handbook for Enterprises* by John Rhoton, Recursive Press (2009). ISBN-10: 0956355609.
3. *Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide* by David S. Linthicum, Addison-Wesley Professional; 1st

Edition (2009). ISBN-10: 0136009220.
4. *Cloud Computing Bible* by Barrie Sosinsky, Wiley; 1st Edition (2011). ISBN-10: 0470903562.

Course Name: **Mobile & Pervasive Computing**
Credit Hours: 3
Prerequisites: **Operating Systems, Web Systems and Technologies**

Course Outline:

Mobile and Pervasive Computing Basics, Vision And Challenges. Wireless Technologies. Mobile and Pervasive Computing Environments: Mobile Computing Infrastructure, Characteristics of Mobile Computing Environments, Challenges of Mobile Computing, Infrastructure of Pervasive Computing, Characteristics of Pervasive Computing Environments. Pervasive Computing Applications. Requirements of Pervasive Computing Applications. Smart Devices and Services. HCI Aspects of Smart Devices. Tagging, Sensing and Controlling. Context-Aware Computing and Systems. Intelligent Systems and Interaction. Ubiquitous Communication. Overview of P2P Computing, RFID, Smart Home, Autonomic Systems and Artificial Life, Utility Computing, Management of Smart Devices.

Reference Materials:

1. *Ubiquitous Computing: Smart Devices, Environments and Interactions* by Stefan Poslad, Wiley; 1st Edition (April 27, 2009). ISBN-10: 0470035609
2. *Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML* by Reza B'Far and Roy T. Fielding, Cambridge University Press (2004). ISBN-10: 0521817331.
3. *Fundamentals of Mobile and Pervasive Computing* by Frank Adelstein, Sandeep KS Gupta, Golden Richard III and Loren Schwiebert, McGraw-Hill Professional; 1st Edition (2004). ISBN-10: 0071412379.
4. *Fundamentals of Mobile and Pervasive Computing* by Golden Richard, McGraw-Hill Professional Publishing; December 2004.

Course Name: **Enterprise Data Centre Design and Methodology**
Credit Hours: 3
Prerequisites: **Information Security and Assurance, IT Infrastructure**

Course Outline:

Introduction to Data Centres, Application Architecture Models, Data Centre Architecture, Data Centre Services. Data Centre Requirements. Server Architecture. Application Architectures. Data Centre Design. Network Infrastructure. Power Distribution. Data Centre Security. Server Load-Balancing. Designing the Data Centre Infrastructure. Integrating Security into the Infrastructure. Server Performance Metrics. Server Capacity Planning. Performance Metrics of Data Centre Devices.

Reference Materials:

1. *Data Center Fundamentals* by Mauricio Arregoces and Maurizio Portolani, Cisco Press (December 14, 2003). ISBN-10: 1587050234
2. *Administering Data Centers: Servers, Storage, and Voice over IP* by Kailash Jayaswal, Wiley; 1st Edition (November 28, 2005). ISBN-10: 047177183X
3. *The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines* by Urs Hoelzle and Luiz Andre Barroso, Morgan and Claypool Publishers; 1st Edition (May 29, 2009). ISBN-10: 159829556X.

Course Name: **Data Centre Network Design, Implementation, and Security**
Credit Hours: 3
Prerequisites: **Enterprise Data Centre Design and Methodology**

Course Outline:

Network Devices & Technologies. IP, TCP, and UDP Protocols (In-depth Investigation). HTTP and Related Concepts (In-depth Investigation). SSL and TLS : Operations, Performance Implications, Authentication and Digital Certificates, SSL, Ciphersuites, Analyzing SSL Traces. DNS Essentials and Site-Selection Considerations. Streaming Protocols. Infrastructure Layer 2 Protocol. Infrastructure Layer 3 Protocol. Security Protocols and Technologies. Load-Balancing. Modes and Predictors. Server Health Management. Persistence Mechanisms on Load Balancers. Network Design. Internet Access Technologies and VPNs. Voice over IP and Converged Infrastructure. Disaster Recover.

Reference Materials:

1. *Data Center Fundamentals* by Mauricio Arregoces and Maurizio Portolani, Cisco Press (December 14, 2003). ISBN-10: 1587050234
2. *Administering Data Centers: Servers, Storage, and Voice over IP* by Kailash Jayaswal, Wiley; 1st Edition (November 28, 2005). ISBN-10: 047177183X
3. *The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines* by Urs Hoelzle and Luiz Andre Barroso, Morgan and Claypool Publishers; 1st Edition (May 29, 2009). ISBN-10: 159829556X

Course Name: **Virtualized Data Centre**
Credit Hours: 3
Prerequisites: **Enterprise Data Centre Design and Methodology**

Course Outline:

Virtualization, Virtualization Types, Virtualization Management, Cloud Computing, Service Models, Cloud Adoption and Barriers, Return on Investment and Cloud Benefits; Typical Design Patterns and Use Cases, Design Patterns, Cloud Use Cases, Deployment Models, IaaS as a Foundation, Cloud Consumer Operating Model. Data Centre Architecture and Technologies. IT Services. The Cisco Cloud Strategy. Cloud Management Reference Architecture. Cloud Service Fulfilment. Cloud Service Assurance. Billing and Chargeback. Technical Building Blocks of IaaS. Automating and Orchestration Resources. Cloud Capacity Management. Case Study - Hybrid Cloud: Cisco Cloud Enablement Services, Company Profile, Business Goals, Cloud Strategy, Cloud Maturity, IT Platform, Cloud Reference Model, Private Cloud Services, Orchestration and Automation Transition Architecture, Telco Solution, Solution, Out-of-the-Box Services, Diggit Service Requirements.

Reference Materials:

1. *Cloud Computing: Automating the Virtualized Data Centre* by Venkata Josyula, Malcolm Orr and Greg Page, Cisco Press; 1st Edition (December 9, 2011). ISBN-10: 1587204347.
2. *IT Virtualization Best Practices: A Lean, Green Virtualized Data Centre Approach* by Mickey Iqbal, Mithkal Smadi, Chris Molloy, and Jim Rymarczyk, Mc Press; 1st Edition (January 1, 2011). ISBN-10: 1583473548
3. *Microsoft Private Cloud Computing* by Aidan Finn, Hans Vredevoort, Patrick Lownds, and Damian Flynn, Sybex; 1st Edition (July 10, 2012). ISBN-10: 1118251474
4. *Advanced Server Virtualization: VMware and Microsoft Platforms in the Virtual Data Centre* by David Marshall , Wade A. Reynolds, and Dave McCrory, Auerbach Publications; 1st Edition (May 17, 2006). ISBN-10: 0849339316
5. *Data Center Virtualization: A practical guide to successful deployments of a Virtualized Data Center Infrastructure* by Sukento Sukirya, Pete Gore, Brian Clay, and Pierre Vachon, Cisco Press (December 14, 2003). ISBN-10: 1587050234.

Course Name: **Advanced Computer Networks**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Network architecture, Networking principles, Network services and Layered architecture, Future Networks. Advanced Technologies. Performance of Networks. Advanced Routing: Routing architecture , Routing between peers (BGP) , IP switching and Multi-Protocol Label Switching MPLS), MPLS Architecture and related protocols, Traffic Engineering (TE) and TE with MPLS, NAT and Virtual Private Networks (L2, L3, and Hybrid), CIDR – Introduction, CIDR addressing, CIDR address blocks and Bit masks. Mobile IP- characteristics, Mobile IP operation, Security related issues. Mobility in networks. Voice and Video over IP (RTP, RSVP, QoS) IPv6: Why IPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbor discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6. Ad Hoc Networking: An Introduction, A DoD Perspective on Mobile Ad Hoc Networks, DSDV: Routing over a Multihop Wireless Network of Mobile Computers, Cluster-Based Networks, DSR: The Dynamic Source Routing Protocol for Multihop Wireless Ad Hoc Networks.

Reference Materials:

1. *Computer Networks: A Systems Approach* by Larry L. Peterson, Bruce S, Morgan Kaufmann; 5th Edition (March 25, 2011). ISBN-10: 0123850592.
2. *Internetworking with TCP/IP Vol –I* by Douglas E. Comer, Addison-Wesley; 5th Edition (July 10, 2005). ISBN-10: 0131876716
3. *High Performance Communication Networks* by Jean Walrand and Pravin Varniya, Morgan Kaufmann; 2nd Edition (October 25, 1999). ISBN-10: 1558605746
4. *Metro Ethernet* by Sam Halabi Publisher: Cisco Press ISBN: 158705096X
5. *Computer Networks* by A. S. Tanenbaum, Prentice Hall; 5th Edition (October 7, 2010). ISBN-10: 0132126958

Course Name: **Network Performance Modeling and Evaluation**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Introduction to Probability Theory. Random Variables. Conditional Probability. Markov Chains. The Poisson Process. Continuous Time Markov Processes. Queuing Theory. Modeling Complex Communication Networks -- Congestion Control Analysis, End-to-End Analysis, Multiple Access Control, Wireless Networks, Adhoc Networks, Simulating Complex Communication Networks – Discrete Event Simulation, Event Derivations, Scheduler, Advancing Simulation Clock, Terminating Simulation, Results Definition and

Accumulation, Selecting Input Probability Distributions, Input Traffic Modeling. Communication Network Performance Analysis Tools - NS-2, NS-3, Glomosim, OMNET++, Comparative Analysis of Performance Analysis Tools.

Reference Materials:

1. *Performance Analysis of Queuing and Computer Networks (Chapman & Hall/CRC Computer & Information Science Series)* by G. R. Dattatreya, Chapman and Hall/CRC; 1st Edition (2008). ISBN-10: 1584889861
2. *Performance Analysis of Network Architectures* by Dietmar Tutsch, Springer; 1st Edition (2006). ISBN-10: 3540343083
3. *Network Performance Analysis (ISTE)* by Thomas Bonald and Mathieu Feuillet, Wiley-ISTE; 1st Edition (2011). ISBN-10: 1848213123
4. *Modeling and Tools for Network Simulation* by Klaus Wehrle, Mesut Günes and James Gross, Springer; 1st Edition (2010). ISBN-10: 3642123309

Course Name: **Integrated Services over Packet Networks**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Multimedia Service Requirements. Speech, Image and Video Coding Techniques. Internet and Components of Network Qos - Connectivity and Routing, Predictable Per-Hop Behaviour, Predictable Edge-to-Edge Behaviour. Per-Hop Packet Processing - Classification, Policing, Marking, Queue Management, Scheduling. Transporting Multimedia (Voice) - Real Time Transport Protocol (RTP), RTCP, H.323 Architecture, H.245 Signaling. Session Initiation Protocol (SIP) - SIP Signaling, SDP, Interworking with H.323. Media Gateway Control - Soft Switch Architecture, MGCP, MEGACO, H.248. Edge To Edge Network Models - Integrated Services (Intserv), Differentiated Services (Diffserv), MPLS. Edge to Edge IP Qos - Resource Reservation Protocol (RSVP). Voip and SS7. IMS (IP Multimedia Subsystem) and IP-TV. NGN (Next Generation Networks).

Reference Materials:

1. *Quality of Service in IP Networks, Grenville Armitage*, Macmillan Technical Publishing. ISBN: 1578701899, 2000
2. *Carrier Grade VOIP, by Irakli Natsvlishvili*, McGraw-Hill Osborne Media; 3rd Edition 2010. ISBN: 0071494219
3. *Carrier Grade Voice Over IP*, 2nd Edition by Daniel Collins, 2003, McGraw-Hill Publishing.

Course Name: **Stochastic Systems**
Credit Hours: 3
Prerequisites: **Probability and Statistics**

Course Outline:

Overview of Probability. The Axioms of Probability. Repeated Trials. Random Variable. Distribution and Density Functions, Specific Random Variables, Conditional Distributions, Asymptotic Approximations for Binomial Random Variable. Functions of One Random Variable. Two Random Variables. Sequences of Random Variables. Stochastic Convergence and Limit Theorems, Random Numbers, Meaning and Generation. Essential concepts of Statistics.

Reference Materials:

1. *Probability, Random Variables and Stochastic Processes* by Athanasios Papoulis and S. Unnikrishna Pillai, McGraw-Hill Europe; 4th Edition (January 1, 2002). ISBN-10: 0071226613
2. *Dynamics of Stochastic Systems* by V. I. Klyatskin, Elsevier Science; 1st Edition (December 15, 2005). ISBN-10: 0444517960
3. *Stochastic systems* by George Adomian, Academic Press (May 28, 1983). ISBN-10: 012410956X

Course Name: **Stochastic Processes**
Credit Hours: 3
Prerequisites: **Stochastic Systems**

Course Outline:

Review of basic probability. Systems with Stochastic Inputs, The Power Spectrum, Discrete-Time Processes, Continuity, Differentiation, Integration, Shift Operators and Stationary Processes. Finite Markov Chains. Branching Processes. Renewal Theory. Markov Processes. Brownian Motion. Random Walks and Other Applications. Mean Square Estimation.

Reference Materials:

1. *Classical and Spatial Stochastic Processes* by Rinaldo B. Schinazi, Birkhäuser (May 1, 1999). ISBN-10: 1461272033.
2. *Probability, Random Variables and Stochastic Processes* by Athanasios Papoulis and S. Unnikrishna Pillai, McGraw-Hill Europe; 4th Edition (January 1, 2002). ISBN-10: 0071226613
3. *Basic Stochastic Processes: A Course Through Exercises* by Zdzislaw Brzezniak, Tomasz Zastawniak, Springer (September 6, 2000). ISBN-10: 3540761756
4. *Stochastic Processes with Applications* by Rabi N. Bhattacharya and Edward C. Waymire, Society for Industrial & Applied (August 5, 2009). ISBN-10: 0898716896
5. *Stochastic* **Processes: with Applications to Reliability Theory by**

Toshio Nakagawa, Springer; 1st Edition (June 9, 2011). ISBN-10: 0857292730

Course Name: **Knowledge-Based Systems**
Credit Hours: 3
Prerequisites: **Intro to Artificial Intelligence**

Course Outline:

Introduction to knowledge-based systems, Logic and automatic reasoning (forward and backward reasoning), Knowledge representation and reasoning models, Bayesian inference and other models of reasoning and decision making under uncertainty, Software lifecycle in knowledge-based systems, Rule-based expert systems, Architecture of a knowledge-based system, Feasibility analysis, Requirements specification and design, Knowledge acquisition and system implementation, Verification and validation.

Reference Material:

1. I*ntroduction to Expert Systems* by Peter Jackson; Addison-Wesley Longman Publishing Company; 3rd Edition (January 1999).
2. *Expert Systems: Principles and Programming* by Joseph C. Giarratano, Gary D. Riley; PWS Publishing Co.; 4th Edition, Thomson/PWS Publishing Company; or latest edition.
3. *Artificial Intelligence: A Modern Approach (Latest Edition)* by Stuart Russel, Peter Norvig, Prentice Hall.
4. *Artificial Intelligence: Structures and Strategies for Complex Problem Solving* by George F. Luger, Benjamin/Cummings Publishing.
5. *The Engineering of Knowledge-Based Systems* by A. Gonzalez and D. Dankel; 2nd Edition (Preprint), Prentice Hall, 2004.

Course Name: **Distributed Database Systems**
Credit Hours: 3
Prerequisites: **Network Programming**

Course Outline:

Distributed Data Processing, Distributed Database Systems: Architecture, General Systems Issues, Example Systems. Distributed Control for Synchronization and Concurrency (Will Include the Models for Concurrent Processing and Transactions, Theory of Serializability, Classes of Concurrency Control Approaches, Performance Evaluation of these Classes, Centralized Control vs. Decentralized Control). Distributed Commitment/Termination (Involves Preservation of Atomicity of Transaction Execution, Blocking/Non-Blocking Protocols). Resiliency in Distributed Systems (Involves Design of Protocols for Site Failure, Network Partitioning, Loss of Messages or Variable Transmission Delays, Consistent Recovery). Security in Distributed Systems. (Involves Study of a Variety of Attacks on the Components of System (Such as on Routing Protocols in Adhoc Networks),

Privacy Issues in Peer to Peer Systems, Trusted Collaboration and Dissemination of Data Among Cooperative Entities). Design and Implementation of Prototype/Commercial Systems, Experimental Evaluations. Details of Peer to Peer System Developed at Purdue and Several Commercial Systems. Security Issues in DDBs. Latest developments and Research Trends in Distributed Databases.

Reference Materials:

1. *Distributed Database Systems Integration: Models and Approaches* by Mohamed Osman Hegazi, LAP LAMBERT Academic Publishing (January 24, 2012). ISBN-10: 3847372971
2. *Principles of Distributed Database Systems* by M. Tamer Özsu and Patrick Valduriez, Springer, 3rd Edition, (March 2, 2011). ISBN-10: 1441988335
3. *Distributed Database Management Systems: A Practical Approach* by Saeed K. Rahimi, and Frank S. Haug, Wiley-IEEE Computer Society Pr; 1st Edition (May 23, 2011). ASIN: B005CDYQSC
4. *Distributed Systems: Principles and Paradigms* by Andrew S. Tanenbaum and Maarten van Steen, Prentice Hall; US edition (January 15, 2002). ISBN-10: 0130888931
5. *Distributed Systems: Concepts and Design* by Jean Dollimore, Tim Kindberg and George Coulouris, Addison Wesley; 4th Edition (May 20, 2005). ISBN-10: 0321263545.

Course Name: **Advanced Telecommunication Networks**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:
Next Generation Wireless Networks: ZigBee, Personalized and Extended WiFi, Wireless Mesh Networks (IEEE 802.11s for WMN), M-WiMAX, Long Term Evolution (LTE), Evolution Data Optimized (EVDO), Cognitive (and Software Defined) Radios and their internetworking. Wireless Sensor Networks (WSN) and their Management. Broadband Wireless Networks (IEEE 802.11n, IEEE 802.16). Quality of Service (QoS) in NGNs. Quality of Service (QoS) in New Generation Networks. Research Trends in networks. Advanced topics need to be covered.

Reference Materials:

1. *Telecommunications and Data Communications Handbook* by Ray Horak, Wiley-Interscience; 2nd Edition (July 21, 2008). ISBN-10: 0470396075
2. *Next Generation Telecommunications Networks, Services, and Management* by Thomas Plevyak, Veli Sahin; IEEE Press Series on Network Management 1st Edition 2010. ISBN-10: 047057528X
3. *The Essential Guide to Telecommunications* by Annabel Z. Dodd, Prentice hall; 5th Edition (July 1, 2012). ISBN-10: 0137058918

4. *Business Data Networks and Telecommunications* by Panko, Raymond R., Panko Julia L. 8th Edition, Prentice Hall: 2009. ISBN: 0136153402

Course Name: **Multimedia Databases**
Credit Hours: 3
Prerequisites: **Database Systems**

Course Outline:

Introduction to Multimedia Databases, Multimedia Data, The Human Sensory System and Multimedia, Introduction to SQL and Multimedia, Querying Multimedia Data, Modeling Multimedia Databases, Using Multimedia Metadata, Multimedia Database Architecture and Performance, Multimedia and the Internet, Quality-of-service Issues, Dealing with Text Databases, Content-dependent Metadata, Dealing with Image Databases, Dealing with Video Databases.

Reference Material:

1. *Multimedia Databases: An Object-Relational Approach* by Lynne Dunckley, Pearson Education (January 31, 2003). ISBN-10: 0201788993
2. *Multimedia Database Systems: Design and Implementation Strategies* by Kingsley C. Nwosu, B. Thuraisingham and P. Bruce Berra, Springer; (October 28, 2011). ISBN-10: 146138060X
3. *Principles of Multimedia Database Systems* by V.S. Subrahmanian, Morgan Kaufmann Publishing Company, San Francisco, CA. 1998. ISBN: 1558604669.
4. *Distributed Multimedia Database Technologies Supported* by MPEG-7 and MPEG-21 by HaraldKosch, CRC Press; 1st Edition (November 24, 2003). ISBN-10: 0849318548.

Course Name: **Telecommunication Systems**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Communication Channel and the Communication Network Technologies. Digital Telephony. Switching and Signaling Systems. Switching Fabric Interfaces and ICs, Optics and the Future. Cellular Systems. Fixed Wireless Access Technologies. Digital Subscriber Loop. Transmission Techniques. Telecommunication Systems Testing. Embedded Systems Design for Telecommunications: AMR Speech Codecs and the GSM Environment, Digital Signal Processor Architecture, AD6526 Multiprocessor Architecture, AMR Speech Codec, Algorithmic Complexity of the AMR Speech Codec, Implementation considerations of AMR Speech Codec and porting the Code. Emerging Technologies in Telecommunication Systems.

Reference Materials:

1. *Essentials of Modern Telecommunications Systems* by Nihal Kularatna and Dileeka Dias, Artech House (May 2004). ISBN-10: 1580534910
2. *The Irwin Handbook of Telecommunications* by James Harry Green, McGraw-Hill; 5th Edition (October 26, 2005). ISBN-10: 0071452222
3. *Telecommunications Essentials: The Complete Global Source for Communications Fundamentals, Data Networking and the Internet, and Next-Generation Networks* by Lillian Goleniewski, Addison-Wesley Professional; 1st Edition (January 5, 2002). ISBN-10: 0201760320.

Course Name: **Advanced Network Security**
Credit Hours: 3
Prerequisites: **Computer Communication and Networks**

Course Outline:

Network Security Overview. Data Encryption Algorithms. Public-Key Cryptography and Key Management. Data Authentication. Network Security Protocols in Practice. Wireless Network Security. Network Perimeter Security. Anti Malicious Software. Intrusion Detection, Network-Based Detections and Host-Based Detections, Signature Detections, Statistical Analysis, Behavioral Data Forensics, Honeypots. Latest Development in Network Security.

Reference Materials:

1. *Computer Network Security: Theory and Practice* by Jie Wang, Springer; (March 16, 2009). ISBN-10: 3540796975
2. *Network Security: The Complete Reference* by Mark Rhodes-Ousley, Roberta Bragg, and Keith Strassberg, McGraw-Hill Osborne Media; 1st Edition (November 17, 2003). ISBN-10: 0072226978
3. *Network Security and Management* by Brijendra Singh, PHI Learning Private Limited; 3rd Edition (April 13, 2012). ASIN: B007U49118
4. *Network Security Bible* by Eric Cole, Wiley; 2nd Edition (September 8, 2009). ISBN-10: 0470502495
5. *Network Warrior* by Gary A. Donahue, O'Reilly Media; 2nd Edition (June 2, 2011). ISBN-10: 1449387861

Course Name: **Principles of Multimedia Systems**
Credit Hours: 3
Prerequisites: **None**

Course Outline:

Introduction to Multimedia and Tools, Graphics and Image Data Representations, Colour in Image and Video, Basics of Digital Audio, Lossless Compression Algorithms, Lossy Compression Algorithms, Image Compression Standards, Basic Video Compression Techniques, MPEG Video Coding MPEG-1, 2, 4-7; Basic Audio Compression Techniques, MPEG

Audio Compression. Latest Compression techniques and Research Trends in Multimedia systems.

Reference Materials:

1. *Fundamentals of Multimedia* by Z. M. Li and M. S. Drew, Prentice Hall (2004), ISBN: 0-13-127256-X
2. *Digital Multimedia* by N. Chapman and J. Chapman. 2nd Edition, Wiley 2004, ISBN: 0-470-85890-7
3. *The Technology of Video and Audio Streaming* by David Austerberry, Focal Press; 2nd Edition (2004). ISBN-10: 0240805801
4. *Multimedia Security: Watermarking, Steganography, and Forensics* by Frank Y. Shih, CRC Press; 1st Edition (2012), ISBN-10: 1439873313
5. *Multimedia Computing* by Daniel Cunliffe and Geoff Elliott, Lexden Publishing Ltd (2005). ISBN-10: 1904995055
6. *Multimedia Foundations: Core Concepts for Digital Design* by Vic Costello, Ed Youngblood and Susan Youngblood, Focal Press; 1st Edition (2012). ISBN-10: 0240813944.

Course Name: **Advanced Multimedia Systems**
Credit Hours: 3
Pre-requisites: **Multimedia Systems: Theory & Principles**

Course Outline:

Multimedia Basic Concepts. Multimedia Building Blocks. Windows Multimedia Support. Multimedia Database Systems, Multimedia Authoring Tools. Text: Types Of Text, Text Compression. Digital Image Processing. Image Data Types, and Image File Formats. Image Acquisition, Storage Processing, Communication, And Display, Image Enhancement. Image Compression. Audio and Audio Compression. Video: Video Signal Formats, Video Transmission Standards. Video Recording Systems. Video File Formats. Virtual Reality and Multimedia. VR Applications, VR Devices. Virtual Objects Basics of VRML. Animation: Uses of Animation, Types of Animation, Principles of Animation, Techniques and Technologies of Animation. Animation on the Web, 3D Animation, Creating Animation Using Flash, 3DMAX, Maya. Latest developments and Research Trends in Animations Technologies.

Reference Materials:

1. *Principles of Multimedia* by Ranjan Parekh, McGraw-Hill Higher Education. ISBN-10: 0070588333
2. *Multimedia Computing, Communication and Applications* by Ralf Steinmetz and Klara Nahrstedt, Prentice Hall; US edition (July 27, 1995). ISBN-10: 0133244350
3. *Multimedia Making It Work* by Tay Vaughan, McGraw-Hill Osborne Media; 8th Edition (October 29, 2010). ISBN-10: 0071748466
4. *Fundamentals of Multimedia* by Ze-Nian Li, Marks S. Drew, Prentice Hall;

1st Edition (November 1, 2003). ISBN-10: 0130618721
5. *Digital Multimedia* by Nigel Chapman and Jenny Chapman, Wiley; 3rd Edition (March 31, 2009). ISBN-10: 0470512164

Course Name: **Principles of Soft Computing**
Credit Hours: 3
Prerequisites: **Intro. to Artificial Intelligence**

Course Outline:

Introduction to Soft Computing: Soft-Computing, Intelligent Systems and Soft Computing, Importance, Decision Support Systems, Soft Computing for Smart Machine Design. Fuzzy Set Theory: Fuzzy Systems, Fuzzy Sets, Fuzzy Logic, Fuzzy Rules/Relations, Membership Functions, Fuzzification and Defuzzification, Fuzzy System Design, Fuzzy Arithmetic, Decision Making With Fuzzy Information, Fuzzy Classification and Clustering. Neural Networks: Single-Layer Networks, The Multi-Layer Perceptron, Radial Basis Functions, Error Functions, Parameter Optimization Algorithms, Learning and Generalization, Bayesian Nets: Symmetric Matrices, Dynamic Neural Networks and their Applications, Neuro-Fuzzy Systems. Evolutionary Computation and Genetic Fuzzy Systems: Introduction GA For Problem Solving, Theoretical Foundations. Machine Learning: Concept Learning and the General-to-Specific Ordering, Decision Tree Learning, Evaluating Hypotheses, Computational Learning Theory, Instance-Based Learning, Learning Sets of Rules, Analytical Learning, Combining Inductive and Analytical Learning. Programming with Matlab.

Reference Materials:

1. *Soft Computing and Intelligent Systems Design: Theory, Tools, and Applications* by F. Karray, C. De Silva, Addison-Wesley; 1st Edition (June 4, 2004). ISBN-10: 0321116178
2. *Fuzzy Logic with Engineering Applications* by T. Ross, 3rd Edition, Wiley; 3rd Edition (March 1, 2010). ISBN-10: 047074376X
3. *Neural Networks and Pattern Recognition* by C. Bishop, Oxford University Press, 1996. ISBN-10: 0198538642
4. *An Introduction to Genetic Algorithms* by M. Mitchell. A Bradford Book; Third Printing Edition (February 6, 1998). ISBN-10: 0262631857
5. *Machine Learning* by T. Mitchell, McGraw-Hill Science/Engineering/Math; 1st Edition (March 1, 1997). ISBN-10: 0070428077.