

Proposed Revised Scheme of Studies for BS (CS)

Semester I			Semester II		
CS3101	Fundamentals of Computers	3(2+1)	CS3201	Multivariate Calculus	3(3+0)
CS3102	Calculus and Analytical Geometry	3(3+0)	CS3202	Discrete Structures	3(3+0)
CS3103	Probability and Statistics	3(3+0)	CS3203	Pakistan Studies/ Islamic Studies	3(3+0)
CS3104	Functional English	3(3+0)	CS3204	Object Oriented Programming	4(3+1)
CS3105	Programming Fundamentals	4(3+1)	CS3205	Digital Logic Design	3(2+1)
Total Credit Hours		16	Total Credit Hours		16
Semester III			Semester IV		
MATH-432	Computation in MATLAB	3(2+1)	CS4401	Database Systems	4(3+1)
CS4301	Data Structures and Algorithms	4(3+1)	CS4402	Operating Systems	4(3+1)
CS4302	Communication Skills	3(3+0)	CS4403	Computer Networks	3(3+0)
CS4303	Data Communication	3(3+0)	CS4404	Theory of Automata	3(3+0)
CS4304	Linear Algebra	3(3+0)	CS4405	Web Technologies	4(3+1)
CS4305	Artificial Intelligence	3(3+0)	Total Credit Hours		18
Total Credit Hours		19			
Semester V			Semester VI		
CS5501	Design and Analysis of Algorithms	3(3+0)	CS5601	Computer Organization and Architecture	4(4+0)
CS5502	Object Oriented Analysis and Design	3(2+1)	CS5602	Software Engineering	3(3+0)
CS5503	Advanced Programming	4(3+1)	CS5603	Mobile Applications Development	4(3+1)
CS5504	Information Security	3(3+0)	CS5604	Human Computer Interaction	3(3+0)
BES-475	Geographic Information System	3(3+0)	CS5605	Applied Image Processing	3(2+1)
Total Credit Hours		16	Total Credit Hours		17
Semester VII			Semester VIII		
CS6701	Technical and Scientific Writing	3(3+0)	CS6801	Natural Language Processing	3(3+0)
CS6702	FYP - I	3(0+3)	CS6802	Professional Practices	3(3+0)
BA565	Entrepreneurship	3(3+0)	CS6803	FYP - II	3(0+3)
CS67XX	Specialization Elective - I	3(3+0)	CS68XX	Specialization Elective - III	3(3+0)
CS67XX	Specialization Elective - II	3(3+0)	CS68XX	Specialization Elective - IV	3(3+0)
Total Credit Hours		15	Total Credit Hours		15

Total Credit Hours = 132

Distribution of Courses According to HEC Framework

1. Computing - CS Core Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
1	CS3105	-	Programming Fundamentals	4(3+1)	1
2	CS3204	1	Object Oriented Programming	4(3+1)	2
4	CS3205	-	Digital Logic Design	3(2+1)	2
5	CS3202	18, 34	Discrete Structures	3(3+0)	2
6	CS4301	1	Data Structures and Algorithms	4(3+1)	3
7	CS4303	-	Data Communication	3(3+0)	3
8	CS4401	21	Database Systems	4(3+1)	4
9	CS4402	1, 6	Operating Systems	4(3+1)	4
10	CS4403	7	Computer Networks	3(3+0)	4
11	CS4405	21, 2	Web Technologies	4(3+1)	4
12	CS5502	2	Object Oriented Analysis and Design	3(2+1)	5
13	CS5503	2, 9	Advanced Programming	4(3+1)	5
14	CS5602	12	Software Engineering	3(3+0)	6
15	CS5603	1, 2	Mobile Applications Development	4(3+1)	6
16	CS5604	21, 1	Human Computer Interaction	3(3+0)	6
17	CS6702 & CS6803	13	Final Year Project (I & II)	(0+ 3) + (0+3)	7 and 8
Total Credit Hours				59	

2. Computing - Supporting Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
18	CS3102	-	Calculus and Analytical Geometry	3(3+0)	1
19	CS3103	-	Probability and Statistics	3(3+0)	1
20	CS4304	-	Linear Algebra	3(3+0)	3
Total Credit Hours				9	

3. Computing - General Education Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
21	CS3101	-	Fundamentals of Computers	3(2+1)	1
22	CS3104	-	Functional English	3(3+0)	1
23	CS3203	-	Pakistan Studies/Islamic Studies	3(3+0)	2
24	CS4302	22	Communication Skills	3(3+0)	3
25	CS6701	-	Technical and Scientific Writings	3(3+0)	7
26	CS6802	-	Professional Practices	3(3+0)	8
Total Credit Hours				18	

4. Computer Science - Core Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
27	CS5504	2, 8, 10, 11	Information Security	3(3+0)	5
28	CS4404	1, 5, 6	Theory of Automata	3(3+0)	4
29	CS4305	5	Artificial Intelligence	3(3+0)	3
30	CS5501	1, 6	Design and Analysis of Algorithms	3(3+0)	5
31	CS5601	4	Computer Organization and Architecture	4(4+0)	6
32	CS5605	-	Applied Image Processing	3(2+1)	6
33	CS6801	1, 29	Natural Language Processing	3(3+0)	8
Total Credit Hours				22	

5. Computer Science - Supporting & University Elective Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
34	CS3201	18	Multivariate Calculus	3(3+0)	2
35	MATH-432	2	Computation in MATLAB	3(2+1)	3
36	BES-475	-	Geographic Information System	3(3+0)	5
37	BA565	-	Entrepreneurship	3(3+0)	7
Total Credit Hours				12	

6. 7th Semester Specializations Elective Courses

Please use the following abbreviations for specializations:

GT - General Track

WE - Web Engineering

CN - Computer Networks

DS - Database Systems

SE - Software Engineering

PR - Pattern Recognition

#	Course Code	Pre Req.	Course Title	Credit Hours	GT	WE	CN	DS	SE	PR
38	CS6703	1, 28	Compiler Construction	3(3+0)	✓					
39	CS6704	21, 11	E-Commerce Technologies & Applications	3(3+0)	✓	✓				
40	CS6705	29	Expert Systems	3(3+0)	✓			✓		
41	CS6706	13, 31	Introduction to Parallel Computing	3(3+0)	✓					
42	CS6721	11	Information Architecture	3(3+0)	✓	✓		✓	✓	
43	CS6722	11	Web Content Management Systems	3(2+1)	✓	✓		✓	✓	
44	CS6723	11, 13, 14	Web Engineering	3(3+0)	✓	✓			✓	
45	CS6731	10	Routing and Switching	3(3+0)	✓		✓			

46	CS6732	1, 10	Internet of Things(IoT)	3(3+0)	✓		✓			
47	CS6733	10, 13	Network Programming	3(3+0)	✓		✓			
48	CS6734	10	Wireless and Mobile Networks	3(3+0)	✓		✓			
49	CS6741	8	Advanced Database Systems	3(3+0)	✓			✓	✓	
50	CS6742	8	Fundamentals of Data Warehousing	3(3+0)	✓			✓		
51	CS6751	-	Usability Engineering	3(3+0)	✓	✓			✓	
52	CS6752	13, 14	Computer Aided Software Engineering	3(3+0)	✓				✓	
53	CS6753	14	Software Architecture and Design	3(3+0)	✓	✓			✓	
54	CS6761	6, 29	Natural Computation	3(3+0)	✓			✓		✓
55	CS6762	6, 13, 18, 19, 20	Introduction to Neural Networks	3(3+0)	✓			✓		✓

7. 8th Semester Specializations Elective Courses

Please use the following abbreviations for specializations:

GT - General Track

WE - Web Engineering

CN - Computer Networks

DS - Database Systems

SE - Software Engineering

PR - Pattern Recognition

#	Course Code	Pre Req	Course Title	Credit Hours	GT	WE	CN	DS	SE	PR
56	CS6804	2, 20	Computer Graphics and Imaging	3(2+1)	✓					✓
57	CS6805	18, 20, 34	Numerical Computing	3(2+1)	✓					
58	CS6806	18, 20, 29	Digital Image Processing	3(3+0)	✓					✓
59	CS6807	10	Telecommunication Systems	3(3+0)	✓		✓			
60	CS6808	7, 10	Network Security	3(3+0)	✓		✓			
61	CS6809	-	Introduction to Bioinformatics	3(3+0)	✓			✓	✓	
62	CS6810	19	Differential Equations	3(3+0)	✓					
63	CS6821	11,13, 19, 20	Information Retrieval and Web Search	3(3+0)	✓	✓		✓	✓	
64	CS6822	11, 13	Service-Oriented Architecture	3(3+0)	✓	✓			✓	
65	CS6823	15	Wearable Technology	3(3+0)	✓	✓				
66	CS6831	48	Emerging Computer Networks	3(3+0)	✓		✓			
67	CS6832	10	Network Administration	3(3+0)	✓		✓			
68	CS6841	8	Big Data Concepts	3(3+0)	✓	✓		✓	✓	

69	CS6842	8	Database Administration	3(3+0)	✓			✓		
70	CS6843	-	ETL (Extract, Transform, Load) Programming	3(3+0)	✓			✓		
71	CS6851	14	Software Project Management	3(3+0)	✓	✓		✓	✓	
72	CS6852	13, 14	Software Testing	3(3+0)	✓				✓	
73	CS6853	12, 13, 14	Open Source Development	3(3+0)	✓	✓		✓	✓	
74	CS6861	6, 13, 19, 20	Machine Learning	3(3+0)	✓			✓		✓

Revision at a Glance

During revision, the following changes and additions are performed in each of the semester and specializations elective courses.

Semester I			
Course Code	Course Title	Credit Hours	Remarks
CS3101	Fundamentals of Computers	3(2+1)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated • Lab is included
CS3102	Calculus and Analytical Geometry	3(3+0)	<ul style="list-style-type: none"> • New course is added in place of Mathematicians-1 • Course code is changed
CS3103	Probability and Statistics	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3104	Functional English	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3105	Programming Fundamentals	4(3+1)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated • Lab is included
Total Semester Credit Hours:		16	

Semester II			
Course Code	New Title	Credit Hours	Remarks
CS3201	Multivariate Calculus	3(3+0)	<ul style="list-style-type: none"> • New course is added in place of Mathematicians-1 • Course code is changed
CS3202	Discrete Structures	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Contents are changed • Books are updated

CS3203	Pakistan Studies/Islamic Studies	3(3+0)	<ul style="list-style-type: none"> • Course code is changed
CS3204	Object Oriented Programming	4(3+1)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3205	Digital Logic Design	3(2+1)	<ul style="list-style-type: none"> • Moved from semester III • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		16	

Semester III			
Course Code	New Title	Credit Hours	Remarks
MATH-432	Computation in MATLAB	3(2+1)	<ul style="list-style-type: none"> • New course is added in place of Electronics • Course code is changed • Code from the Department of Mathematics is used
CS4301	Data Structures and Algorithms	4(3+1)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Contents are changed • Books are updated • Lab is added
CS4302	Communication Skills	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are kept same • Books are updated
CS4303	Data Communication	3(3+0)	<ul style="list-style-type: none"> • New course is added • New code is used
CS4304	Linear Algebra	3(3+0)	<ul style="list-style-type: none"> • New course is added • New code is used
CS4305	Artificial Intelligence	3(3+0)	<ul style="list-style-type: none"> • Moved from semester V • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		19	

Semester IV			
Course Code	New Title	Credit Hours	Remarks
CS4401	Database Systems	4(3+1)	<ul style="list-style-type: none"> • Moved from semester III • Course code is changed • Title is changed • Contents are changed • Books are updated
CS4402	Operating Systems	4(3+1)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS4403	Computer Networks	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Contents are changed • Books are updated
CS4404	Theory of Automata	3(3+0)	<ul style="list-style-type: none"> • Moved from Semester VI • Course code is changed • Title is changed • Contents are changed • Books are updated
CS4405	Web Technologies	4(3+1)	<ul style="list-style-type: none"> • Course is moved from Semester V • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		18	

Semester V			
Course Code	New Title	Credit Hours	Remarks
CS5501	Design and Analysis of Algorithms	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Contents are changed • Books are updated
CS5502	Object Oriented Analysis and Design	3(2+1)	<ul style="list-style-type: none"> • New course is added in place of Software Engineering - I • Course code is changed
CS5503	Advanced Programming	4(3+1)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS5504	Information Security	3(3+0)	<ul style="list-style-type: none"> • New course is added.

			<ul style="list-style-type: none"> • New code is used
BES-475	Geographic Information System	3(3+0)	<ul style="list-style-type: none"> • New course is added in place of Human Resource Management • Course code is changed • Code from the Department of Environmental Science is used
Total Semester Credit Hours:		16	

Semester VI			
Course Code	New Title	Credit Hours	Remarks
CS5601	Computer Organization and Architecture	4(4+0)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Contents are changed • Books are updated
CS5602	Software Engineering	3(3+0)	<ul style="list-style-type: none"> • New course is added in place of Software Engineering - II • New course code is used
CS5603	Mobile Applications Development	4(3+1)	<ul style="list-style-type: none"> • Course moved from electives of semester VIII • New course code is used • Title is changed • Contents are changed • Books are updated
CS5604	Human Computer Interaction	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS5605	Applied Image Processing	3(2+1)	<ul style="list-style-type: none"> • New course is added • New course code is used
Total Semester Credit Hours:		17	

Semester VII			
Course Code	New Title	Credit Hours	Remarks
CS6701	Technical and Scientific Writing	3(3+0)	<ul style="list-style-type: none"> • New course is added • New code is used
BA565	Entrepreneurship	3(3+0)	<ul style="list-style-type: none"> • New course is added • Course code is changed • Code from the Department of IM Studies is used
CS6702	FYP-I	3(0+3)	<ul style="list-style-type: none"> • Course code is changed • Title is changed
CS67XX	Specialization Elective - I	3	<ul style="list-style-type: none"> • Remarks are shown in the 7th

			semester specializations elective courses table
CS67XX	Specialization Elective - II	3	<ul style="list-style-type: none"> • Remarks are shown in the 7th semester specializations elective courses table
Total Semester Credit Hours:		15	

Semester VIII			
Course Code	New Title	Credit Hours	Remarks
CS6801	Natural Language Processing	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6802	Professional Practices	3(3+0)	<ul style="list-style-type: none"> • New course is added • New code is used
CS6803	FYP-II	3(0+3)	<ul style="list-style-type: none"> • Course code is changed • Title is changed
CS68XX	Specialization Elective - III	3	<ul style="list-style-type: none"> • Remarks are shown in the 8th semester specializations elective courses table
CS68XX	Specialization Elective - IV	3	<ul style="list-style-type: none"> • Remarks are shown in the 7th semester specializations elective courses table
Total Semester Credit Hours:		15	

7th Semester Specializations Elective Courses			
Course Code	Course Title	Credit Hours	Remarks
CS6703	Compiler Construction	3(3+0)	<ul style="list-style-type: none"> • Course moved into electives from semester VII • Course code is changed • Content are changed • Books are updated
CS6704	E-Commerce Technologies & Applications	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Content are changed • Books are updated
CS6705	Expert Systems	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Content are changed • Books are updated
CS6706	Introduction to Parallel	3(3+0)	<ul style="list-style-type: none"> • New course is added

	Computing		<ul style="list-style-type: none"> • New course code is used
CS6721	Information Architecture	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6722	Web Content Management Systems	3(2+1)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6723	Web Engineering	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6731	Routing and Switching	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6732	Internet of Things (IoT)	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6733	Network Programming	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6734	Wireless and Mobile Networks	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6741	Advanced Database Systems	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6742	Fundamentals of Data Warehousing	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6751	Usability Engineering	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6752	Computer Aided Software Engineering	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6753	Software Architecture and Design	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6761	Natural Computation	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6762	Introduction to Neural Networks	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used

8th Semester Specializations Elective Courses			
Course Code	Course Title	Credit Hours	Remarks
CS6804	Computer Graphics and Imaging	3(2+1)	<ul style="list-style-type: none"> • Course code is changed • Title is changed • Content are changed • Books are updated
CS6805	Numerical Computing	3(2+1)	<ul style="list-style-type: none"> • Course moved into electives from semester VI • Course code is changed • Title is changed • Content are changed

			<ul style="list-style-type: none"> • Books are updated
CS6806	Digital Image Processing	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Content are changed • Books are updated
CS6807	Network Security	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Content are changed • Books are updated
CS6808	Telecommunication Systems	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Content are changed • Books are updated
CS6809	Introduction to Bioinformatics	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6810	Differential Equations	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6821	Information Retrieval and Web Search	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6822	Service-Oriented Architecture	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6823	Wearable Technology	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6831	Emerging Computer Networks	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6832	Network Administration	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6841	Big Data Concepts	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6842	Database Administration	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6843	ETL (Extract, Transform, Load) Programming	3(3+0)	<ul style="list-style-type: none"> • Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6851	Software Project Management	3(2+1)	<ul style="list-style-type: none"> • Course moved into electives from semester VIII • Course code is changed • Title is kept same • Content are changed

			<ul style="list-style-type: none"> • Books are updated
CS6852	Software Testing	3(2+1)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6853	Open Source Development	3(2+1)	<ul style="list-style-type: none"> • New course is added • New course code is used
CS6861	Machine Learning	3(3+0)	<ul style="list-style-type: none"> • New course is added • New course code is used

Courses Archived

The following courses are archived due to not offering any more.

#	Course Code	Course Title	Status
1	CS312	Mathematics - I	Semester - I
2	CS322	Mathematics - II	Semester - II
3	CS323	Physics	Semester - II
4	CS432	Database - I	Semester - III
5	CS435	Electronics	Semester - III
6	CS441	Database - II	Semester - IV
7	CS444	Computer Organization and Assembly Language	Semester - IV
8	CS445	Data Communication and Networking	Semester - IV
9	CS446	Psychology	Semester - IV
10	CS557	Human Resource Management	Semester - IV
11	CS566	Foreign and Regional Language	Semester - VI
12	CS674	Digital Signal Processing	Elective - Semester VII
13	CS677	Data Mining and Data Warehousing	Elective - Semester VII
14	CS678	Management Information System	Elective - Semester VII
15	CS679	Distributed Computing	Elective - Semester VII
16	CS242	Programming Languages II	Elective - Semester VII
17	CS356	Network Strategies	Elective - Semester VII
18	CS687	Database Administration	Elective - Semester VIII
19	CS686	Modeling and Simulation`	Elective - Semester VIII
20	CS689	Multimedia Technologies	Elective - Semester VIII

Semester I Courses

Course Code	Course Title	Credit Hours
CS3101	Fundamentals of Computers	3(2+1)

Prerequisites: Nil

Course Description: This course is designed for students with little or no computer experience. This course introduces computer concepts, hardware components, basic computer operations and use of software applications to solve problems. Students will have complete understanding and use of personal computers and application software such as Microsoft Word, Excel and PowerPoint.

Aims and Objectives: Students successfully completing this course should be able to:

- Develop a vocabulary of key terms related to the computer and to software programs.
- Identify the components of a personal computer system.
- Demonstrate mouse and keyboard functions.
- Demonstrate window and menu commands and how they are used.
- Demonstrate how to organize files and documents on a USB/hard drive.
- Compose, format and edit a word document.
- Send email messages and navigate and search through the internet.

Course Contents: Data and Information, Information Processing Cycle, Components of a Computer, Advantages and Disadvantages of Using Computers, Categories of Computers, Computer Applications in Society. Keyboard and Pointing Devices, Types of Input, Input for Smart Phones, Game Controllers, Digital Cameras, Voice Input, Video Input, Scanners and Reading Devices, Biometric Input, Terminals. Display Devices, LCD Monitors and LCD Screens, Plasma Monitors, CRT Monitors, Printers, Nonimpact Printers, Impact Printers, Speakers, Headphones, Data Projectors. Interactive Whiteboards, Storage, Hard disks, Flash Memory Storage, Solid State Drives, Memory Cards, USB Flash Drives, Cloud Storage, Optical Discs, Blue-Ray Discs, Magnetic Tapes, Magnetic Stripe Cards and Smart Cards, Microfilm and Microfiche, Enterprise Storage. Motherboard, Processor, Control Unit, Arithmetic Logic Unit, Machine Cycle. Data Representation, Memory Sizes, Types of Memory, RAM, Cache, ROM, Flash Memory. System Software, Operating Systems, Utility Programs. Application Software, Business Software, Graphics and Multimedia Software, Software for Home, Personal, and Educational Use, Web Applications. Application Software for Communications. Internet, World Wide Web, Networks, Intranets. Enterprise Computing, Computer Security Risks, Viruses. Introduction to MS Word, MS Excel, MS PowerPoint.

Recommended Books

1. Shelly, G. B., & Vermaat, M. E. (2012). *Discovering computers fundamentals: your interactive guide to the digital world (Latest ed.)*. Cengage Learning.

Bibliography

1. Sawyer, S. C., & Williams, B. (2000). *Introduction to Using Information Technology (Latest ed.)*. McGraw-Hill Higher Education.

2. Brookshear, G. G., & Brookshear, J. G. (2002). *Computer science: an overview (Latest ed.)*. Addison-Wesley Longman Publishing Co., Inc.
3. O'Leary, T. (2010). *Computing Essentials (Introductory ed.)*. Career Education.
4. Sinha, P.K.(2007). *Computer Fundamentals (6th ed.)*. BPB publication.

Course Code	Course Title	Credit Hours
CS3102	Calculus and Analytic Geometry	3(3+0)

Prerequisites: Nil

Course Description: The course focuses on differential and integral calculus and other topics that are relevant to an undergraduate program studies.

Aims and Objectives:

- The aim of this course is to give students background of calculus necessary for the proposed computer science studies in the curriculum.

Course Contents: 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 Trigonometric Functions, Derivatives of Inverse Trigonometric Functions; Hyperbolic Functions. Conic Sections, Parameterized 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.

Recommended Books

1. Thomas, G. B., & Finney, R. L. (1995). *Calculus and Analytic (10th Ed.)*. Addison Wesley.
2. Swokowski, E. W. (1194). *Calculus and Analytical Geometry (6th Ed.)*. Brooks/Cole Publishers.
3. Anton, H., Bivens, I., & Davis, S. (2012). *Calculus (10th Ed.)*. Hoboken: Wiley.
4. Anton, H., Bivens, I. C., & Davis, C. (2012). *Calculus (10th Ed.)*. Wiley.
5. Anton, H. (1995). *Calculus with Analytic Geometry: Student Solution Manual (5th Ed.)*. Wiley.

Course Code	Course Title	Credit Hours
CS3103	Probability and Statistics	3(3+0)

Prerequisites: Nil

Course Description: Probability has extensive application in many computer science disciplines. This course is intended to fill the gap in students' knowledge of probability.

Aims and Objectives: After completing the course, the student will be able to:

- Understand some advanced probability concepts and use them for problem solving in computer science.

Course Contents: Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. 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, Discrete, Probability Distributions. Continuous Probability Distributions.

Recommended Books

1. Baron, M. (2014). *Probability and Statistics for Computer Scientists* (2nd ed.). CRC Press, Taylor and Francis Group, U.S.
2. Ross, S. (2009). *Probability and statistics for engineers and scientists* (4th Ed.). Elsevier.
3. Hayter, A. (2012). *Probability and statistics for engineers and scientists (Latest ed.)*. Nelson Education.
4. Schiller, J., Srinivasan, R. A., & Spiegel, M. (2008). *Schaum's Outline of Probability and Statistics* (3rd Ed.). McGraw Hill Professional.

Course Code	Course Title	Credit Hours
CS3104	Functional English	3(3+0)

Prerequisites: Nil

Course Description: This course focuses on teaching of basic language skills: reading, speaking, writing, and listening. The aim is to give students good foundations in basic English with a focus on both accuracy and fluency required for academic progress as well performing specific functions in real life. The course will equip students with the ability to: ask/answer questions, make suggestions, express certainty/uncertainty, give reasons, ask for permission, describe things, agree and disagree, and express likes and dislikes, etc.

Aims and Objectives: After completing the course, the students will be able to:

1. Use grammar and language structure in context.
2. Teaching English through use.

3. Teach different language structures needed in different situations.
4. Make learning English a meaningful and interesting activity

Course Contents: Course contents are divided into the following functions:

Function Asking and Answering Questions

- | | | |
|----|-----------|--|
| a) | Structure | The Present Perfect |
| b) | Reading | Guessing the Meanings of Words |
| c) | Writing | Informal Letters: Beginning and Ending |
| d) | Listening | Understanding Directions |

Function Seeking Agreement and Confirmation

- | | | |
|----|-----------|---|
| a) | Structure | The Present Perfect and Simple Past Tense |
| b) | Reading | Guessing the Meanings of Words |
| c) | Writing | Joining Sentences |
| d) | Listening | Listening to a Narrative Account |

Function Agreeing and Disagreeing

- | | | |
|----|-----------|------------------|
| a) | Structure | Reported Speech |
| b) | Reading | Predicting |
| c) | Writing | Informal Letters |
| d) | Listening | Giving Advice |

Function Possibility/Impossibility

- | | | |
|----|-----------|---------------------------|
| a) | Structure | Conditionals |
| b) | Reading | Skimming and Scanning |
| c) | Writing | Formal Letters |
| d) | Listening | Listening to Talk/Lecture |

Function Certainty/Uncertainty: Obligations

- | | | |
|----|-----------|---------------------------|
| a) | Structure | The Passive |
| b) | Reading | Function in a Text |
| c) | Writing | Formal Letters |
| d) | Listening | Listening to an Interview |

Function Preferences/Interactions

- | | | |
|----|-----------|--|
| a) | Structure | The ing Form |
| b) | Reading | Reading the Main Idea and Supporting Details in Text |
| c) | Writing | Formal Letters |
| d) | Listening | Listening to a Talk/Lecture |

Function Permission

- | | | |
|----|-----------|---|
| a) | Structure | The Past Perfect and Future Perfect Tense |
| b) | Reading | Classification |
| c) | Writing | Applying for a Job |
| d) | Listening | Listening to a Radio Broadcast |

Function		Appreciation, Regret and Indifference
a)	Structure	Relative Clauses
b)	Reading	Thematization
c)	Writing	Note Taking
d)	Listening	To an Argument

Function		Suggesting/Warning
a)	Structure	Relative Clauses
b)	Reading	Facts and Opinion
c)	Writing	Summarizing
d)	Listening	Listening to a Story.

Recommended Books

1. Bloor, T., & Bloor, M. (2013). *The functional analysis of English (Latest ed.)*. Routledge.
2. Klammer, T. P., Schulz, M. R., & Della Volpe, A. (2000). *Analyzing English Grammar (6th ed.)*. Pearson Education India.
3. CA Exams Study Text. (2015). *Functional English AFC 01 (Latest ed.)*. Emile Wolf International.

Course Code	Course Title	Credit Hours
CS3105	Programming Fundamentals	4(3+1)

Prerequisites: Nil

Course Description: This is the first programming courses in this program. It provides the core knowledge to begin programming. The course covers creating programs to explore data types, conditions, loops, variables, and expressions; working with different kinds of data and seeing how they affect memory.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the motivation for programming for a Computer Science (CS) graduate.
- Understand the basic components of a program development environment.
- Analyze a problem and devise a solution for it.
- Implement small programs.
- Define a problem and implement its sub-problems using functions.

Course Contents: Introduction to Programming and Importance for a CS Graduate, Basics of Programming and Software Development, C++ Development Environment and Basic Program Construction, Header Files and Library Files, Variables and Data Types, Operators (Arithmetic, Logical, Increment, Decrement) and Precedence, Type Conversion, Input and Output Statements in C++, IF Statement, IF -ELSE Statement, ELSE-IF Statement, Conditional Operator Switch Statement, GOTO Statement, Arrays, One Dimensional and Two Dimensional Arrays, FOR Loop, Nested FOR loops, Loops with Arrays, WHILE Loop, DO-WHILE Loop, Break

Statement, Continue Statement, Functions and its Importance, Parts of Functions, Passing Arguments to Functions, Returning Values from Functions, Inline Functions, Default Arguments, Recursion, Strings, String Manipulation Functions, Structures and its Importance, Declaring Structures and Structures Variables, Accessing Structures Members, Nested Structures, Passing Structures Function, Enumerations, Array of Structures, Pointers and its Importance, Pointers and Arrays, Pointers and Function (Call by Value and Call by Reference), Pointers and Strings, File Handling in C++, Reading from a File, Writing to a File.

Recommended Books

1. Deitel, P., & Deitel, H. (2016). *C++ How to Program (Latest ed.)*. Prentice Hall.
2. Lafore, R. (2005). *Object-oriented programming in C (Latest ed.)*. Indianapolis, Ind: Sams.

Bibliography

1. Sahay, S. (2012). *Object oriented programming with C (Latest ed.)*. Oxford University Press.
2. Kanetkar, Y. (2004). *Basic programming in C++ (Latest ed.)*. BPB Publications.

Semester II Courses

Course Code	Course Title	Credit Hours
CS3201	Multivariate Calculus	3(3+0)

Prerequisites: Calculus and Analytical Geometry

Course Description: This is an extension of single variable calculus. It focuses on the calculus as it applies to functions of two or more variables. The concept learnt in this course will be useful in analyzing geometry of curves and surfaces.

Aims and Objectives: On completing this course, students will have:

- An understanding of the basic concepts of multivariable calculus.
- Fluency with such concepts as parametric curves, matrix algebra, gradients, directional derivatives, and multiple integrals will be gained.
- Physical interpretation of these concepts and application in constrained-unconstrained optimization will be acquired.

Course Contents: Calculus of parametric curves, polar coordinates, coordinates and vectors in three-dimensions, dot and cross products, lines and planes in three-dimensions, conic sections and quadratic surfaces, parametric curves in three-dimensions, functions of two and three variables, partial derivatives, tangent planes and differentiability, the chain rule, the gradient and directional derivatives, maxima and minima, Lagrange multipliers, double integrals over rectangles and general regions, double integrals in polar coordinates, applications of double integrals, surface area as double integral, triple integral, cylindrical and spherical coordinates, vector fields and line integrals, Greens theorem, divergence and curl, Stokes theorem, divergence theorem.

Recommended Books

1. Stewart, J., & Cole, B. (2015). *Multivariable Calculus* (8th ed.). Cengage Learning.
2. Briggs, W. L., Cochran, L., & Gillett, B. (2014). *Multivariable Calculus* (2nd ed.). Pearson Education India.

Course Code	Course Title	Credit Hours
CS3202	Discrete Structures	3(3+0)

Prerequisites: Calculus and Analytical Geometry, Multivariate Calculus

Course Description: This course is designed to provide students of computer science with several topics and ideas that will help them to develop and analyze algorithms as well as enable them to think about and solve problems in new ways. This course introduces the discrete structures that can be applied to computer science problems.

Aims and Objectives: When students complete this course, they will be able to:

- Express a logic sentence in terms of predicates, quantifiers, and logical connectives.
- Use mathematically correct terminology and notation.

- Apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction, and mathematical induction.
- Count some different types of discrete structures.
- Use tree and graph algorithms to solve problems.

Course Contents: Evaluate Boolean Functions and Simplify Expressions using the Properties of Boolean Algebra, Propositional Logic, Rules of Propositional Logic, Predicate Logic, Symbols, Tautologies, Quantifiers, Inference Rules, Logic Programming, Recursive Function, Sets Terminology and Operations, Set Identities, Sum Rule, Product Rule, Pigeon-Hole Principle, Permutations, Combinations, Trees in Counting, Inclusion-Exclusion Principle, Discrete Probability, Trees and Graphs, Binary Trees, Recursive Definition of Binary Tree, Applications of Binary Trees, Directed and Un-directed Graphs, Adjacency Matrix, Boolean Algebra Operators and Functions, Functional Completeness, Combinational Circuits, Functions and Relations, Types of Functions and Relations, Regular Expressions, Regular Grammar, Context-Free Grammar.

Recommended Books

1. Rosen, K. H. (2012). *Discrete Mathematics, and its Applications (6th ed.)*. McGraw-Hill.

Bibliography

1. Shaum's. (1992). *Solved Problems Series in Discrete Mathematics (International ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS3203	Pakistan Studies/Islamic Studies	3(3+0)

Prerequisites: Nil

Pakistan Studies:

Course Description: This course introduces students about the historical back ground of the creation of Pakistan. It focuses on major historical events both national and international and their impact.

Aims and Objectives: The course is aimed to:

- Sensitize students about the importance of Pakistan's geographical and strategic position in South Asia.
- Promote the knowledge of Pakistani culture and civilization.
- Aware new generation about the current affairs and important pillars of Pakistan's political system

Course Contents: Ideology of Pakistan in the Historical Perspective, Two Nation Theory, Pakistan Movement, Creation of Pakistan and Role of Quaid-e-Azam, Initial Difficulties, Islamization in Pakistan, The Land of Pakistan

Recommended Books

1. Rabbani, M. I. (2001). *A comprehensive book of Pakistan Studies (3rd ed.)*. The Caravan Press, Lahore, Pakistan.

Islamic Studies:

Course Description: The purpose of the course is to introduce to students the Islamic teachings about basic beliefs, practices, Qura'n and sunnah of the holy prophet (S.A.W.S.) and social, moral and cultural aspects of Islamic way of life.

Aims and Objectives: After completing this course, the students will:

- Have knowledge of and ability to articulate major themes in the study of Islam, gender, and the state, and political system of Islam
- Be able to give an account of pluralism in modern Muslim family law
- Have developed an understanding of central themes in contemporary Muslim family law debates, as well as their historical roots.

Course Contents: Definition and Meaning of Islam, The place of Quran in Islamic World Nations, The Hadith, The Political System of Islam, The Legal System of Islam, Principles of an Islamic State and Chances of Their People.

Recommended Books

1. AbulA'laMaududi, S. (1997). *The Islamic Law and Constitution (12th ed.)*. Islamic Publications (Pvt) Ltd, Lahore, Pakistan.

Bibliography

1. Muhammad, F. N. (2000). *Islamiyat for Students (2nd ed.)*. Feroz sons (Pvt) Ltd. Lahore, Pakistan.

Course Code	Course Title	Credit Hours
CS3204	Object Oriented Programming	4(3+1)

Prerequisites: Programming Fundamentals

Course Description: This course discusses the object oriented model in programming. Students taking this course would have already taken a course on programming. This will help build good quality software using object-oriented techniques.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the importance of OOP as compared to Structured Programming.
- Understand the basic constructs of a C++ program.
- Define a problem and implement its solution using classes and objects.
- Effectively use and implement OOP analysis and design.
- Understand object-oriented programming features in C++.
- Understand object-oriented concepts and how they are supported by C++.
- Gain some practical experience of C++.

Course Contents: Object Oriented Programming (OOP) and its Significance as a Modeling Technique. Comparison of Structured Programming and OOP, Classes and Objects in C++, Abstraction, New User Defined Data Types, Creating Objects from Classes, Accessing Member, Access Specifiers, Member Functions, Defining Member Functions, Constructors and Properties, Default Constructor, Constructor Overloading, Copy Constructor, Deep Copy, Shallow Copy, Destructors, “this” Pointer, Constant Member Function, Static Variables, Accessing Static Data Member, Static Member Function, Comparison of Global Variables and Static Variable, Arrays of Objects, Pointer to Objects Templates, Function Templates, Class Templates, Data Encapsulation and Abstraction, Importance of Data Encapsulation and Abstraction, Correctly Using the Access Modifiers, Friend Functions, Composition, Aggregation, Operator Overloading, Overloading Assignment Operator, Friend Function and Operator Overloading, Unary Operators Overloading, Inheritance and Importance, Inheritance in C++, Comparison of Overloading and Overriding, Hierarchy of Inheritance, Types of Inheritance, Private Inheritance, Protected Inheritance Multiple Inheritance Problem in Multiple Inheritance, Polymorphism and Importance, Virtual Functions, Static Binding, Dynamic Binding, Abstract Classes and Concrete Classes, Virtual Destructors, Virtual Functions and Pure Virtual Functions, Virtual Functions Usage, Dynamic Dispatch, Namespaces and Using Namespaces, Memory Management and Importance, Memory Areas(Heap, Stack), Use of new Operator, malloc() and calloc() Functions Calls.

Recommended Books

1. Deitel, P., Deitel, H. (2016). *C++ How to Program (Latest ed.)*. Prentice Hall.
2. Laurence, P. (2017). *C++: The Ultimate Crash Course to Learning the Basics of C++ (Latest ed.)*. Prentice Hall.

Bibliography

1. Lafore, R. (2005). *Object-oriented programming in C (Latest ed.)*. Indianapolis, Ind: Sams.
2. Kanetkar, Y. (2004). *Basic programming in C++ (Latest ed.)*. BPB Publications.

Course Code	Course Title	Credit Hours
CS3205	Digital Logic Design	3(2+1)

Prerequisites: Nil

Course Description: This course introduces digital Logic to the students. The main objective of this course is to establish proficiency in fundamental concepts of Digital logic, and to teach the students Boolean Logic, Boolean algebra, gates, functions, multiple logic circuit designs. A key part of this course is to make the students understand the background processing in the computer.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the numbering system, boolean algebra, logic gates.
- Understand boolean functions, how to simplify them by using different techniques, and design logic circuit for them.
- Understand the combinational logic circuits, adders, subtractors, decoder/encoder, multiplexer/de-multiplexer.
- Understand the sequential logic circuits, working, purpose and circuitry of flip-flops, registers, counters and memory units.
- Understand the asynchronous sequential logic.
- Use of digital logic simulators, such that the students get hands on familiarity with the concepts they come across in the course.

Course Contents: Introduction to Numbering Systems, Conversion and Complements, Binary Arithmetic, Boolean Algebra, Boolean Functions, Standard and Canonical Forms of Boolean, Functions, Logic Gates, Implementation of Boolean Functions with AND, OR, and Not Gates. Simplification of Boolean Functions by Algebraic Manipulation, Map and Tabulation Methods, Boolean Function Implementation with NAND and NOR Gates. Combinational Logic Design and Analysis, Adders, Subtractions, Code Converters. Combinational Logic with MSI and LSI, Binary Parallel Adder, Decimal Adder, BCD Adder, Magnitude Comparator, Decoders, De-multiplexers, Encoders, Multiplexers, ROMs, PLAs and its Implementations. Sequential Logic, Introduction to Latches, Flip Flops, Types of Flip-Flops, Registers, Counters, Timing Sequence and Memory Unit. Asynchronous Sequential Logic, Digital Integrated Circuits, RTL and DTL Circuits, MOS, CMOS. Digital Logic Simulator as Logic Gate Simulator, Multimedia Logic.

Recommended Books

1. Morris, M. M. (2009). *Digital Logic and Computer Design (5th ed.)*. Pearson Education India.
2. Floyd, T. (2011). *Digital Computer Electronics (9th ed.)*. Pearson Education India.

Semester III Courses

Course Code	Course Title	Credit Hours
MATH-432	Computation in MATLAB	3(2+1)

Prerequisites: Object Oriented Programming

Course Description: This course familiarizes students with the implementation of mathematical concepts in MATLAB.

Aims and Objectives: When students complete this course, they will be able to:

- Write small programs for mathematical problems and to perform computations in MATLAB.
- Use MATLAB effectively.

Course Contents: Introduction to MATLAB Windows, Built-in Functions, Arrays, Matrices, Script Files, Plots, Functions and Function Files, Loops, Selection Statements, Polynomials, Curve Fitting and Interpolation.

Recommended Books

1. Lipsman, R. L., & Rosenberg, J. M. (2001). *A Guide to MATLAB (Latest ed.)*. Cambridge University Press Textbooks.
2. Etter, D. M., Kuncicky, D. C., & Hull, D. W. (2002). *Introduction to MATLAB 6 (Latest ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS4301	Data Structures and Algorithms	4(3+1)

Prerequisites: Programming Fundamentals

Course Description: The purpose of this course is to provide the students with solid foundations in the basic concepts of programming: data structures and algorithms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter. This course is also about showing the correctness of algorithms and studying their computational complexities. This course offers the students a mixture of theoretical knowledge and practical experience.

Aims and Objectives: Students successfully completing this course should be able to:

- Be familiar with basic techniques of algorithm analysis.
- Be familiar with writing recursive methods.
- Master the implementation of linked data structures such as linked lists and binary trees.
- Be familiar with several sub-quadratic sorting algorithms including quicksort, mergesort and heapsort.

Course Contents: Introduction and Overview, Abstract Data Type, Arrays, Stacks(Push and Pop), Infix, Postfix and Prefix, Basic Operations, Queues(Insertion, Deletion, De-queues), Heap, Lists, Linked Lists, Searching(Binary and Sequential), Sorting, Sorting and Hashing, Recursion, Trees, Linked Lists Implementation, Binary Trees, B-Trees, Trees Traversal, Basic Operations, Traversals Sets, Graph, Representation of Directed and Undirected Graphs, Traversals, Minimum Cost Spanning Tree, Complexity(Space and Time).

Recommended Books

1. Miller, B. N., & Ranum, D. L. (2011). *Problem Solving with Algorithms and Data Structures Using Python (2nd Ed.)*. Franklin, Beedle & Associates Inc.
2. Lambert, K. (2014). *Fundamentals of Python: Data Structures (Latest ed.)*. Nelson Education.

Course Code	Course Title	Credit Hours
CS4302	Communication Skills	3(3+0)

Prerequisites: Functional English

Course Description: This course aims to develop students' ability to focus on the outcome, tune in to their audience and develop their message for clarity and impact. It enhances their ability to create an environment for open discussion and ongoing dialogue which is crucial for communication success.

Aims and Objectives: The course aims to:

- Enable the students to meet their real-life communication needs.
- Provide well defined goals for more effective communications
- Provide the ability to create an open environment for communication
- Provide the skill to communicate clearly
- Provide emotional intelligence to deal with difficult situations

Course Contents: Paragraph writing: Practice in writing a good, unified and coherent paragraph. Essay writing, CV and job application, Translation skills, Study skills: Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension, Academic skills: Letter/memo writing, minutes of meetings, use of library and internet, Presentation skills: Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books

1. Thomson, A. J., Martinet, A. V., & Draycott, E. (1986). *A practical English grammar (3rd Ed.)*. Oxford University Press.

2. Boutin, M., Brinand, S., and Grellet, F. (1993). *Intermediate by. Oxford Supplementary Skills (Third Impression)*. Oxford Press.
3. Nolasco, R. (1992). *Upper-Intermediate by. Oxford Supplementary Skills (Third Impression)*. Oxford Press.
4. Tomlinson, B., and Ellis, R. (1991). *Advanced by Oxford Supplementary Skills (Third Impression)*. Oxford Press. 1991. ISBN 0 19 453403 0.
5. Langan, J. (1978). *Reading and Study Skills (Latest ed.)*. Mc Graw-Hill.

Course Code	Course Title	Credit Hours
CS4303	Data Communication	3(3+0)

Prerequisites: Nil

Course Description: Data communication is the fundamental course about the concept, design and management of data over a network. This course focuses on the components of communication system, the representation of data and the transmission mechanisms. The main focus of the course is on the physical layer of the OSI model.

Aims and Objectives: When students complete this course, they will be able to:

- Identify the different components and their respective roles in a communication system.
- How the data is represented in analog and digital forms.
- Identify the transmission mechanism and the induced challenges.

Course Contents: Data Transmission Concept, Introduction to Data Communication, Advantages of Digital Communication, Communication Model, Codes for Digital Signal Transmission, Parallel and Serial Transmission, Synchronous and Asynchronous Transmission, Baseband and Broadband Transmission, Simplex, Half-duplex and Full-duplex Transmission, Modems, Types of Modems, Properties of Modems. Transmission Impairments, Attenuation, Delay Distortion, Noise, Channel Capacity, Transmission Media, Guided Transmission Media, Twisted Pair, Coaxial Cable and Optical Fiber, Wireless Transmission- Terrestrial & Satellite Microwave and Broadcast Radio, Data Encoding, Digital and Analog transmission, ASK, PSK, QAM, Digital Data & Digital Signals, Line Coding Schemes, Block Coding, Scrambling, Analog Data & Digital Signals, Pulse Code Modulation (PCM), Delta Modulation (DM), Analog Data & Analog Signals, AM, FM, PM, Data Communication Interface, Line Configuration, Interfacing, Null Modem, Point to Point and Multipoint Link, Physical Layer and Media, Analog and Digital Data, Periodic and Aperiodic signal, Sine Wave, Phase, Wavelength, Time and Frequency Domain, Composite Signal and Bandwidth, Digital Signals, Bit Rate, Bit Length, Transmission of Digital Signals, Data Rate Limits, Noiseless Channel, Nyquist Bit Rate, Noisy Channel, Shannon Capacity, Performance, Throughput, Latency, Jitter, Multiplexing, Frequency Division Multiplexing, Synchronous and Statistical Time Division Multiplexing, Spread spectrum. Error Correction and Detection, CRC, FEC etc.

Recommended Books

1. Stallings, W. (2007). *Data and Computer Communications (8th Ed.)*. Prentice Hall.

Bibliography

1. Forouzan, B. A. (2012). *Data Communications and Networking (Global Ed.)*. McGraw Hill.
2. Tenenbaum, A. S. (2003). *Computer Networks (4th Ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS4304	Linear Algebra	3(3+0)

Prerequisites: Nil

Course Description: This elementary course in linear algebra prepares students for learning advanced concepts in computer science.

Aims and Objectives: After studying this course, students will be able:

- To understand the use of linear algebra in some computer science concepts and apply it to computer science problems.

Course Contents: Introduction to Vectors. Solving Linear Equations. Elimination Factorization. Vector Spaces and Subspaces. Orthogonality. Determinants. Eigen values, and Eigenvectors. Linear Transformations. Linear Transformation, Applications of Matrices in Engineering. Graphs and Networks, Marko 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 Transform.

Recommended Books

1. Strang, G. (2009). *Introduction to Linear Algebra (4th Ed.)*. Wellesley Cambridge Press.

Bibliography

1. Poole, D. & Cole, B. (2010). *Linear algebra: A modern introduction (3rd Ed.)*. Cengage Learning.
2. Kolman, B. & Hill, D. (2007). *Elementary Linear Algebra with Applications (9th Ed.)*. Prentice Hall.
3. Strang, G. & Coonley, B. (2005). *Strang's Linear Algebra And Its Applications (4th Ed.)*. Brooks/Cole.
4. Anton, H. (2005). *Elementary Linear Algebra: Applications Version (9th Ed.)*. Wiley.

Course Code	Course Title	Credit Hours
CS4305	Artificial Intelligence	3(3+0)

Prerequisites: Programming Fundamentals, Discrete Structures

Course Description: Artificial intelligence (AI) is an area of computer science that emphasizes the creation of intelligent machines that work and reacts like humans. This course introduces Artificial Intelligence. It covers the basics of modern AI as well as some of the representative applications of AI.

Course Contents: Basic Concepts: Intelligence, Artificial Intelligence, Branches of Artificial Intelligence. Tools: Prolog language, LISP language, Expert System Shells. Techniques: Searching (Blind search, knowledge-directed search); Knowledge Representation (Logic, Rules, Semantic Networks, scripts). Applications: Natural Language Processing, Expert Systems

Recommended Books

1. Partridge, D. (1986). *Artificial intelligence: applications in the future of software engineering (Latest ed.)*. Halsted Press.
2. Rich, E., & Knight, K. (1991). *Artificial intelligence (Latest ed.)*. McGraw-Hill, New. York.
3. Tanimoto, S. T. (1987). *The Elements of Artificial Intelligence: An Introduction Using LISP (Latest ed.)*. Computer Science Press, W.H.Freeman and Company.
4. Orban, G. A., & Nagel, H. H. (2012). *Artificial and biological vision systems (Latest Editoin)*. Springer Publishing Company, Incorporated.
5. Luger, G. F. (2005). *Artificial intelligence: structures and strategies for complex problem solving (Latest ed.)*. Pearson education.

Bibliography

1. Jones, M. T. (2015). *Artificial Intelligence: A Systems Approach: A Systems Approach (Latest ed.)*. Jones & Bartlett Learning.

Semester IV Courses

Course Code	Course Title	Credit Hours
CS4401	Database Systems	4(3+1)

Prerequisites: Data Structures and Algorithms

Course Description: Establish proficiency in the fundamental concepts of database systems and the database system development life cycle of an enterprise database.. It discusses the theoretical foundations of database architecture, Relational Algebra and Relational calculus. This course also focuses on the principles, design and implementation of multi-user databases and its applications in client/server environment.

Aims and Objectives: When students successfully complete this course, they will be able to:

- Understand intricacies involved in the design and implementation of a database system.
- Have in-depth knowledge of entity-relationship (ER) modeling
- Demonstrate competence with the fundamental tasks involved in gathering and analyzing user requirements, build conceptual, logical, and physical data models that reflect the organization's requirements.
- Apply normalization techniques.
- Query a relational DBMS to create and maintain databases in a client server environment.

Course Contents: Introduction to database systems, The Relational Data Model, Relational Algebra and Relational Calculus, Database environment, Database Management System, Conceptual database modeling using the entity-relationship model and Enhanced Entity-Relationship modeling, Schema quality through the study of functional dependencies and normalization, Logical and Physical Database Design, The SQL (DDL, DML, and DCL), Database application development, data integrity, constraints (entity integrity, referential integrity, domain integrity etc.), Database Transaction Management.

Recommended Books

1. Connolly, T. M., & Begg, C. E. (2014). *Database Systems: A Practical Approach To Design, Implementation And Management (6th Ed.)*. Addison Wesley Publishing Company.

Bibliography

1. Ramakrishnan, R., & Gehrke, J. (2003). *Database Management Systems (3rd Ed.)*. WCB/McGraw Hill.
2. Elmasri, R., & Navathe, S.B. (2016). *Fundamentals of Database Systems (Global Ed.)*. Pearson Education Limited.
3. Hoffer, J., Venkataraman, R., & Topi, H. (2015). *Modern database management (Latest ed.)*. Prentice Hall Press.
4. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). *Database system concepts (4th Ed.)*. New York: McGraw-Hill.

Course Code	Course Title	Credit Hours
CS4402	Operating Systems	4(3+1)

Prerequisites: Programming Fundamentals, Data Structure and Algorithms

Course Description: This course will introduce the core concepts of operating systems, such as processes and threads, scheduling, synchronization, memory management, file systems, input and output device management and security. The course will consist of assigned reading, weekly lectures, a midterm and final exam, and a sequence of programming assignments. The goal of the readings and lectures is to introduce the core concepts. The goal of the programming assignments is to give students some exposure to operating system code. Students are expected to read the assigned materials prior to each class, and to participate in in-class discussions.

Aims and Objectives: When students complete this course, they will be able to:

- To understand the services provided by and the design of an operating system.
- To understand what a process is and how processes are synchronized and scheduled.
- To understand different approaches to memory management.

Course Contents: Introduction & Overview, Computer Organization, Interrupts, Components of Operating System, Processes & PCB, Process Creation, Process Management, Processes, Process States, Process State Models, Inter-Process Communication, Process Scheduling, Threads, Synchronization Issues, Busy Waiting Algorithm & Bakery Algorithm, TSL & Priority Inversion, Semaphores, Classical Synchronization Problems, Dead Locks, Deadlock Detection, Deadlock recovery, Deadlock Avoidance, Deadlock Prevention, Memory management, Real Memory Organization and Management, Virtual Memory Organization: Paging, Segmentation, Virtual Memory Management: Placement, Replacement, and Fetch Strategies Input Output Management, File System.

Recommended Books

1. Silberschatz, A., Galvin, P. B., Gagne, G., & Silberschatz, A. (2012). *Operating system concepts (9th Ed.)*. John Wiley & Sons.

Bibliography

1. Ritchie, C. (2003). *Operating Systems (4th Ed.)*. BPB Publications.

Course Code	Course Title	Credit Hours
CS4403	Computer Networks	3(3+0)

Prerequisites: Data Communication

Course Description: This course familiarizes the students about the fundamental concepts of computer networks, its components and design. The main focus is on the data link, network and

transport layers. The course discusses the design, working and different protocols working on these layers.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the fundamental concepts of networking.
- Know different protocols and working.
- Identify the challenges involved in data flow and error control.

Course Contents: Networking Concepts, Topologies: Bus, Star, Ring, Tree, Mesh, Need of Networks, Peer- to-Peer networks, Client- Server Networks, Hybrid Networks, Network Models, TCP/IP Model, OSI Model, Data Link Layer, Error Detection/Correction & Control Techniques, Error Control Techniques, Stop and Wait ARQ, Go-Back-N ARQ, Selective-Reject ARQ, High Level Data Link Control Protocols (HDLC, Stop & Wait, Sliding Window, Access Techniques, Random Access techniques, Aloha, Slotted Aloha, CSMA, CSMA/CD, Controlled Access Techniques, Reservation, Token Passing , Internetworking Devices, Hubs, Switches, Routers. NICs, Switching Techniques, Circuit and Packet Switching, Message Switching, Structure of a Switch, LAN Architectures, Wired LANs, IEEE Standards, Ethernet, Fast and Gigabit Ethernet, Logical Addressing, IPv4 and IPv6 Addressing and Packet Structure, Transition from IPv4 to IPv6, ICMPv6, IGMP, Forwarding and Routing, Unicast and Multicast Routing Protocols, UDP, TCP and SCTP Protocols, Fundamentals of DNS, FTP, SMTP, WWW, HTTP and SNMP Protocols.

Recommended Books

1. Stallings, W. (2007). *Data and Computer Communications (8th Ed.)*. Prentice Hall.
2. Forouzan, B. A. (2007). *Data Communications and Networking (4th Ed.)*. McGraw Hill.
3. Tenenbaum, A. S. (2003). *Computer Networks (4th Ed.)*. Prentice Hall.
4. Forouzan, B. A., & Mosharraf, F. (2012). *Computer Networks: A Top-down Approach (Latest ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS4404	Theory of Automata	3(3+0)

Prerequisites: Programming Fundamentals, Discrete Structures, Data Structures and Algorithms

Course Description: This course serves as an introduction to the basic theory of Computer Science and formal methods of computation. This course will present the theory of finite automata, as the first step towards learning advanced topics, such as compiler design. It will also enable the student to apply the concepts learned in fundamental courses such as Discrete Mathematics, in a theoretical setting; in particular, the application of proof techniques. The applications of finite automata towards text processing will be discussed. This course will also develop an understanding of computation through Turing Machines.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the working of computer at abstract level.

- Design software and some electronic circuits.
- Understand the basic theory behind computer languages.
- Have a sound background for Translator software.

Course Contents: Introduction to Language: Language as a set, string, string terminologies, alphabet, operations on languages (Union, Concatenation, Kleene Closure), Language Representation: Recursive Definition, Regular Expression (Basic Regular Expressions, Complex Regular Expressions using notational short hands), Grammars, Automata Introduction: What is Automata? Types of Automata, Parts of Automata, Determinism, Finite Automata (FA): Definition of FA, Elements of FA, Nondeterministic Finite Automata (NFA), Deterministic Finite Automata (DFA), Working of FA, Regular Expression to NFA conversion, NFA to DFA conversion, Minimization of number of states in a DFA, DFA coding in C language, Kleene's Theorem: Transition Graph (TG), Generalized Transition Graph (GTG), Statement and Proof of Kleene's Theorem, Finite Automata With output: Moore Machine, Mealy Machine, Moore=Mealy, Context Free Grammars: Definition, Derivation, Problems in Context Free Grammars (Ambiguity, Left Recursion, Common Prefixes), Methods for removal of these problems, Chomsky Normal Form (CNF), Pushdown Automata (PDA): Definition of PDA, Elements of PDA, Creation of PDA i.e. CFG=FA, Touring Machines: Definition of Turing Machines, Elements of Turing Machines, Creation of Turing Machines, Pumping Lemma.

Recommended Books

1. Cohan, D. A. (1997). *Introduction to Computer Theory* (2nd Ed.).
2. Kellye, D. (1998). *Automata and Formal Languages: An Introduction* (1st Ed.). Prentice Hall.
3. Spiser, M. (2007). *Theory of Computation* (Latest ed.). Cengage Learning.

Course Code	Course Title	Credit Hours
CS4405	Web Technologies	4(3+1)

Prerequisites: Fundamentals of Computers, Object Oriented Programming

Course Description: This course provides a detailed presentation and understanding of the basic concepts and principles of the World Wide Web and the essential web development languages, tools, and technologies. Course content will focus on introducing and familiarizing students with the basic tools required for web programming including HTML, CSS, JavaScript, and server-side programming using PHP. Questions such as what are they, when should we use these languages, for what purpose and to what extent these languages help us create modern, engaging and stable websites will be covered. Students will experience how to create basic web pages with HTML, including basic structuring of page content, apply basic formatting styles using CSS, understanding JavaScript for basic interactivity and client-side scripting, and create dynamic web pages by implementing server-side script to perform operations on a web server. A key part of this course is its problem-based approach which requires students to design and create a website of ever-increasing sophistication as the course progresses.

Aims and Objectives: When students complete this course, they will be able to:

- Know the fundamentals of web application architecture and web programming.
- Apply a structured approach to identifying needs, interests, and functionality of a website.
- Design dynamic websites that meet specified needs and interests.
- Write well-structured, easily maintained, standards-compliant, accessible HTML code.
- Write well-structured, easily maintained, standards-compliant CSS code to present HTML pages in different ways.
- Use JavaScript for client-side scripting and add dynamic content to pages.
- Use PHP to implement server-side script for creating dynamic web pages and access databases.
- Design and implement an interactive web site(s) with regard to issues of usability, accessibility, and internationalisation.
- Further study web technologies, both those that exist today and those that will be developed in the future.
- Work in collaborative environment by working in group assignments.

Course Contents: History and Advantages and Disadvantages of Internet, Web Server, Web Browser, Web Clients, and Search Engines, Client-Server Architecture, Types and Categories of Websites, Creation and Basic Structure of HTML Document, HTML Tags (Headings , Paragraphs, Line Break, Horizontal Line, Font, Preformatted Text, Lists, Images, Tables, Hyperlink, Form, and Form), CSS, Inserting JavaScript Code in HTML Document, JavaScript Constructs (Variables and Rules of Naming Variables, Operators, Type Casting, Decision Control Structures, Loops, Function, Array, and DOM), Installing and Configuring Apache and PHP, Creating PHP File, Overview of Variables and Constants, Output Statement in PHP, Passing Variables Between Pages (URL, Sessions, Cookies, and Forms), Accessing and Using Database in PHP, and Database, AJAX, Introduction to Service Oriented Architecture and Web Services, Designing and Implementing Web Services with SOAP and JSON.

Recommended Books

1. Duckett, J. (2014). *Web Design with HTML, CSS, JavaScript and jQuery Set (Latest ed.)*. Wiley Publishing.
2. Nixon, R. (2015). *PHP: 20 Lessons to Successful Web Development (Latest ed.)*. McGraw-Hill Education Group.
3. Nixon, R. (2012). *Learning PHP, MySQL, JavaScript, and CSS: A step-by-step guide to creating dynamic websites (Latest ed.)*. O'Reilly Media, Inc.

Bibliography

1. Boronczyk, T., Naramore, E., Gerner, J., Scouarnec, Y. L., & Stolz, J. (2009). *Beginning PHP 6, Apache, MySQL 6 Web Development (Latest ed.)*. Wrox Press Ltd.

Semester V Courses

Course Code	Course Title	Credit Hours
CS5501	Design and Analysis of Algorithms	3(3+0)

Prerequisites: Programming Fundamentals, Data Structures and Algorithms

Course Description: This core course covers good principles of algorithm design, elementary analysis of algorithms, and fundamental data structures. The emphasis is on choosing appropriate data structures and designing correct and efficient algorithms to operate on these data structures.

Aims and Objectives: When students successfully complete this course, they will be able to:

- Understand how to design computer software.
- What can be the most efficient solution (algorithm) for the in hand problems.
- How a very time consuming task can be made very efficiently.
- How to utilize multiple cores of computer using parallelism.

Course Contents: Algorithm introduction, properties of correct algorithms, factors influencing the performance of algorithms (not in control of the programmer), of algorithms (in control of the programmer), Analysis of Algorithms: computational complexity, order of growth and runtime of an algorithm, $T(n)$, some examples to calculate the $T(n)$ of algorithms (including examples from searching and sorting), Asymptotic Notations, usefulness and limitations of the Asymptotic notation, Implementation of algorithms, rules for implementation, empirical analysis, Introduction to Generating functions, Divide and conquer approach: full exploration using examples, complete understanding of recursion, Basic Recurrences, Recurrence Solutions (e.g. using master theorem, iterative method, substitution method), Examples to calculate the $T(n)$ of recursive algorithms, Dynamic programming, Greedy algorithms, Evolutionary Algorithms, Genetic Algorithms, Swarm Optimization Algorithms, Ant Colony Optimization Algorithms, Parallel Algorithms and Parallel Programming, Introduction to supercomputing.

Recommended Books

1. Cormen, T. H. (2009). *Introduction to algorithms (Latest ed.)*. MIT press.
2. Sedgewick, R., & Flajolet, P. (2013). *An introduction to the analysis of algorithms (Latest ed.)*. Addison-Wesley.

Bibliography

1. Roosta, S. H. (2012). *Parallel processing and parallel algorithms: theory and computation (Latest ed.)*. Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS5502	Object Oriented Analysis and Design	3(2+1)

Prerequisites: Object Oriented Programming

Course Description: The course introduces the concepts and methods required for the development of large software intensive systems. The aim is to develop a broad understanding of the discipline of software engineering. The course focuses on the object-oriented approach for analysis and design. Students will understand the difference between writing programs and doing analysis and design. Problem analysis and solution design will be emphasized. Students will work in teams and will be responsible for analysis, design and implementation of a software system. Automated Software engineering tools will be introduced in several stages of the development process. It provides a brief account of associated professional and management issues.

Aims and Objectives: The course is designed to:

- Develop a working understanding of formal object-oriented analysis and design processes.
- Develop an understanding of the application of object oriented analysis and design practices from a software project management perspective.
- Provide details of software development and make students visualize software development process.
- Enable students to identify, formulate, and solve software development problems.
- Make students build object oriented analysis and design artifacts
- Introduce the techniques, skills, and modern engineering tools necessary for software engineering practice.

Course Contents: Software development life cycle (SDLC), Understanding large scale project perspective, Object Oriented Analysis and Development concepts. Analysis vs Object Oriented Analysis (OOA), Object Modeling, Object Modeling Technique (OMT), Unified Modeling Language (UML) for modeling, using UML modeling tools, OOA: Requirement gathering and development, Requirements categories FURPS+, Modeling and analyzing requirements, Analysis modeling (Scenarios, Use Case, User Stories). Requirement prioritization, verifying and validating requirements, Requirement specification, Object Oriented Design (OOD): Principles of OOD, SOLID (Single-responsibility Principle, Open-Closed Principle, Liskov Substitution Principle, Interface Segregation Principle, Dependency Inversion Principle), Identifying objects and entities, Designing Data Model (ERD), Relationships and associations. Mapping concepts, O/R Mapping, Shadow information and scaffolding, Mapping metadata, Mapping inheritance, Mapping object relationships, Mapping relational database relationships. UML modeling (structured and behavior diagrams. Concept of static, dynamic and functional model), Structural diagrams and use, Behavioral diagrams and use, User Interface (UI) design process, State machines, Architectural analysis, Architectural styles, Software implementation, Use of right tools for implementation, Selecting algorithms, Software testing: Test Case design, Levels of testing: Unit testing, Integration testing, Acceptance testing, Regression testing, Testing object-oriented systems, Use-case based testing, Class diagram based testing, Sequence diagram-based

testing, Writing and using basic unit tests, Concept of deployment and cutover, Basic deployment tasks.

Recommended Books

1. Stephens, R. (2015). *Beginning software engineering (Latest ed.)*. Indianapolis: Wrox Publishing.
2. Ambler, S. W., & Lines, M. (2012). *Disciplined Agile Delivery: A Practitioner's Guide to Agile Software Delivery in the Enterprise (1st Ed.)*. IBM Press.
3. Eriksson, H. (2004). *UML 2 toolkit (Latest ed.)*. Indianapolis, IN: Wiley Publishing.

Bibliography

1. Larman, C. (2005). *Applying UML and patterns: an introduction to object-oriented analysis and design and iterative development (3rd Ed.)*. Upper Saddle River, NJ: Prentice Hall Professional Technical Reference.
2. McConnell, S. (2004). *Code complete: Code complete: a practical handbook of software construction (2nd Ed.)*. Redmond (Washington): Microsoft Press.

Course Code	Course Title	Credit Hours
CS5503	Advanced Programming	4(3+1)

Prerequisites: Object Oriented Programming, Operating Systems

Course Description: This course comprises of advanced programming topics in the Java programming Language. This course builds on the earlier programming offered on Object Oriented Programming. Advanced concepts of program design, implementation and testing will be introduced within a framework of object oriented programming using the Java programming language.

Aims and Objectives: This course assumes that students know the basic concepts of Object Oriented Programming. When students complete this course, they will be able to:

- Create Java application using sound OOP practices.
- Create multi-threaded applications which can execute faster on current multi-core architectures.
- Create network and distributed applications.
- Create event driven Graphical User Interfaces (GUIs).
- Create Java applications connected to databases.
- Understand how Java can be used for Functional programming.

Course Contents: Java Platform, Java Virtual Machine and Portability, Classes and Object Creation in Java, OOP Concepts in Java, Data Encapsulation and Abstraction, Inheritance and Polymorphism, Abstract Classes and Interfaces in Java, Java Packages, Inner Classes and Usage, Accessing Private Members, Java Collections and Generics , Exception Handling and Importance, Throwing and Catching Exceptions, try-catch-finally Blocks, Threads and

Importance, Creating Threads, Starting Threads, Sleep, Join, Priority, Daemon Threads, Thread Synchronization and Importance, Sharing Objects Between Threads and Race Conditions, Synchronized Methods and Synchronized Blocks, wait(), notify(), notifyall(), Explicit Locks for Synchronization, features in the Java Concurrent Package, Reading and Writing String Values from a File, Preserving Object State using Serialization, Network Programming, Java Sockets and the java.net package, TCP Based Programming, UDP Based Programming, Sending Objects Over the Network Using Serialization, Java Remote Method Invocation (RMI), Graphical User Interfaces (GUIs), Event Driven Programming and using it with GUIs, Java Database Connectivity (JDBC), Functional Programming and Importance, Lambdas, Data Streams in Java.

Recommended Books

1. Deitel, H., Deitel, P. (2015). *Java How to Program (Latest ed.)*. Prentice Hall.
2. Schildt, H. (2017). *Java: A Beginners Guide (Latest ed.)*. McGraw-Hill Education.

Bibliography

1. Schildt, H. (2017). *Java: The Complete Reference (Latest ed.)*. McGraw-Hill Education.

Course Code	Course Title	Credit Hours
CS5504	Information Security	3(3+0)

Prerequisites: Object Oriented Programming, Database Systems, Computer Networks, Web Technologies

Course Description: The protection of information assets underpins the commercial viability and profitability of all enterprises and the effectiveness of public sector organizations. It should not be left to chance. If you work in an organization concerned (directly or indirectly) with valuable information assets, this practical course will enable you to understand and manage strategic and operational aspects of information security, including IT governance and risk analysis and management. It will also provide the knowledge and skills needed to plan the implementation of an information security management system that provides efficient, effective safeguards and responds to your organization's needs.

Course Objectives: When students complete this course, they will be able to:

1. Understand contemporary issues in information security management
2. Analyze and prioritize information security risks
3. Identify countermeasures and review techniques appropriate to the management of information security risks
4. Understand the policy and technology trade-offs involved in developing information security systems of adequate quality
5. Locate, read, comprehend and evaluate developments in the field as they appear in contemporary professional and research publications.

Course Contents: Security Management: Need, Aims and Objectives of Security Management, Various Approaches to Solve Security Problems, Cryptography and Security Mechanisms: Main Types of Cryptographic Mechanism, Security Services, Key Management, Cryptographic Algorithms, Network Security: Networking Security Technologies, User Identification Techniques, Authentication Protocols and Key Distribution Mechanisms, Security Solutions for a Variety of Types of Practical Networks, include LANs, WANs, Proprietary Computer Networks, Mobile Networks and Electronic Mail, Computer Security: Security Requirements/Policy, Security Models, Security Features and Mechanisms in Operating Systems, Security-related Issues of Computer Architecture, Security of Middleware, Software Protection and Web Security, Secure Electronic Commerce and other Applications, Standards and Evaluation Criteria, Database Security: Concurrency Control in Distributed Databases, Methods for Concurrency Control and Failure Recovery in Distributed Databases and the Interaction Between those Methods and Security Requirements, Adapting Access Control Policies to Relational and Object-Oriented Databases, Information Crime: History, Causes, Development and Repression through Studies of Surveys, Types of Crime, Legal Measures, and System and Human Vulnerabilities, Effects of Computer Crime, Motives and Attitudes of Hackers and other Computer Criminals.

Recommended Books

1. Stamp, M. (2011). *Information security: principles and practice (Latest ed.)*. John Wiley & Sons.
2. Stamp, M. (2003). *Information Security (Latest ed.)*. Principles and Practice, Wiley-Interscience Publishers.
3. Anderson, R.J. (2008). *Security Engineering: A Guide to Building Dependable Distributed Systems (Latest ed.)*. Wiley Publishers.
4. Layton, T. P. (2006). *Information Security: Design, Implementation, Measurement, and Compliance (Latest ed.)*. Auerbach Publications.
5. Tipton, T. P. & Krause, M. (2008). *Information Security Management Handbook (Latest ed.)*. Auerbach Publications.

Course Code	Course Title	Credit Hours
BES-475	Geographic Information System	3(3+0)

Prerequisites: Nil

Course Description: The course introduces the principles of Geographic Information System as tool for data collection and analysis.

Aims and Objectives: When students complete this course, they will be able to:

- Understand fundamental concepts and practices of Geographic Information Systems (GIS).
- Apply basic graphic and data visualization concepts.

- Demonstrate proficiency in the use of GIS tools to create maps that are fit-for-purpose and effectively convey the information they are intended to.
- Give examples of interdisciplinary applications of Geospatial Information Science and Technology.

Course Contents: Fundamentals of GIS, Components of GIS, Hardware and Software, Maps, Spatial Data (Point Line, Area) Structure (Vector, Raster), Attribute Data, Data Input, Digitizing, Scanning, Manual Coordinate Entry, Data Linkage, Use of Remotely Sensed Data and Global Positioning System in GIS, Database Systems, Types: Hierarchical, Relational, Network Types, Data Analysis and Output, Data Storage, Classification, Reclassification, Measurement Operations, Arithmetic, Geometric and Statistical Operation, Overlay and Buffering, Digital Elevation Models (DEM), Construction, Importance Calculating Slope Angle and Direction, Important Aspects in the Design of Out Maps, Data Output Types, Cartographic Tools and Visual Variable, GIS Application

Recommended Books

1. Lulla, K. P., & Dessinov, L. V. (2000). *Dynamic Earth Environments: remote sensing observations from shuttle-Mir missions (Latest ed.)*. John Wiley & Sons.
2. Rancez, A.N. (1999). *Remote Sensing for the Earth Sciences (Latest ed.)*. John Wiley & Sons. Inc.
3. Foody, G.M., & Curran, P.J. (1994). *Environmental Remote Sensing from Regional to Global scales (Latest ed.)*. John Wiley & Sons. Inc.
4. Murai, S. (Ed). (1996). *Remote Sensing Note, 2nd ed. Japan Association on Remote Sensing (Latest ed.)*.
5. Lillesand, T.M. & Kiefer, R.W, *Remote Sensing and image Interpretation (Latest ed.)*. John Wiley & Sons In..
6. Paine, D. P., & Kiser, J. D. (2003). *Aerial photography and image interpretation (Latest ed.)*. John Wiley & Sons.
7. Luder D.R. *Aerial Photographic Interpretation (Latest ed.)*.
8. Wales H.R. *Introduction to Aerial Stereo-photographs (Latest ed.)*.
9. Burroughs, P.A. (1993). *Principles of Geographic Information System for land resources assessment (Latest ed.)*. Clarendon Press Oxford.
10. Bernhardsen, T. (1992). *Geographic information Systems, The Microcomputer and modern cartography (Latest ed.)*. Pergamon press.

Semester VI Courses

Course Code	Course Title	Credit Hours
CS5601	Computer Organization and Architecture	4(4+0)

Prerequisites: Digital Logic Design

Course Description: Modern computer technology requires an understanding of both hardware and software, as the interaction between the two offers a framework for mastering the fundamentals of computing. This course covers basics of modern computer organization and architectures. The emphasis is on understanding the interaction between computer hardware and software at various levels. The students will learn the concepts of computer technology, performance evaluation, instruction set design, computer arithmetic, data path and control unit design of processors and enhancing performance with pipelining.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the underlying organization of modern computing systems.
- Understand microprocessor organization and architecture.
- Understand performance analysis and evaluation.
- Understand arithmetic logic unit and control unit implementations.
- Understand pipelined processor organization and hazards.
- Understand memory hierarchy and storage devices.
- Understand multiprocessors.

Course Contents: Computer Architecture and Importance for Computer Science Graduates, Instruction Set Architectures (ISA), Complex Instruction Set Computing (CISC), Reduced Instruction Set Computing (RISC), Operations of the Computer Hardware, Assembly Language, Registers, Data and Instruction Representation, Different Types of Instructions, Loops and IF Statements in Assembly, Supporting Procedures/Functions in Computer Hardware, Supporting Different Data Types in Hardware, Immediate and Addresses in Instructions, Compiling and Linking Processes to Convert a C/Java Program into Assembly and Converting that into Machine Code, Review of Number Systems, Signed and Unsigned Data Types, Arithmetic Operations (Subtraction, Multiplication, Division) in Hardware, Float Data Types and Arithmetic Operations on Float, Evaluating Performance of a System, Latency, Response Time, and Throughput, CPU Execution Time, Calculating CPU Execution Time for a Program, Benchmarks and Amdahl's Law, Processor Design, Building a 32-bit ALU, Processor Data path, Designing a Processor to Execute Instructions and Include Control Unit, Pipelining and Hazards in Pipelining and Solutions, Memory Hierarchy, Caches, Measuring and Improving Cache Performance, Direct Mapped Cache, Fully Associative Caches and Cache Optimizations, Virtual Memory, Virtual Machines. Storage and other I/O topics, Multiprocessors, Multi-cores and Clusters.

Recommended Books

1. Patterson, D. A., & Hennessy, J. L. (2013). *Computer Organization and Design the Hardware/Software Interface (Latest ed.)*. Morgan Kaufmann.

Bibliography

1. Hennessy, J. L., & Patterson, D. A., (2012). *Computer Architecture: A Quantitative Approach (Latest ed.)*. Morgan Kaufmann.

Course Code	Course Title	Credit Hours
CS5602	Software Engineering	3(3+0)

Prerequisites: Object Oriented Analysis and Design

Course Description: This course builds upon the concepts presented in Object Oriented Analysis and Design course. The students will be provided with more concise description of state of the art software process models and application of software engineering concepts as used in a professional software development environment. This course covers advanced theoretical concepts in software engineering and provides an extensive hands-on experience in dealing with various issues of software development. It involves a semester-long group software development project. Emphasis will be placed on agile software development methodologies for team development, quality assessment, and knowledge management in software engineering.

Aims and Objectives: After completing his course, the students will be able to:

- Use and apply different state of the art software development methodologies.
- Understand success and failure indicators, advantages, and disadvantages of different methodologies.
- Understand and apply agile software development through Extreme Programming methodology which focuses on human factor along with technical details of software development.
- Have a hands-on experience with a complete software development project simulating the industry like environment through practices of extreme programming methodology.

Course Contents: Introduction and comparison of important software process models, Predictive Models (Waterfall Model, Waterfall with Feedback, V-Model. Success and failure indicators, advantages and disadvantages), Incremental Models (Prototyping Model, Spiral Model, Rational Unified Process, advantages and disadvantages), Agile Models, Lean vs Agile Principles, Extreme Programming (XP) Process, XP Roles, Principles, Values and Practices, Planning Game, Releases and Iterations, Test Driven Development, Refactoring, Pair Programming, Collective Ownership, Continuous Integration, On-site Customer, Coding Standards, Agile Project Management Concepts, Open Source Development (OSS vs FOSS), Commercial off-the-shelf development Process Model.

Recommended Books

1. Stellman, A. (2013). *Learning Agile: Understanding Scrum, XP, Lean, and Kanban (1st Ed.)*. O'Reilly Media.

2. Stephens, R. (2015). *Beginning software engineering (1st Ed.)*. Indianapolis: Wrox Publishing.

Bibliography

1. Beck, K., & Andres, C. (2012). *Extreme programming explained: embrace change (2nd Ed.)*. Boston: Addison-Wesley.
2. Martin, R. C., Feathers, M. C., Ottinger, T. R., Langr, J. J., Schuchert, B. L., Grenning, J. W., & Wampler, K. D. (2015). *Clean code: a handbook of agile software craftsmanship (Latest ed.)*. Upper Saddle River, N.J: Prentice Hall.
3. Larman, C. (2005). *Applying UML and patterns: an introduction to object-oriented analysis and design and iterative development (3rd Ed.)*. Upper Saddle River, NJ: Prentice Hall Professional Technical Reference.

Course Code	Course Title	Credit Hours
CS5603	Mobile Applications Development	4(3+1)

Prerequisites: Programming Fundamentals, Object Oriented Programming

Course Description: This course introduces mobile applications programming. The goal of this course is to teach and train students how to design, implement, test, debug and publish smartphone applications on smartphone platforms, especially Android. Students will learn how to take their innovative ideas from conception to the apps market through a series of rigorous hands-on programming assignments and group projects. This is an introductory course aimed at undergraduate students, who have object oriented programming experience. However, there is a significant amount of programming in this course requiring a commitment on the part of the student. A key part of this course is group projects where students will work in small teams for joint problem solving.

Aims and Objectives: When students complete this course, they will be able to:

- Describe those aspects of mobile programming that make it unique from programming for other platforms.
- Critique mobile applications on their design pros and cons.
- Utilize rapid prototyping techniques to design and develop sophisticated mobile interfaces.
- Program mobile applications for the Android operating system that use basic and advanced phone features.
- Design, implement, test, debug and publish smartphone applications.
- Deploy applications to the Android marketplace for distribution.
- Create innovative and robust example mobile applications that will be valuable addition to their programming portfolio.
- Work in collaborative environments by working in group projects.

Course Contents: Android Platform and Architecture, Comparison of Android and Other Platforms, Configuring Development Environment, Activities, Services, Broadcast Receiver, Fragments, Intents, Designing Interface Using Views and Widgets, Linear Layout, Relative

Layout, Table Layout, Scrollview Layout, List View, ActionBar, Dialogs and Notification, Multi-threading, Location and Maps Services, Shared Preferences, Creating and Using Database, Content Providers, Accessing External Storage, Displaying Videos and Listing Audios Using Media Player, Accessing and Handling Sensors, Publishing and Deploying Applications on Android Market.

Recommended Books

1. Horton, J. (2015). *Android Programming for Beginners (Latest ed.)*. Packt Publishing Ltd.
2. Phillips, B., & Hardy, B. (2013). *Android programming: the beginners guide (Latest ed.)*. Pearson Education.
3. Lee, W. M. (2012). *Beginning android 4 application Development (Latest ed.)*. John Wiley & Sons.

Bibliography

1. Meier, R. (2012). *Professional Android 4 application development (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS5604	Human Computer Interaction	3(3+0)

Prerequisites: Fundamentals of Computers, Programming Fundamentals

Description: This course aims to give students some basic understanding of the area of Human Computer Interaction and introduces students to various methods and techniques that could be used to design and evaluate interactive systems.

Aims and Objectives: Students successfully completing this course should be able to:

- Demonstrate knowledge and understanding of the main concepts (conceptual model, metaphors, and paradigms) that influence human-computer interaction
- Understand to design, prototype and evaluate a user interface for an interactive system.
- Choose appropriate methods of evaluating an interactive system.

Course Contents: Human and Computer and Interactions, Human Psychology and Ergonomics, Interaction Paradigms, Usability Paradigm and Principles, Interaction Design Basics, Prototyping HCI in the Software Process, Design Rules, Implementation Support, Evaluation Techniques, Heuristic Evaluation, Cognitive Walkthrough, Participatory Design, Observational Methods, Universal Design, User Support, Cognitive Models, Socio -Organizational Issues and Stakeholder Requirements, Communication and Collaboration Models, Task Analysis, Models of the System, Modeling Rich Interaction, Groupware, Augmented Realities Pervasive and Ubiquitous Applications.

Recommended Books

1. Dix, A., & Beale, R. (2003). *Human-Computer Interaction (Latest ed.)*. Prentice Hall.
2. Rogers, Y., Sharp, H., & Preece, J. (2014). *Interaction Design (4th Ed.)*. Wiley & Sons.

Course Code	Course Title	Credit Hours
CS5605	Applied Image Processing	3(2+1)

Prerequisites: Nil

Course Description: The course provides an opportunity to students to gain an insight into applied image processing. Students will implement image processing algorithms in MATLAB or other tools and complete a graduate level project.

Aims and Objectives: When students complete this course, they will be able to:

- Implement image processing algorithms in MATLAB or other appropriate tools.
- Gain familiarity with the practical aspects of the concepts and techniques in digital image processing.

Course Contents: Intensity Transformations, Linear and Nonlinear Spatial Filtering, Filtering in the Frequency Domain, Image Restoration and Registration, Color Image Processing, Wavelets, Image Data Compression, Morphological Image Processing, Image Segmentation, Regions and Boundary Representation and Description, and Object Recognition.

Recommended Books

1. Yaroslavsky, L. P. (2016). *Advanced Digital Imaging Laboratory Using MATLAB (Latest ed.)*. IOP Publishing Ltd.
2. Yaroslavsky, L. P. (2012). *Theoretical Foundations of Digital Imaging Using MATLAB (Latest ed.)*. CRC Press.
3. Gonzalez, R. C., Woods, R. E., Eddins, S. L. (2009). *Digital Image Processing Using MATLAB (Latest ed.)*. Gatesmar Publishing.

Semester VII Courses

Course Code	Course Title	Credit Hours
CS6701	Technical Writing	3(3+0)

Prerequisites: Nil

Course Description: This course introduces students to different aspects of technical writing in the context of academic writing for computer science.

Aims and Objectives: When students complete this course, they will be able to:

- Understand requirements of technical and academic writings in computer science.
- Have familiarity of different aspects of technical writing.
- Have improved technical writing skills.
- Have understanding of how to avoid informal language in academic writing.

Course Contents: 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, Articles, Research Papers, Feasibility Reports, Project Reports, Technical Research Reports, Manuals and Documentation, Thesis. Electronic Documents, Writing Hypotheses, Questions and Evidence, Describing Mathematics, Describing Algorithms, Explaining Graphs, Figures, and Tables, Discussing Experimentation, Writing a Paper, Presentations , Introduction to Latex, Introduction to Popular Reference Management Tools such as EndNote, Mendeley.

Recommended Books

1. Zobel, J. (2009). *Writing for Computer Science (2nd Ed.)*. Springer.
2. Hardesty, R. E. (2010). *Technical and Business Writing for Working Professionals (Latest ed.)*. Xlibris Corporation.
3. Brown, B. W. (1993). *Successful Technical Writing/Instructor's Guide (Latest ed.)*. Goodheart-Willcox Publisher.

Course Code	Course Title	Credit Hours
BA565	Entrepreneurship	3(3+0)

Prerequisites: Nil

Course Description: This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Aims and Objectives: When students complete this course, they will be able to:

- Identify and assess sources of support for small businesses and entrepreneurs.
- Identify the critical factors that are used to identify business start-up ideas – including forms of ownership.
- Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.
- Identify the critical concepts of business planning.
- Increase the chances for business success.
- Seek out financing sources for start-ups.
- Discuss examples of current entrepreneurs.

Course Contents: 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.

Recommended Books

1. Hisrich, R., Peters, M., & Shepherd, D. (2012). *Entrepreneurship* (9th Ed.). McGraw-Hill/Irwin.
2. Greene, C. L. (2011). *Entrepreneurship: Ideas in Action* (5th Ed.). South-Western Educational Pub.

Bibliography

1. Bygrave, W. D. & Zacharakis, A. (2010). *Entrepreneurship* (2nd Ed.). Prentice Hall.
2. Kuratko, D. F. (2008). *Entrepreneurship: Theory, Process, and Practice* (8th Ed.). South-Western College Pub.
3. Barringer, B. R., & Ireland, D. (2011). *Entrepreneurship: Successfully Launching New Ventures* (4th Ed.). Prentice Hall.

Seventh (7th) Semester Specializations Elective Courses
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Course Code	Course Title	Credit Hours
CS6703	Compiler Construction	3(3+0)

Specialization: General Track

Prerequisites: Programming Fundamentals, Theory of Automata

Course Description: The course is intended to teach the students the basic techniques that underlie the practice of Compiler Construction. The course will introduce the theory and tools that can be employed in order to perform syntax-directed translation of a high-level programming language into an executable code. These techniques can also be employed in wider areas of application, whenever we need a syntax-directed analysis of symbolic expressions and languages and their translation into a lower-level description. They have multiple applications for man-machine interaction, including verification and program analysis. In addition to the exposition of techniques for compilation, the course will also discuss various aspects of the run-time environment into which the high-level code is translated. This will provide deeper insights into the more advanced semantics aspects of programming languages, such as recursion, dynamic memory allocation, types and their inferences, object orientation, concurrency and multi-threading.

Aims & Course Objectives: Students successfully completing this course should be able to:

- Understand programming language concepts deeply.
- Understand processing of programming languages by computers.
- Have full command on techniques used by Translator software.

Course Contents: Introduction to Translators, Compiler, Interpreter, Assembler, Context of Compiler, Pre-processor, Assembler, Linker, Loader, Compiler introduction: Analysis-Synthesis Model of Compiler, Phases of Compiler, Two-Pass Assembly, Physical Organization of Compiler, Cousins of compiler, Compiler-Compilers, Lexical Analysis: Role of Lexical Analyzer, Lexical Error Handling, Buffering Issues in Lexical Analyzer, Lexical Analyzer Implementation (Hand coding, Lex), Syntax Analysis: Introduction to Top-Down and Bottom-Up Parsers, Recursive-Descent Parsers, Predictive Parsers, Non-Recursive Predictive Parser, Shift-Reduce Parser, Operator Precedence Parsers, LR Parsers, LL(1) Grammars, LR(1) Grammars, YACC, Syntax Error Handling, Type Systems, Symbol Table Management, Runtime Environment, Intermediate Code: Triples, Indirect Triples, Quadruples, Symbol Table: Techniques such as Lists and Hash Tables, Code Optimization, Code Generation.

Recommended Books

1. Watson, D. (2017). *A Practical Approach to Compiler Construction (Latest ed.)*. Springer.
2. Mogensen, T. Æ. (2011). *Introduction to compiler design (Latest ed.)*. Springer Science & Business Media.
3. Dave, P. H., & Dave, H. B. (2012). *Compilers: Principles and Practice (Latest ed.)*. Pearson Education India.
4. Puntambekar, A. A. (2009). *Principles of compiler design (Latest ed.)*. Technical Publications.
5. Cooper, K., & Torczon, L. (2011). *Engineering a compiler (Latest ed.)*. Elsevier.

Course Code	Course Title	Credit Hours
CS6704	E-Commerce Technologies & Applications	3(3+0)

Specializations: General Track

Prerequisites: Fundamentals of Computers, Web Technologies

Course Description: This course will help students to learn about electronic commerce concepts, applications of electronic commerce, types of electronic commerce, how people, organization and industries take benefits from electronic commerce. role of electronic commerce in our daily life.

Aims and Objectives: When students complete this course, they will be able to:

- Understand electronic commerce transactions.
- Electronic ecommerce models.
- Business life cycle.
- Credit card, debit card and visa cards transactions.
- How to protect from Fraudulent activities on the web doing businesses.
- On-Line banking.
- To design and allow students to gain firsthand experience in studying and developing real-world systems for e-commerce.

Course Contents: Principles of E-Commerce. Origin and Growth of E-Commerce. Technologies for Development of E-Commerce Applications. Business Models and Strategies, Legal Issues Related to E-Commerce, Information Security, Information and Communication Technology. Security Infrastructure, Transaction Processing System, Secure Electronic Transactions, Sequence of Events for Transactions, Visa Transaction Life Cycle, Visa Authorization Process, Card Not Present Transactions Requirements and Tips, CVS Information, Digital Certificate, X.509 Standard, Contents and Structure of Digital Certificate, Digital Certificate and Website Security, Digital Signature. HTTPS, SSL, TLS, Blind Signature, Digital Cash, Electronic Funds Transfer. Financial Transactions, Electronic Money, Electronic Payment System, Electronic Bill Payment, Peer-to-Peer Payment System, Paypal, Online Banking Scrip,

E-Business Models, Portal Sites, Market Model, E-Payment and Key Issues in E-Payment Systems, Types of E-payments, Effective E-Business Process, Customer Relationship Management, Analytical CRM, Customer Interactions, Operational CRM, Personalization. Supply Chain Management, Demand Management, Inbound/Outbound Logistics, Supply Management, Core Operations, Claims Processing, Internet and B2B, M-businesses, Internet or Electronic Marketing, E-Marketing Management, Steps in E-Marketing & Business Management. E-advertising, Banner Ads, Buying and Selling Space on the Web. Pay-per-Thousand, Pay-per-Click, Pay-per-Lead, Pay-per-Sale, Exchanging Space for Ads. Search Engine, Anatomy of Search engine, Registering Website with Search Engines, Domain, Types of Domains, Types of Queries for Sites. Business Life Cycle, Stages of Business Life Cycle. Cross-Border E-commerce Concepts. Omni Channel Retail, Ecommerce Logistics Companies. Entrepreneurship through E-Commerce.

Recommended Books

1. Deitel, H. M., Deitel, P. J., & Nieto, T. R. (2001). *e-Business & e-Commerce: how to program (Latest ed.)*. Prentice Hall.
2. Reynolds, J., & Mofazali, R. (2004). *The complete e-commerce book: design, build, and maintain a successful web-based business (2nd Ed.)*. Cmp Books.

Course Code	Course Title	Credit Hours
CS6705	Expert Systems	3(3+0)

Specializations: Artificial Intelligence, Database Systems

Prerequisites: Artificial Intelligence

Course Contents: Introduction, The Principles of operation of expert systems, State transition model: Expert system models: Planning actions, solving a problem, diagnosis, Producing advice; how to backtrack; a structure for expert system. The structure of state spaces: connectivity, form; the implicit description of state spaces; search: depth and breadth first search. Functions for handling lists: functions for search; best first search. Eliciting knowledge from on expert: interviewing, examples, problem solving, psychological techniques. Knowledge representation schemes: rules, semantic nets, logic, frames. Some existing expert systems: MYCIN, DENDRAL, MACSYMA, PROSPECTOR. Characteristics of knowledge-bases systems, features of problem solvers, Architectural principals. The choices of system (language/package) production pit falls.

Recommended Books

1. Marshall, G. (1990). *Advanced Students' Guide to Expert Systems (Latest ed.)*. Heinemann Newnes Publications, Oxford.

Course Code	Course Title	Credit Hours
CS6706	Introduction to Parallel Computing	3(3+0)

Specializations: General Track

Prerequisites: Advanced Programming, Computer Organization and Architecture

Course Description: Single processor systems have become obsolete and the future of computing is in Parallelism. This course is an introductory course on parallel computing. It covers both the hardware and software aspect of parallel computing along with a discussion on parallel algorithms.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the basic concepts of parallel computing.
- Understand the parallelism available at the hardware level.
- Understand how to design parallel algorithms and write simple parallel programs.

Course Contents: Introduction to Parallel Computing and its Importance, Concurrent Processes Basic Concepts of Concurrency, Concurrency in Operating Systems, Problems in Concurrent Programming, Basic Models of Parallel Computation, Shared Memory Model and Examples, Network Model and Examples, Parallel Algorithms, Evaluation of Parallel Algorithms, Amdahl's Law, Gustafson-Barsis's Law, Karp-Flatt Metric, Algorithms for Shared Memory and Network Models, Parallel Algorithms for Shared Memory, Parallel Algorithms for Network Models, Designing Parallel Algorithms, Steps of Designing, Problem Decomposition, Granularity of Computation, Minimizing Overheads, Task Allocation and Load Balancing, Parallel Architectures (Multi-cores, Multiprocessors, Heterogeneous Systems with Graphical Processing Units), Unconventional Architectures, Message-passing Programming and Examples, Shared Memory Programming and Examples.

Recommended Books

1. Czech, Z. J.(2017). *Introduction to Parallel Computing (Latest ed.)*, Cambridge University Press.

Bibliography

1. Patterson, D. A., & Hennessy, J. L. (2013). *Computer Organization and Design the Hardware/Software Interface (Latest ed.)*. Morgan Kaufmann.
2. Hennessy, J. L., & Patterson, D. A. (2012). *Computer Architecture: A Quantitative Approach (Latest ed.)*. Morgan Kaufmann.

Course Code	Course Title	Credit Hours
CS6721	Information Architecture	3(3+0)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Web Technologies

Course Description: The post-AJAXian Web 2.0 world of wikis, folksonomies, and mashups makes well-planned information architecture even more essential. How to present large volumes of information to people who need to find what they're looking for quickly? This course will enable information architects, designers, and web site developers to build large-scale and maintainable web sites that are appealing and easy to navigate. This course will cover emerging technologies with recent examples, new scenarios, and information on best practices.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the fundamental components of an architecture, illustrating the interconnected nature of these systems.
- Know about the latest concepts of the social web including Tagging, Folksonomies, Social Classification, and Guided Navigation.
- Understand the tools, techniques, and methods that takes from research to strategy and design to implementation.
- Series of short essays that provide practical tips and philosophical advice for those who work on information architecture.
- Business context of practicing and promoting information architecture, including recent lessons on how to handle enterprise architecture.
- Case studies on the evolution of large information architectures, illustrating best practices along the way.

Course Contents: Role of Information Architect, Collaboration and Communication, Organizational Challenges, Creating Cohesive Organization Systems, Browser Navigation Features, Types of Navigation Systems, Building Context, Improving Flexibility, Effective Labeling Systems, Types of Labeling Systems, Searching and Websites, Designing Search Interface, Indexing Right Stuff, Metaphor Exploration, High- Level Architecture Blueprints, Architectural Page Mockups, Design Sketches, Web-based Prototypes, Content Mapping, Web Page Inventory, Architecture Style Guides, Thesauri, Controlled Vocabulary, Metadata, Information Architecture Strategy, Information Architecture and Business Strategy, Tools and Software.

Recommended Books

1. Rosenfeld, L., & Morville, P. (2015). *Information architecture for the Web and Beyond* (4th Ed.). O'Reilly Media, Inc.
2. Governor, J., Hinchcliffe, D., & Nickull, D. (2009). *Web 2.0 Architectures: What entrepreneurs and information architects need to know* (Latest ed.). O'Reilly Media, Inc.
3. Rosenfeld, L., & Morville, P. (2006). *Information architecture for the world wide web* (Latest ed.). O'Reilly Media, Inc.

Course Code	Course Title	Credit Hours
CS6722	Web Content Management Systems	3(2+1)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Web Technologies

Course Description: Advancement in information technologies, especially the in the area of World Wide Web (WWW) enabled companies and individuals to expend their businesses by developing attractive websites. In a rapidly changing world, the need for online publishers to keep up with the needs and expectations of their site visitors is paramount. Today, many web publishers use content management systems (CMS) to allow them to instantly and dynamically update web pages and properties as new content becomes available so that every visit to a site is engaging, informative, and meaningful. This course explores the use of the three most popular open source web-based content management systems—WordPress, Joomla, and Drupal—to create dynamic and flexible websites and landing pages. Students explore the fundamentals of planning dynamic websites, CMS database management, developing CSS-controlled site templates, and creating database-driven websites through the planning and creation of their own topic-based sites.

Aims and Objectives: When students complete this course, they will be able to:

- Introduce learners to the three most popular open source content management systems (CMS) in use on the web today, including WordPress, Drupal, and Joomla.
- Understand the difference between a CMS website, a static website, and websites using other server-side technologies.
- Understand the benefits of working with a server-side database and the power it brings to creating and managing websites.
- Compare and contrast the three most popular open source CMS.
- Create and deploy websites using CMS, including creating and editing content, adding functionality, and creating custom templates and themes.
- Understand ongoing maintenance considerations with CMS websites.
- Help in freelancing and outsourcing.

Course Contents: Contents, Contents Management, Implementing Content Management Solutions, Introduction to WordPress, Extending WordPress, WordPress Theming, Introduction to Joomla, Extending Joomla, Custom Joomla Templates, User management and permissions, Introduction to Drupal, Extending Drupal Content, Extending Drupal Functionality via Modules, Creating Lists of Content with Views, Custom Theming.

Recommended Books

1. Hackos, J. T. (2002). *Content management for dynamic Web delivery (Latest ed.)*. John Wiley & Sons, Inc..
2. Barker, D. (2016). *Web Content Management: Systems, Features, and Best Practices (Latest ed.)*. O'Reilly Media, Inc.

3. Glaman, M. (2016). *Drupal 8 Development Cookbook (Latest ed.)*. Packet Publishing Ltd.
4. Williams, A. (2017). *WordPress for Beginners 2017: A Visual Step-by-Step Guide to Mastering WordPress (Latest ed.)*. CreateSpace Independent Publishing Platform.
5. Burge, S. (2011). *Joomla! Explained: Your Step-by-step Guide (Latest ed.)*. Pearson Education.

Course Code	Course Title	Credit Hours
CS6723	Web Engineering	3(3+0)

Specializations: Web Engineering, Software Engineering, General Track

Prerequisites: Advanced Programming, Web Technologies, Software Engineering

Course Description: The World Wide Web has become a major delivery platform for information resources. Many applications continue to be developed in an ad-hoc way, contributing to problems of usability, maintainability, quality and reliability. Web Engineering introduces a structured methodology utilized in software engineering to web development projects. This course examines systematic, disciplined and quantifiable approaches to developing of high-quality, reliable and usable web applications. The course addresses the concepts, methods, technologies, and techniques of developing Web sites that collect, organize and expose information resources.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the concepts, principles and methods of Web engineering.
- Apply the principles, and methods of Web engineering to Web applications development.
- Analyze and design comprehensive systems for the creation, dissemination, storage, retrieval, and use of electronic records and documents.
- Learn techniques and evaluation metrics for ensuring the proper operability, maintenance and security of a web application.
- Apply the web engineering methodologies for web application development

Course Contents: Categories of Web Applications, Characteristics of Web Applications, Product-Related and Usage-Related and Development-Related Characteristics, Requirements Engineering Activities Specifically Web Engineering, Principles for Requirements Engineering of Web Applications, Adapting Requirements Engineering Methods to Web Application Development, Modelling Specifics in Web Engineering (Requirements, Content, Hypertext, Presentation, and Customization), Design Guidelines, Web Usability Engineering Methods, Web Usability Engineering Trends, Client/Server Communication on the Web(SMTP, RTSP,HTTP, Session Tracking), Client-side Technologies, Document-specific Technologies (HTML, SVG, SMIL, XML), Server-side Technologies (URI Handlers, Web Services, Middleware Technologies), Web Application Development Process, Parallel Development of Different Releases, Analysis of the Rational Unified Process, Analysis of Extreme Programming, Software Project Management to Web Project Management, Challenges in Web Project Management, Managing Web Teams, Managing the Development Process of a Web Application.

Recommended Books

1. Chopra, R. (2016). *Web Engineering (Latest ed.)*. PHI Learning Pvt. Ltd.
2. Suh, W. (2005). *Web Engineering Principles and Techniques (Latest ed.)*. Idea Group Publishing.
3. Pressman, R., & Lowe, D. (2009). *Web Engineering: A Practitioners Approach (Latest ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS6731	Routing and Switching	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: This course is a study of Routing and Switching fundamentals, and how the Internet is integrated into the computing environment to enable organizations to share resources, collaborate, and meet organizational goals. In the Computer Networks essentials and the creation of simple Local Area Networks (LANs) introduced, Networking Technologies, are expanded upon to incorporate the linking of these simple networks to each other and to the Internet, to create an internetwork. Routing and Switching devices such as switches and routers will be examined in great detail. Students will focus on techniques to analyze, plan, and manage an enterprise network. In support of these techniques, lab activities will include sub-netting, packet-sniffing, and switch and router configuration.

Aims and Objectives: When students complete this course, they will be able to:

- Configure and subdivide an IP network.
- Differentiate between routable, non-routable, and routing protocols. Differentiate between Exterior Gateway Protocols and Interior Gateway Protocols. Configure static routing and default routes. Configuration of RIP v1, RIP v2, OSPF, IGRP, EIGRP, BGP routing protocols.
- Use advanced routing concepts such as CIDR, summarization, and VLSM.
- Identify the differences between IPv4 and IPv6.
- Configure a router dealing with modes, prompts, passwords, context-sensitive help, and enhanced editing feature.
- Configure HyperTerminal to access routers and switches.
- Manipulate the router boot process.
- Use Cisco Discovery Protocol.

Course Contents: IP Addressing, Subdividing IP Classes, Variable Length Subnet Masks, Working with Hexadecimal Numbers e. IPv4 vs. IPv6, Basic of IOS, Benefits of Routing, Cisco Router User Interface, Router Components, Router Startup, IP on the Router, IP Connectivity, CDP, Cisco IOS, Router Password Recovery, Security Device Manager, Non-routable protocols, Routed Protocols, Routing Protocols, Routing Information Protocol, Interior Gateway Routing

Protocol, Open Shortest Path First, Static Routing, Classful and Classless Routing Protocols, Routing Information Protocol version 2, Enhanced Interior Gateway Routing Protocol, Open Shortest Path First, OSPF Authentication, Controlling Route Traffic, Network Address Translation, Configuring Network Address Translation, Domain Name System, Dynamic Host Configuration Protocol, Security Device Manager, Benefits of VLANs, Static vs. Dynamic VLANs, VLAN configuration, VLAN Trunking Protocol (VTP), Access List: Usage and Rules, Standard IP Access Lists, Extended IP Access Lists, Using Named Lists, Controlling VTY Line Access, Using Security Device Manager to Create Access Control Lists, Using Security Device Manager to Create a Router Firewall, Border Gateway Protocol.

Recommended Books

1. Lammle, T., Tedder, W. (2014). *CCNA Routing and Switching Deluxe Study Guide (Latest ed.)*. John Wiley & Sons Ltd..
2. Empson, S. (2008). *CCNA Routing and Switching Portable Command Guide (Latest ed.)*. Cisco Press.
3. Puzmanova, R. (2002). *Routing and Switching: Time of Convergence? (Latest ed.)*. Addison-Wesley.

Course Code	Course Title	Credit Hours
CS6732	Internet of Things	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Programming Fundamentals, Computer Networks

Course Description: The module is designed to provide students with a solid technical introduction to the Internet of Things (IoT). The course is broadly divided into two parts, namely development at the edge and development in the cloud. A systems engineering approach is adopted reviewing the key technologies employed at different levels of the IoT stack and how they are integrated to form complete IoT systems.

Aims and Objectives: When students complete this course, they will be able to:

- To introduce students to the concepts underlying the Internet of Things (IoT).
- To provide overview list of popular protocols and standards helping power IoT devices, apps and applications.
- To introduce devices including sensors, low power processors, hubs/gateways and cloud computing platforms.

Course Contents: Introduction to IOT and Importance, Elements of IoT Ecosystem, Technology Drivers, Business Drivers, Typical IoT Applications, IoT Protocols and Development Platforms(Arduino, Raspberry Pi, Particle Core, Electric Imp, Pinoccio), Advantages and Disadvantages, Fast, Reliable, Lightweight and Bidirectional Characteristics of IoT Protocols, Protocols such as HTTP, Web sockets and Message Queuing Telemetry Transport (MQTT) Protocols in addition to Nano IP, Content Centric Networking (CCN), Time Synchronized Mesh

Protocols (TSMP), MQTT-SN (Sensor Networks), CoAP and Related Protocols, Trends, Implications and Future of IoT, Current Challenges to the IoT, How IoT Devices Interact with each other, Sensing Devices Sensor Modules, Nodes and Systems, Wireless Technologies for the IoT, Edge Connectivity and Protocols, Fundamental Concepts of Sensor Network Design, Sensor Network Software and Hardware, Sensor Network Protocols, Mechanisms, Algorithms to Implement Sensing Systems, Program and Experiment with Sensors, Signal Processing, Real-Time and Local Analytics, Databases, Cloud Analytics and Applications, Industry Perspective - Business Considerations, Legal Challenges, Local Processing on the Sensor Nodes, Understanding Privacy Implications and Security Issues in IoT, Mini-project.

Recommended Books

1. Biron, J., Follett, J. (2016). *Foundational Elements of an IoT Solution (Latest ed.)*. O'Reilly Media.
2. Keysight Technologies (2016). *The Internet of Things: Enabling Technologies and Solutions for Design and Test (Latest ed.)*. Application Note.
3. Bell, C. (2013). *Beginning Sensor Networks with Arduino and Raspberry Pi (Latest ed.)*. Apress.

Course Code	Course Title	Credit Hours
CS6733	Network Programming	3(3+0)

Specializations: Computer Networks, General Track

Prerequisite: Computer Networks, Advanced programming

Course Description: This course focuses on the network programming. This course will help understand the students about all the networking concepts, their working and applications.

Aims and Objectives: When students complete this course, they will be able to:

- Analyse the requirements of a networked programming environment and identify the issues to be solved.
- Create conceptual solutions to those issues and implement a programming solution.
- Understand the key protocols that support the Internet.
- Apply several common programming interfaces to network communication.
- Understand the use of TCP/UDP Sockets.

Course Contents: Network Programming Skills and Concepts, Covers Application Layer Protocol and How Applications Use the Transport Layer, Principles and Practice of Network Programming; The Client-Server Model, Concurrent Processing, Introduction to Client and Server Software Design with Examples, Principles, Issues and Challenges in E-mail and Web Application Protocols; Security Protocols; and Network Life System Concepts, Unix Programming Environment, TCP Protocol Suit, Socket Programming, Implementation of Communication Protocols Including HTTP, 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, Implementation of Mutexes, Spins, Binary and Counting Semaphores, POSIX Shared Memory, Doors and RPC (Remote Procedure Calls).

Recommended Books

1. Ciubotaru, B., Muntean, G. (2013). *Advanced Network Programming (Latest ed.)*. Springer Science & Business Media.
2. Reid, F. (2004). *Network programming in .NET (Latest ed.)*. Digital Press.
3. Harold, E. R. (2013). *Java Network Programming (Latest ed.)*. O'Reilly Media.

Course Code	Course Title	Credit Hours
CS6734	Wireless and Mobile Networks	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: Wireless and mobile networking is one of the fastest growing segments of the computer industry. Wireless network has been around for many years and it has already started to dominate the wired network. This course is focused on the introduction and fundamental concepts about wireless and mobile networks. Students will be able to understand how wireless standards and protocols are developed. Furthermore, students will be exposed to the history and future trends in wireless and mobile technologies.

Aims and Objectives: When students complete this course, they will be able to:

- The fundamental concepts about the wireless and mobile networks.
- The techniques in the design and operation of wireless networks.
- Students will be able to survey the breadth of wireless and mobile devices and protocols in commercial use today.
- The students will be familiar with the wireless networks, its configuration and use.

Course Contents: Principles of Wireless Communication, Wireless Networks, Main Components of a Wireless System, Modes of Operation Infrastructure Mode, ad-hoc Mode, Compatibility of Different Technologies, Nyquist-Shannon Sampling Theorem, Nyquist Bandwidth, Signal-to-Noise Ratio, Multiplexing, Antenna and Types, Modes of Propagation, Radio Channel Characterization, Multipath Propagation, co-channel Interference, Exponential Power Delay Profile, Propagation Effects - Scattering, Ground Reflection, Fading, Log-normal Shadowing, Rayleigh & Rician Fading, Coherence Bandwidth, PHY Layer Techniques, Wideband Modulation Techniques to CPE with Inter-symbol Interference (Diversity, Spread Spectrum, Frequency Hopping, Direct Sequence, Adaptive Equalization, and Orthogonal Frequency Division Multiplexing), Components of a Satellite-based Network, Multiple Access Techniques (FDMA, TDMA and CDMA, CSMA/CA and Slotted Aloha), Orthogonal and Non-orthogonal Multiple Access (NOMA), Cellular Concepts, Sectorization and Cell Splitting, Handover and Types, Frequency Reuse, Reuse Distance, Cluster Size, Channel Assignment

Strategies, Handoff Strategies, co-channel Interference and System Capacity, Trunking and Grade of Service, Mobile Network Generations (1G, 2G, 3G, 4G and 5G Concepts), Wireless Local Area Networks (WLANs), 802.11 Networks and Versions (802.11 a, b, g, n), ad-hoc Wireless Personal Area Networks (WPANs), Bluetooth Standard 802.15 and Version, Infrared Communication, Femtocells, Multi-hop Relay Networks, Wireless Mesh Networks, Homogeneous and Heterogeneous Networks, Integration and Challenges, Coordinated Multipoint (CoMP) and Cooperative Communication Concepts and Advantages.

Recommended Books

1. Stallings, W. (2013). *Wireless Communications & Networks (Pearson New International Ed.)*. Pearson Education Limited.
2. Molisch, A. F. (2010). *Wireless communications (Latest ed.)*. Wiley.
3. Rappaport, T. S. (2002). *Wireless communications: Principle and Practice (2nd Ed.)*. Prentice Hall.
4. Tanenbaum A. S. (2002). *Computer Networks (4th Ed.)*. Prentice Hall.

Bibliography

1. Schiller, J. (2013). *Mobile communications (2nd Ed.)*. Addison-Wesley.
2. Goldsmith, A. (2005). *Wireless Communications (Latest ed.)*. Cambridge University.

Course Code	Course Title	Credit Hours
CS6741	Advanced Database Systems	3(3+0)

Prerequisites: Database Systems, Software Engineering, General Track

Course Description: This course is designed for the students seeking career in database designing to master some of the advanced concepts of database systems.

Aims and Objectives: When students complete this course, they will be able to:

- Understanding of advanced concepts in database systems.
- Discuss and evaluate methods of storing, managing and interrogating complex data.
- Explain and evaluate the fundamental theories and requirements that influence the design of modern database systems.

Course Contents: Advanced Normalization, Multi-Valued Functional Dependency, Database Security, Possible threats to database, Computer-Based Counter Measures, Authorization and Authentication, Access Controls, Backup and Recovery, Views, Integrity Constraints, Encryption, RAID, Database Concurrency, Transactions and Its ACID Properties, Anomalies due to concurrent execution of transaction and Concurrency Control, Serializability, Lock-Based Concurrency Control, handling Deadlocks in concurrency, Time-Stamping technique for concurrency control, Optimistic Methods, Granularity of Data Items, Database Recovery, Transactions and Recovery, Recovery Facilities (Backup, Log File, Check-Pointing), Recovery Protocols, Deferred Updates, Immediate Updates, Shadow Paging, Query Optimization

Techniques (Join Ordering, Nested Query Planning, Cost Estimation), Distributed Databases, DDBMS, Homogeneous vs. Heterogeneous DDBMS, Distribution Transparencies, Distributed Database Design, Data allocation, Fragmentation, Object Oriented Database and OODBMS, Comparison of OO Data Modeling vs. Conceptual Data Modeling

Text Book

1. Coronel, C., & Morris, S. (2016). *Database systems: design, implementation, & management (Latest ed.)*. Cengage Learning.

Bibliography

1. Ramakrishnan, R., & Gehrke, J. (2003). *Database Management Systems (3rd Ed.)*. WCB/McGraw Hill.
2. Elmasri, R., & Navathe, S.B. (2016). *Fundamentals of Database Systems (Global Ed.)*. Pearson Education Limited.
3. Hoffer, J., Venkataraman, R., & Topi, H. (2015). *Modern database management (Latest ed.)*. Prentice Hall Press.
4. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). *Database system concepts (4th Ed.)*. New York: McGraw-Hill.
5. Garcia-Molina, H. (2008). *Database systems: the complete book (Latest ed.)*. Pearson Education India.

Course Code	Course Title	Credit Hours
CS6742	Fundamentals of Data Warehousing	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Database Systems

Course Description: The primary focus of this course is on the basic concept of Data Warehousing. The course concentrates on topics like: Planning and requirements gathering for data warehousing, data warehouse architecture, dimensional model design for data warehousing, extracting, transforming, and loading strategies.

Aims and Objectives: Students successfully completing this course should be able to:

- Overview of a data warehouse development project, and identify key factors in the success or failure of such projects.
- Identify key data warehousing products, services, tools and consultancy requirements.
- Implement key features of a data warehouse within popular relational DBMSs.

Course Contents: Introduction to Data Warehousing and Decision-Support Systems, Operational vs Informational Systems, online transaction processing (OLTP) and online analytical processing (OLAP), Data Warehouses and Data Marts, Building Blocks and Components of Data warehousing, requirements and planning, requirements gathering methods

and information package, Introduction to the Dimensional Model (Facts, Dimensions, Star schema, Snowflake schema), aggregated fact tables, De-normalization, The Architectural Plan, Data Storage Specifications, Data Design, Levels of Detail, Information Delivery Strategy, Role of Metadata and Metadata Types by Functional Areas as Data Acquisition, Data Storage, Information Delivery, Data Warehouse Queries, Extract Transform Load (ETL), MDX Query, Multidimensional data (Cube).

Recommended Books

1. Kimball, R., & Ross, M. (2011). *The data warehouse toolkit: the complete guide to dimensional modeling (Latest ed.)*. John Wiley & Sons.
2. Inmon, W. H. (2005). *Building the data warehouse (Latest ed.)*. John Wiley & sons.
3. Hammergren, T. C. (2009). *Data warehousing for dummies (Latest ed.)*. John Wiley & Sons.
4. Ponniah, P. (2004). *Data warehousing fundamentals: a comprehensive guide for IT professionals (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS6751	Usability Engineering	3(3+0)

Specializations: Software Engineering, Web Engineering, General Track

Prerequisites: Nil

Course Description: Usability engineering is integral to the design process of an individual software product or service in terms of how the end-users perceive and use that product or design. The objective of this course is to provide students an advanced understanding of the role of usability engineering in the software design process. The students will also have practical experience with tools and methods that are used as part of the usability engineering process.

Aims and Objectives: After completing the course, students should be able to:

- Understand the concept of usability engineering and its importance in software development.
- Learn the concept and apply techniques of usability engineering.

Course Contents: Usability Definitions, Justification for Usability, User Centered Design, Interaction Design, Users, Tasks, Usability Engineering, Interface Evaluation, Usability Methods, Usability Testing, Usability Data Analysis and Reporting, User Experience.

Text Book

1. Klein, L., & Rutter, K. (2016). *Build Better Products: A Modern Approach to Building Successful User - Centered Products (1st Ed.)*. Rosenfeld Media.

Bibliography

1. Platt, D. (2016). *The joy of UX: User Experience and interactive design for developers (1st Ed.)*. Boston: Addison-Wesley.
2. Rubin, J. (2008). *Handbook of Usability Testing: How to Plan; Design; and Conduct Effective Tests (2nd Ed.)*. Wiley.

Course Code	Course Title	Credit Hours
CS6752	Computer Aided Software Engineering	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Advanced Programming, Software Engineering

Course Description: This course provides an overview of the professional development environment which accommodates different automation tools for different phases in a development process. *CASE (computer-aided software engineering)* is the use of a computer-assisted method to organize and control the development of software. The course puts emphasis on using a complete automated development environment including project management, team management, testing and build.

Aims and Objectives: After completing the course, students should be able to:

- Understand different perspectives for CASE tools classification.
- Understand the cost of using and building CASE tools.
- Use different CASE tools for each software development phase.
- Compare and contrast the fitness of existing CASE Tools to the needs of specific software development context.

Course Contents: Setting up a proper development environment, development environment vs staging, vs. production environment, need for a staging environment, concept of staging database, release management, sandbox, Fundamentals of project management, team management, source code management, configuration management and revision control, Development IDEs, Automated Testing, source code integration and continuous integration, automated build and deployment.

Recommended Books

1. Humble, J., & Farley, D. (2015). *Continuous delivery: reliable software releases through build, test, and deployment automation (1st Ed.)*. Upper Saddle River, NJ: Addison-Wesley.

Bibliography

1. Loeliger, J. (2012). *Version Control with Git: Powerful Tools and Techniques for Collaborative Software Development (Latest ed.)*. O'Reilly Media

2. Siriwardena, P. (2015). *Maven Essentials (1st Ed.)*. Packt Publishing
3. Sagar, R. (2015). *Mastering JIRA (1st Ed.)*. Packt Publishing.

Course Code	Course Title	Credit Hours
CS6753	Software Architecture and Design	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Software Engineering

Course Description: To understand importance of architecture in software development and to introduce general guidelines for software architecture design and quality requirements.

Aims and Objectives: When students complete this course, they will be able to:

- Understand fundamentals of software architecture.
- Understand quality requirements of a software system
- Understand fundamental principles and guidelines for software architecture design, architectural styles, patterns, and frameworks.
- Understand software architecture design and evaluation processes.

Course Contents: Introduction to the fundamentals of software architecture, Software architecture and quality requirements of a software system, Fundamental principles and guidelines for software architecture design, architectural styles, patterns, and frameworks, Methods, techniques, and tools for describing software architecture and documenting design rationale, Software architecture design and evaluation processes, Future challenges and emerging trends in software architecture discipline.

Recommended Books

1. Bass, L., Clements, P., & Kazman, R. (2013). *Software architecture in practice (3rd Ed.)*. Upper Saddle River, NJ: Addison-Wesley.

Bibliography

1. Babar, M. A., Brown, A.W., & Mistrik, I. (2013). *Agile Software Architecture: Aligning Agile Processes with Software Architecture (Latest ed.)*. Morgan Kaufmann Publishers.

Course Code	Course Title	Credit Hours
CS6761	Natural Computation	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: Data Structures and Algorithms, Artificial Intelligence

Course Description: The aim of the course is to acquaint students with problems in search and optimization and give them a basic knowledge of the computational techniques used to solve such problems. The course focuses on heuristic methods and covers a spectrum of such methods including both population-based and single evolution method. The course aims to provide students working knowledge of GA, ACO, PSO, and other techniques for solving computationally hard problems. The objective is to enable students to apply the heuristic framework to practical problems.

Aims and Objectives: Upon completing this course,

- Students will have knowledge of search and optimization problems and their complexity, and the computational technique to solve them.
- They will understand the working of the heuristic methods and be able apply them to known optimization problems in resource allocation, routing, etc.

Course Contents: Search and optimization problem; Heuristic methods for search and optimization: local versus global search, single-evolution versus population based methods, hybrid and mimetic methods; Tabu search (TS); Simulated annealing (SA); reactive search optimization; Genetic Algorithms (GA): selection, recombination, and mutation, fitness and objective function, inversion, replacement, and other operators, crowding, niching, island, and cellular models, the schema theorem; Ant Colony Optimization (ACO); Particle Swarm Optimization (PSO); Differential evolution; DNA computing; hybrid algorithms, mimetic algorithms, and pareto-optimization; application to travelling salesman, hub location, bin-packing, routing, and other problems.

Recommended Books

1. Sivanandam, S. N., & Deepa, S. N. (2007). *Introduction to Genetic Algorithms (Latest ed.)*. Springer Berlin Heidelberg.
2. Mitchel, M. (1999). *An introduction to Genetic Algorithms (Latest ed.)*. MIT Press.
3. Negnevsky, M. (2005). *Artificial Intelligence-A Guide to Intelligent Systems (2nd Ed.)*. Addison-Wesley.
4. ChengGuo., & Yang, X. *A programming of genetic algorithm in MATLA 7 (Latest Editoin)*. Modern Applied Science.

Course Code	Course Title	Credit Hours
CS6762	Introduction to Neural Networks	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: Data Structures and Algorithms, Advanced Programming, Calculus and Analytical Geometry, Linear Algebra, Probability and Statistics

Course Description: This is a preliminary course in neural networks. The aim of the course is to introduce students to learning and pattern recognition techniques based on the neural network model. Learning objectives include enabling students to gain a knowledge of basic NN models based on single and multilayer perceptrons. Concept of self-organizing systems and competitive learning are introduced through the example of SOMs.

Aims and Objectives: When students complete this course, they will be able to:

- Implement neural networks based on single and multi-perceptron models and apply the models to the recognition and learning problems. Furthermore, they will have the basic knowledge to study the topic of NNs at advanced levels.

Course Contents: Human brain, models of a neuron, neural network architecture, knowledge representation, the learning process, hebbian learning, memory-based learning, competitive learning, Boltzmann learning, memory, adaption, statistical learning theory; Single-layer perceptrons: adaptive filtering problems, unconstrained optimization techniques, linear least square filters, least-mean square algorithms, learning curves, learning rate annealing techniques, perceptron, perceptron convergence theorem; Multi-layer perceptron: back-propagation algorithm, XOR problem, feature detection, back-propagation and differentiation, strengths and limitations of back-propagation; Self-organizing maps: feature-mapping models, the SOM algorithm, properties of feature map.

Recommended Books

1. Haykin, S., & Network, N. (2004). *A comprehensive foundation. Neural Networks (2nd Ed.)*. Pearson Education, Pearson Printice-Hall.
2. Sivanandam, S. N., & Deepa, S. N. (2006). *Introduction to neural networks using Matlab 6.0 (Latest ed.)*. Tata McGraw-Hill Education.

Semester VIII Courses

Course Code	Course Title	Credit Hours
CS6801	Natural Language Processing	3(3+0)

Prerequisites: Artificial Intelligence

Course Description: This course covers the introduction to Natural language Processing. Natural language processing (NLP) is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages and, in particular, concerned with programming computers to fruitfully process large natural language corpora.

Course Contents: Monolingual Natural Language Processing: Difference between natural and formal languages. Natural language understanding: syntax, semantics, phonetics, morphology, discourse analysis. anaphora/cataphora, cohesion/coherence, ellipses, ambiguity (structural, lexical, transient, discourse). Natural language Generation: steps in generation. Natural Language Interfaces. Machine Translation: Translation steps: analysis, transfer and generation. Translation Strategies: direct translation, interlingua and transfer. Types: Bilingual, Multi-lingual. Dictionary design: monolingual, bilingual. Units of translation: word, sentence, discourse. Some operational and R&D machine translation systems. Speech translation, benefits of machine translation, integration of machine translation to other fields of computer science, Urdu, Pashto and machine translation. Natural language processing and computational social sciences. Natural language process and journalism, sentiment analysis and opinion mining.

Recommended Books

1. Khan, M. A. (1995). *Text Based Machine Translation (Latest ed.)*.
2. Jurafsky, D., & James, H. (2000). *Speech and language processing an introduction to natural language processing, computational linguistics, and speech (Latest ed.)*. Pearson Education Inc.
3. Manning, C. D., & Schütze, H. (1999). *Foundations of statistical natural language processing (Latest ed.)*. Cambridge MIT press.
4. Indurkha, N., & Damerau, F. J. (Eds.). (2010). *Handbook of natural language processing (Latest ed.)*. Chapman and Hall/CRC.

Course Code	Course Title	Credit Hours
CS6802	Professional Practices	3(3+0)

Prerequisites: Nil

Course Description: The aim of this module is to help students develop an understanding of the fundamental professional, ethical, and legal issues and how they are being developed and applied.

Aims and Objective: When students complete this course, they will be able to:

- Understand the concepts of key, ethical, managerial and legal issues typically encountered by an IT professional.

- Identify, access and critically review appropriate and relevant literature drawn from academic, technical, legal, professional business sources.
- Evaluate and critically reflect upon self-presentation.
- Work with others.

Course Contents: 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 and Misuses, and Risks of Software, Information Security and Privacy, Business Practices and Economics of Software, Intellectual Property and Software Law (Cyber Law), Social Responsibilities, Software Related Contracts, Software House Organization.

Recommended Books

1. Bott, F., Coleman, A., Eaton, J., & Rowland, D. (2000). *Professional issues in software engineering (Latest ed.)*. CRC Press.
2. Bott, F. (2014). *Professional issues in information technology (2nd Ed.)*. BCS Learning & Development Limited.

Eighth (8th) Semester Specializations Elective Courses

Course Code	Course Title	Credit Hours
CS6804	Computer Graphics and Imaging	3(2+1)

Specialization: General Track, Pattern Recognition

Prerequisites: Linear Algebra, Object Oriented Programming

Course Description: This is a beginning course in computer graphics and imaging. The focus is on computational geometry, animation, and simulation. Various issues in graphics and imaging are discussed and mathematical concepts to model and deal with them are introduced.

Aims and Objectives: After completing this course:

- Students will have knowledge of the issues and solutions in computer graphics and will be able to handle such graphing tasks such as designing interactive video games and games for mobile devices.

Course Content: Creating Images with OpenGL, Mathematical Concepts: Triangles, Normals, Interpolation. Concept of Light and Color and Impact on Display and Printer, Scanline Rendering, OpenGL Pipeline, Triangles, Rasterization, Transformations, Shading, Triangle

Meshes, Subdivision, Marching Cubes, Textures, Light, Color, Cameras, Displays, Tone Mapping, Lighting Equation, Global Illumination, Radiosity, Ray Tracing, Acceleration Structures, Sampling, Antialiasing, Reflection, Transmission, Depth of Field, Motion Blur, Monte Carlo, Bidirectional Ray Tracing, Light Maps.

Recommended Books

1. Marschner, S., & Shirley, P. (2015). *Fundamentals of Computer Graphics (4th Ed.)*. AK Peters/CRC Press.
2. Shreiner, D. (2013). *OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 4.3 (8th Ed.)*. Addison-Wesley Professional.
3. Munshi, A., Gisburg, D., & Shreiner, D. (2008). *OpenGL ES 2.0 Programming Guide (1st Ed.)*. Addison-Wesley Professional.

Reference Books

1. Ableson, W. F., Sen, R., King, C., & Ortiz, C. E. (2011). *Android in action (3rd Ed.)*. Manning Publications.
2. Conway, J. & Hillegass, A. (2012). *iOS Programming: The Big Nerd Ranch Guide (3rd Ed.)*. Big Nerd Ranch Guides.

Course Code	Course Title	Credit Hours
CS6805	Numerical Computing	3(2+1)

Specialization: General Track

Prerequisites: Calculus and analytic Geometry, Multivariate Calculus, Linear Algebra.

Course Description: The course introduces numerical computational methods for various mathematical operations. Numerical techniques for computing integrals, performing differentiation, and solving linear and non-linear equations are covered.

Aims and Objectives: After covering this course:

- Students will be able to implement different numerical computational techniques and think of their applications in computer science.

Course Content: Error Analysis: Definition of Errors, Effect of Rounding Errors, Evaluation Functions. Solving Non-Linear Equations, Linear System of Equations and Methods for Solution, Finite Differences: Difference Table, Difference Operators and Relationship Between Difference Operators, Interpolation: Formulas and Error Estimation in Interpolation, Numerical Differentiation and Formulas for Numerical Differentiation, Numerical Integration: Simpson's, Trapezoidal, Boole's Rules, Weddle's Rule, Newton-cotes Formulas, Repeated use of Trapezoidal Rule, Romberg's Integration Method, Ordinary Differential Equations and Methods for Solution, Taylor Series and Euler's Method, Runge-Kutta and Predictor-corrector Methods, Solving Higher Order Differential Equations.

Recommended Books

1. Burden, R.L., & Douglas, F. J. (1993). *Numerical Analysis (5th Ed.)*. PWS-KENT Publishing Company.
2. Hamming, R. W. (1987). *Numerical methods for scientists and engineers (2nd Ed.)*. Dover Publications.
3. Karris, S. T. (2007). *Numerical analysis using MATLAB and Excel (3rd Ed.)*. Orchard Publications.

Course Code	Course Title	Credit Hours
CS6806	Digital Image Processing	3(3+0)

Specializations: Pattern Recognition, General Track

Prerequisites: Calculus and Analytical Geometry, Linear Algebra, Artificial Intelligence

Course Description: This is an introductory course in digital image processing. The course covers preliminary topics in DIP with emphasis on the mathematics for image processing and enhancement, filtering, segmentation, and restoration issues image processing. The aim is to enable students gain familiarity with digital image processing problems, techniques, and methods.

Aims and Objectives: After completing this course,

- Students would have a basic understanding of the issues involved in image processing and the approaches, algorithms, and tools used to solve them.
- Students are able to compare and evaluate different approaches, and think about alternate solutions.
- Students are able to apply existing techniques to practical problems and undertake an undergrad level project in the area of image processing.

Course Contents: Introduction to Digital Image Processing (DIP); Fundamentals of Digital Image: visual perception, light and electromagnetic spectrum, sensing and acquisition, sampling and quantization, basic relationships between pixels, mathematical tools for digital image processing; Transformation and spatial filtering in spatial and frequency domain: smoothing and filtering, combining spatial enhancement methods, selective filtering; Image restoration and reconstruction: restoration by spatial and frequency domain filtering, linear position invariant degradations, estimation of the degradation function, Wiener, least-squares, and mean filters, image reconstruction from projections; Image segmentation: point, line, and edge detection, thresholding, region based segmentation, and the use of motion in segmentation.

Recommended Books

1. Gonzales, R. C., & Woods, R. E. (2008). *Digital Image Processing (3rd Ed.)*. Pearson Printice-Hall.

2. Gonzales, R. C., Woods, R. E. & Eddins, S. L. (2004). *Digital Image Processing using MATLAB (2nd Ed.)*. Pearson-Prentice-Hall.
3. Efford, N. (2000). *Digital Image Processing (Latest ed.)*. Addison Wesley.

Course Code	Course Title	Credit Hours
CS6807	Telecommunication Systems	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: This course will focus on theoretical frameworks and fundamental concepts behind the design and analysis of telecommunication networks (voice and data). Various algorithmic and optimization techniques used for efficient functioning of modern telecommunication networks will be taught.

Aims and Objectives: When students complete this course, they will be able to:

- Basic components of telecommunication systems.
- The challenges involved in guaranteeing QoS in telecommunication system.
- Different algorithms and processes involved in the design and management of telecommunication system.

Course Contents: Overview, Models and Why We Develop and Use Them, Terminology, Taxonomies of Telecom Systems, Analog and Digital Signals, Noise, Time and Frequency Domains of Signals, Modulation, Synchronous and Asynchronous Transmission, Transmission Subsystems, Transmission Media, Analog and Digital Transport Subsystems, Basic Concepts of Switching, Space and Time Division Switching Networks, ATM and Frame Relay, Store-and-Forward Switching, Characteristics of Switching Equipment and Systems, Examples of Switching Systems, Control Concepts and Definitions, Characteristics of Signaling Mechanisms, Examples of Signaling Subsystems, Network Management Concepts, Primary and Supplementary Access Functions, Simple Telecommunication Systems, Public Switched Telephone Network, Other Telecom Systems such as GSM, Network Services, Network Simulations using MATLAB, Graph Models of Networks, Fundamental Graph Algorithms, Network Optimization Techniques, Centralized and Distributed Network Topology Design, Traffic Characterization, Delay Modeling, Resource Management, QoS Issues and Congestion Control, Routing and Multicasting, Network Reliability, Capacity Planning, Access Network and Backbone Network Design, Stochastic Processes, Queuing Analysis, Flow Analysis, Performance Modeling and Simulation, Optical Network Design.

Recommended Books

1. Devetak F. U., Bosse, J. G. V. (2006). *Signalling in Telecommunication Networks (Latest ed.)*. John Wiley & Sons.
2. Ayers, M. L. (2012). *Telecommunications System Reliability Engineering, Theory and Practice (Latest ed.)*. John Wiley & Sons.

3. Terré, M., Pischella, M., Vivier, E. (2013). *Wireless Telecommunication Systems (Latest ed.)*. John Wiley & Sons.

Bibliography

1. Lakatos, L., Szeidl, L., Telek, M. (2012). *Introduction to Queuing Systems with Telecommunication Applications (Latest ed.)*. Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS6808	Network Security	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Data Communication, Computer Networks

Course Description: This course helps students to learn about cryptography, network security, the need to protect computer networks from unauthorized users and to exercise personal freedom on the network.

Aims and Objectives: When students complete this course, they will be able to:

- Understand network security.
- Services of network security.
- Types of techniques used for network security.
- Secret key cryptography and public key cryptography.
- Message authentication codes.
- Firewalls and protections of sensitive information.

Course Contents: Introduction of Network Security, Cryptography, Cipher , Key, Plain text, Cipher Text, Encipher , Decipher, Services of Cryptography, Ceaser cipher, Types of Cryptography, Secret Key Cryptography, Public Key Cryptography, Message Digest, Famous Algorithm of Secret Key Cryptography, Data Encryption standard, Initial Permutation in DES, Final Permutation in DES. DES round for Encryption, DES round for Decryption, Per-round key generation, Using Secret key cryptography to encrypt messages larger than 64-bits, Electronic Code Book, Cipher block Chaining, Output Feedback Mode, Cipher Feedback Mode, International Data EncryptionAlgorithm (IDEA), Multiple Encryption through DES i.e. Triple DES, Advanced Encryption Standard(AES), Modular Arithmetic, Public Key Cryptography, Congruence, Totient Function, Types of Public Key Cryptography, RSA Algorithm and examples, Deffie-Hellman Algorithm and examples, Step in Deffie-Hellman Algorithm for PKI. Trusted Intermediaries, Key Distribution Center/Key management Center, Digital Certificate, Certifying Authority, Certificate Revocation List, Firewall, Types of Firewalls. Kerberos protocol Working process, Privacy Enhanced Mail , Digital Watermarking, Identity Based Cryptography, Bilinear Map, Ring Signature, VANET security Issues.

Recommended Books

1. Kaufman, C., Perlman, R., Speciner, M. (2002). *Network Security (Latest ed.)*. Pub. Prentice Hall.
2. Stallings, W. (2017). *Network Security Essentials: Applications and Standards (6th Ed.)*. Pearson.
3. Maiwald, E. (2007). *Fundamentals of Network Security (Latest ed.)*. The McGraw-Hill Companies.

Course Code	Course Title	Credit Hours
CS6809	Introduction to Bioinformatics	3(3+0)

Specializations: General Track, Database Systems, Software Engineering

Prerequisites: Nil

Course Description: This course introduces the emerging area of Bioinformatics. This is a cross disciplinary course which highlights the main computational processes related to Biology.

Aims and Objectives: When students complete this course, they will be able to:

- Receive an introduction and historical perspective to the field of bioinformatics
- Learn the key methods and tools used in bioinformatics
- Build a solid foundation and acquire the vocabulary in bioinformatics for further research

Course Contents: 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, How to Write Algorithms, Calculate Complexities, 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, 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.).

Recommended Books

1. Attwood, T. K., & Parry-Smith, D. J. *Introduction to Bioinformatics (Latest ed.)*. Pearson Education
2. Lesk, A. (2013). *Introduction to bioinformatics (Latest ed.)*. Oxford University Press.
3. Benson, G., & Page, R. *Algorithms in Bioinformatics (Latest ed.)*. Springer.
4. Bockenhauer, H., & Bongartz, D. *Algorithmic Aspects of Bioinformatics (Latest ed.)*. Springer.

Course Code	Course Title	Credit Hours
CS6810	Differential Equations	3(3+0)

Specializations: General Track

Prerequisites: Calculus and Analytic Geometry

Course Description: This is a first course in differential equations. The focus is on the geometric interpretation and solution of ordinary differential equations and their application in mathematical modeling in various fields.

Aims and Objectives: The course will enable students to:

- Interpret and solve differential equations of the first order and think of their use in modelling and problem-solving in computer science.

Course Contents: 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, Modeling 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.

Recommended Books

1. Micheal, G. (1996). *Advanced Engineering Mathematics (Latest ed.)*. Prentice Hall Publishers.
2. Erwin, K., Herbert, K., & Edward, N. J. (2015). *Advanced engineering mathematics (Latest ed.)*.
3. Zill, Prindle, Weber, & Schmidt. (1996). *A First Course in Differential Equation (Latest ed.)*. Brooks/Cole Publishing.
4. Zill, D. G. (2016). *Differential equations with boundary-value problems (Latest ed.)*. Cengage Learning.
5. Edwards, C. H., & Penney, D. E. (1989). *Elementary differential equations with applications (Latest ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS6821	Information Retrieval and Web Search	3(3+0)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Linear Algebra, Probability and Statistics, Advanced Programming, Web Technologies

Course Description: The plethora of information and content available on the public Internet wrought forth a boom in the early 2000s in the area of web search engines. Companies such as Alta Vista, Excite, and Yahoo were the players, and the game had ambitious objectives for all the unknown web pages that existed in cyberspace: (1) locate them in some fashion (through links, through guessing, etc.); (2) obtain the content from those pages; and (3) make that content available to users who enter in a few search terms into an input box on a web page. This is an introductory course for students covering the practices, issues, and theoretical foundations of organizing and analyzing information and information content for the purpose of providing intellectual access to textual and non-textual information resources. This course will introduce students to the principles of information retrieval and search engines systems. It will cover algorithms, design, and implementation of modern information retrieval systems. Topics include: retrieval system design and implementation, text analysis techniques, retrieval models (e.g., Boolean, vector space, probabilistic, and learning-based methods), search evaluation, retrieval feedback, search log mining, and applications in web information management.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the basics and core concepts of information retrieval especially web search engines.
- give an account of the structure of a web search engine.
- Learn to process, index, retrieve, and analyze textual data.
- Learn to evaluate information retrieval systems.
- Learn about web search, crawling and link analysis.
- Build working systems that help users find useful information on the Web - Learn about the state of the art in information retrieval research.

Course Contents: Goals and history of IR, Impact of the web on IR, Boolean and Vector-Space retrieval models, Ranked Retrieval, Text-Similarity Metrics, TF-IDF (Term Frequency/Inverse Document Frequency) Weighting, Cosine Similarity, Tokenizing, Stop-Word Removal, and Stemming, Inverted Indices, Performance Metrics(Recall, Precision, and F-Measure), Relevance Feedback; Query Expansion; Query Languages, Word Statistics, Zipf's Law, Porter Stemmer, Morphology, Index Term Selection, Using thesauri, Metadata and Markup Languages (SGML, HTML, XML), Search Engine Architecture, Spidering, Crawlers and Crawling Strategies, Meta-crawlers, Directed Spidering, Link Analysis (Hubs and Authorities, Google PageRank), Shopping Agents, Content Detection and Analysis, Categorization Algorithms, Nearest neighbor, Naive Bayes, Applications to Information Filtering and Organization, Using Naive Bayes Text Classification for Ad-hoc Retrieval, Improved Smoothing for Document Retrieval, Clustering Algorithms, Agglomerative Clustering, k-means, Expectation

Maximization (EM), Ranking, Indexing, Applications to Web Search and Information Organization, Introduction to Nutch, Introduction to Tika, Introduction to Lucene.

Recommended Books

1. Büttcher, S., Clarke, C. L., & Cormack, G. V. (2016). *Information retrieval: Implementing and evaluating search engines (Latest ed.)*. MIT Press.
2. Manning, C. D., Raghavan, P., & Schütze, H. (2008). *Introduction to information retrieval (Latest ed.)*. Cambridge: Cambridge university press.
3. Ceri, S., Bozzon, A., Brambilla, M., Della Valle, E., Fraternali, P., & Quarteroni, S. (2013). *Web information retrieval (Latest ed.)*. Springer Science & Business Media.
4. Baeza-Yates, R., & Ribeiro-Neto, B. (2011). *Modern information retrieval (2nd Ed.)*. Addison-Wesley.

Course Code	Course Title	Credit Hours
CS6822	Service Oriented Architecture	3(3+0)

Specializations: Web Engineering, Software Engineering, General Track

Prerequisites: Web Technologies, Advanced Programming

Course Description: In the past, organizations have adopted computer applications to improve and automate their business processes. These applications have not been implemented according to a strategic plan or based on a common integrated IT infrastructure. Instead, it was based on the needs of each individual department of the company and always according to current technologies. Thus, most organizations have developed information infrastructures consisting of a set of autonomous and in many cases heterogeneous systems. As a result, the need for automated and integrated business processes has increased over the years but organizations were unable to build an integrated IT infrastructure as heterogeneous applications have had several connection problems. In recent years, Service Oriented Architectures (SOA) and technologies are widely used to help organizations overcome these problems. This course focuses on service-oriented architectural model and the service-orientation design paradigm. It will describe Service Oriented Architecture (SOA) concepts and principles, as well as quality considerations for developing modern software systems from a technical and organizational perspective. Specifically, the course will cover principles of SOA design and SOA design patterns. Furthermore, this course covers a wide-range of technologies for gaining the skills to design, build, and maintain a Service-Oriented Architecture (SOA).

Aims and Objectives: When students complete this course, they will be able to:

- Understand the main concepts and principles of SOA.
- Understanding of the strengths and weaknesses of SOA.
- Understand SOA challenges mainly regarding security, governance, testing, and maintenance.
- Implement and deploy simple web services using a suitable development platform.

Course Contents: Definition and Common Understanding of SOA, Relationship Between SOA and Web Services, Advantages and Risks of SOA, SOA History and Present, Compare SOA with other Architectures, SOA Applications' Lifecycle, Techniques and SOA Development Methodologies, Comparison and Evaluation of SOA Development Methodologies and Best Practices, Types and Function of Web Services, XML, SOAP, REST, WSDL, UDDI, Enterprise Service Bus (ESB), Process Driven Service (PDS), Overview of Service Oriented Analysis and Design (SOAD), Web Service Programming using Java EE, SOA QoS, SOA Security.

Recommended Books

1. Papazoglou, M. (2008). Web services: principles and *technology (Latest ed.)*. Pearson Education.
2. Erl, T. (2009). *SOA design patterns (Latest ed.)*. The Prentice Hall Service-Oriented Computing Series, Prentice Hall.
3. Weerawarana, S., Curbera, F., Leymann, F., Storey, T., & Ferguson, D. F. (2005). *Web services platform architecture: SOAP, WSDL, WS-policy, WS-addressing, WS-BPEL, WS-reliable messaging and more (Latest ed.)*. Prentice Hall PTR.

Course Code	Course Title	Credit Hours
CS6823	Wearable Technology	3(3+0)

Specializations: Web Engineering, General Track

Prerequisites: Mobile Applications Development

Course Description: This course invites students to examine the wearable technologies that are just starting to become part of our everyday lives. Wearables live on our wrists, attached to our eyeglasses, and embedded in our clothes. Wearable technologies field has been experiencing explosive growth with exciting applications in the fields of medicine, sports, fitness, entertainment, as well as new ways for people to interact, communicate, and experience the environment around them. This course gives an overview of ecosystem and current and future prospects of the wearable technologies, study the technology building blocks that empower wearable computing, master mobile programming skills for wearable devices, and turn creative ideas into innovative wearable products. It also introduces the basic open-source hardware and software platforms to provide elementary but insightful techniques for students to start their own projects. Through the introduction of wearable technology, the course aims at inspiring students' creativities and interests in generating innovative designs for future wearables systems. This is a agile course which will focus on new and emerging technologies. The individual topics may change if there is a significant new technology available at the start of the course.

Aims and Objectives: When students complete this course, they will be able to:

- Understanding and insight knowledge of wearable technologies and a wide range of cutting-edge projects in the related fields.
- Learn different aspects and issues of using wearable gadgets for solving different daily life problems.

- Learn the basics and differences of a wide range of wearable APIs and SDKs.
- Designing and creating of their projects in the field of wearable technology.
- Implement and deploy simple Android applications for suitable wearable devices.

Course Contents: Ecosystem of Wearable Computing, Background and History of Wearables, Attributes and Taxonomy of Wearables, Impact of Wearable Technology, Wearable Technology in Ethics, Limitations of Wearable Technology, Variety of Wearable Devices and Applications at Various Body Parts, Sensor Technologies for Wearables and Applications, Applications of Wearable Systems in Different Domains, Challenges and Opportunities in Wearable Technology, Security and Privacy Risks, Embedded Software Programming, Bluetooth Low Energy (BLE), Software Platforms for Wearables, Android Wear Programming, Advance Techniques for Wear Programming, Cloud Storage for Wearable Data, Students Group Project.

Recommended Books

1. Sazonov, E., & Neuman, M. R. (Eds.). (2014). *Wearable Sensors: Fundamentals, implementation and applications (Latest ed.)*. Elsevier.
2. Heydon, R. (2013). *Bluetooth low energy (Latest ed.)*. Prentice Hall.
3. Annuzzi Jr, J., Darcey, L., & Conder, S. (2014). *Advanced Android Application Development (4th Ed.)*. Pearson Education.
4. Ruiz, D. C., & Goransson, A. (2015). *Professional Android Wearables (Latest ed.)*. John Wiley & Sons.
5. Ryan, S. E. (2014). *Garments of paradise: wearable discourse in the digital age (Latest ed.)*. MIT Press.

Course Code	Course Title	Credit Hours
CS6831	Emerging Computer Networks	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Wireless and Mobile Networks

Course Description: This course focuses on the advance topics in the area of computer networks. The course consists of both a reading/lecture/discussion component and a project component. The focus will be on the existing technologies in addition to why some of them are not sufficient due to lack of support in technology or changes in fundamental assumptions.

Aims and Objectives: When students complete this course, they will be able to:

- Comparison of current network technologies with futuristic technologies.
- Understanding the requirements of future in relation with connectivity and communication.
- Effective utilization of network resources in comparison of physical and virtual environment.
- Understanding High speed data networks such as 5G and millimetre wave.

Course Contents: Data Center Network Topologies, Networking Issues for Big Data, Wireless Personal Area Networks (LOWPAN), The Challenges and Architecture of Software Defined Networking (SDN), Enabling Technologies of 5G Network and Beyond such as Millimeter Wave Communication, Machine Type Communication (MTC), Massive MIMO, Wireless Full Duplex Communication; Device to Device Communication in LTE-A with and without BS support, Massive and Ultra-Reliable Machine Type Communication and its Support in Cellular Networks, Data Offloading, Aggregation and Caching in Cellular Networks, Advantages and Challenges; SDN for 5G and Network Function Virtualizing (NFV), Radio Frequency Identifier (RFID), Body Area Networks (BAN), Energy Harvesting and Energy efficiency in HetNets, Delay Tolerant Networks, Protocol Suit, Issues and Comparison with TCP/IP Suit, Vehicular Adhoc Networks (VANETs), Performance, Challenges and Comparison with other Emerging Networks, Intelligent Transport System, Application and Architecture.

Recommended Books

1. Rodriguez, J. (2015). *Fundamentals of 5G Mobile Networks (Latest ed.)*. John Wiley & Son Ltd..
2. Makaya, C., & Pierre, S. (2011) *Emerging Wireless Networks: Concepts, Techniques and Applications (Latest ed.)*. CRC Press.
3. Huq, M. S., & Rodrigue, J. (2017). *Backhauling / Fronthauling for Future Wireless Systems (Latest ed.)*. John Wiley & Son Ltd.

Bibliography

1. Lakatos, L., Seidl, L., & Telek, M. (2012). *Introduction to Queuing Systems with Telecommunication Applications (Latest ed.)*. Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS6832	Network Administration	3(3+0)

Specializations: Computer Networks, General Track

Prerequisite: Computer Networks

Course Description: The focus of this course is to manage the local area network under different network operating systems.

Aims and Objectives: When students complete this course, they will be able to:

- Creating and designing a computer network.
- Managing computer networks under different network operating systems.
- Troubleshooting for any network related issues.

Course Contents: Review of TCP/IP, Overview of Network Services-Windows, Network Planning, Implementation, Deployment, and Management under Network Operating System, Implementation and Management of Network Services, Overview, Installation and Configuration

of MRTG, Installation and Maintaining NEO, Overview, Installation and Examples of NETFLOWS, Using and Maintaining OAK, Overview and use of tcpdump, Linux/Solaris Planning for Network Services. Basic of TCP/IP Configuration (Windows/Linux), DNS Services (Windows/Linux), Review and Labs, DHCP Services in Windows and Linux, Directory Services-Windows Active Directory, Windows Domain Service, Print/File Server, Network File System, Troubleshooting TCP/IP, Routing Services-Linux/Solaris, Switch Configuration, Virtualization, Firewall and Policies Implementations, IPv6 Implementation and Deployment, SNMP Implementation and Management.

Recommended Books

1. Wahl, C., Pantol, S. (2014). *Networking for VMware Administrators (Latest ed.)*. Pearson Education.
2. Limoncelli, T. A., Hogan, C. J., Chalup, S. R. (2016). *The Practice of System and Network Administration (Latest ed.)*. Pearson Education.
3. Murphy, N. R., Malone, D. (2005). *IPv6 Network Administration (Latest ed.)*. O'Reilly Media.
4. Hunt, C. (2002). *TCP/IP Network Administration (3rd Ed.)*. O'Reilly Media.
5. Kretchmar, J. M. (2004). *Open Source Network Administration (Latest ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS6841	Big Data Concepts	3(3+0)

Specializations: Database Systems, Software Engineering, General Track

Prerequisites: Database Systems

Course Description: This introductory course in big data helps you understand concepts and issues related to big data systems. Big data consists of very large or complex data sets that cannot adequately be stored, processed or analyzed through traditional, relational database technologies. It also includes a wide variety of data types and high-velocity data streams. You gain an understanding of the concepts and issues related to designing and using big data systems.

Aims and Objectives: Students successfully completing this course should be able to understand:

- What Big Data is?
- The components necessary to build a Big Data environment.
- Map-Reduce Programming Paradigm.
- The Hadoop ecosystem.

Course Contents: Introduction to the Big Data and its problems, Big data and its impacts, Current challenges, trends, and applications, Management of unstructured and structured data, Distributed computing and distributed infrastructure. Introduction to large scale file systems, operations and parallel processing algorithms. Technologies for Big Data management, Big Data

technology and tools, Cloud and Big Data, Operational Databases (relational and non-relational databases, key value pair database, document database, graph database) special consideration made to the Map-Reduce paradigm and the Hadoop ecosystem.

Recommended Books

1. Mayer-Schönberger, V., & Cukier, K. (2013). *Big data: A revolution that will transform how we live, work, and think (Latest ed.)*. Houghton Mifflin Harcourt.
2. Karau, H., Konwinski, A., Wendell, P., & Zaharia, M. (2015). *Learning spark: lightning-fast big data analysis (Latest ed.)*. O'Reilly Media, Inc.
3. Smolan, R. (2013). *The human face of big data. Against All Odds Productions (Latest ed.)*.

Course Code	Course Title	Credit Hours
CS6842	Database Administration	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Database Systems

Course Description: Establish expertise in fundamental concepts of Database Administration. This course concentrates on the principles, rules, techniques, tools used in a Database administration.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand SQL queries of a database system.
- Have in-depth knowledge of RDBMS and Database architecture.
- Strong concept of managing memory areas, performance and tuning of database.
- Apply backup and recovery techniques.

Course Contents: Database, Data, and System Administration, DBA Tasks, The Types of DBAs, Creating the Database Environment, Defining the Organization's DBMS Strategy, Choosing a DBMS, Architecture, Clustering, Proliferation and Issues, Data Modeling and Normalization, Data Modeling Concepts, Normalization Concepts, Database Design, From Logical Model to Physical Database, Database Performance Design, De-normalization, Application Design, Database Application Development and SQL, Types of SQL, Defining Transactions, Locking, Design Reviews and its Types, Design Review Output, Database Change Management, Change Management Requirements, Types of Changes and its Impact Database Structures, Data Availability, Cost of Downtime, Performance Management, Reactive and Proactive measurements, Types of Performance Tuning, System Performance, DBMS Installation and Configuration Issues, Logs Monitoring, Database Performance, Techniques for Optimizing Databases, Indexing and Free Space, Application Performance, Relational Optimization, Additional Optimization Considerations, Data Integrity, Backups And Recovery

Recommended Books

1. LaRock, T. (2010). *DBA Survivor (Latest ed.)*. Springer.
2. Mullins, C. (2002). *Database administration: the complete guide to practices and procedures (Latest ed.)*. Addison-Wesley Professional.
3. Fernandez, I. (2009). *Beginning Oracle Database 11g Administration: From Novice to Professional (Latest ed.)*. Dreamtech Press.

Course Code	Course Title	Credit Hours
CS6843	ETL (Extract, Transform, Load) Programming	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Nil

Course Description: This course focuses on ETL solutions. The designed audience should have adequate SQL programming skills and basic data warehouse concept. This course covers the core components of ETL architecture.

Aims and Objectives: Upon completion of this course, the audience should be able to:

- Understand Power Centre core components and how data flow through each component.

Course Contents: Basic ETL and data warehouse concept, connectivity from/to different types of data source/target, mapping specification and mapping development, creating and running workflow and session, using repository to copy/deploy/maintain ETL codes, debugging mapping, checking log files and finding performance bottleneck, illustrating the best practices of designing ETL solution, Architecture, Administrator's Components of an ETL tool, working with source/target, running and monitoring job execution, Transformations: Source Qualifier, Expression, Filter, Lookup, Router, Update Strategy, Sequence Generator, Normalizer, Other Transformations, Debugging A Mapping: Error Logging, Check Log Files, Debug Step by Step, Reusing/Sharing Designer Objects: Reusable Transformation, Mapplet, Advanced Designer Topic: Slowly-Changing Dimension, Dynamic Lookup, Mapping Parameter and Variable, Foreign-Key Based Loading, Understand Mapping Specification, Advanced Workflow Manager Topic: Parameter File, Worklet, Control Task, Command Task, E-mail Task, Event Raise/Wait Task, Code Promotion

Recommended Books

1. Kimball, R., & Caserta, J. (2011). *The Data Warehouse? ETL Toolkit: Practical Techniques for Extracting, Cleaning, Conforming, and Delivering Data (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS6851	Software Project Management	3(3+0)

Specializations: Software Engineering, Database Systems, General Track

Prerequisites: Software Engineering

Course Description: This course describes the key aspects of a software project and project management. The focus is placed on project management knowledge areas and associated processes as described by Project Management Institute(PMI).

Aims and Objectives: After completing the course, students should be able to:

- Identify organizational influences and project life cycle.
- Work with project management processes.
- Initiate and plan a project.
- Plan for project time management.
- Plan project budget, quality, and communications.
- Plan for risk, procurements, and stakeholder management.
- Execute a project and manage project work, scope, schedules, and cost.
- Control a project. and close a project

Course Contents: Software Crisis and Software Engineering, Classic Mistakes, Overview of Project Management, Project proposal and Request for Proposal (RFP) overview. PMI Process Groups, Software project Phases, Project charter, Statement of Work (SOW), Planning Phase: matching lifecycles to projects, Project plans, Work Breakdown Structures (WBS), Estimation of effort and cost (Expert Judgment, Function Points and Use Case point methods), Scheduling: Project network diagram fundamentals, Critical Path Method(CPM), PERT charts, Gantt charts, Using MS-Project, Assigning Resources, Resource leveling, Team models, Managing conflict and motivating, Project Monitoring and Control: Status reporting, Project metrics, Earned Value Management, Communications Techniques, Risk management and Change control, Documentation, Cutover/Migration, Post Project Reviews, Closing. High level comparison between PMI, CMMI and PRINCE2.

Recommended Books

1. Duncan, W.R. (2015). *A guide to the project management body of knowledge (5th Ed.)*. PMBOK® guide, Beijing: Dianzigongyechubanshe.

Bibliography

1. Hughes, B., & Cotterell, M. (2009). *Software project management (1st Ed.)*. London: McGraw-Hill.

Course Code	Course Title	Credit Hours
CS6852	Software Testing	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Advanced Programming, Software Engineering

Course Description: This course presents theory and practice of software testing. It covers structural testing including such topics as syntax testing, mutation testing, tools for software testing, testing specifications, black-box and white-box testing, code inspections, metrics, usability testing, testing documentation, website testing, security testing, beta testing, quality assurance, and software safety.

Aims and Objectives: After completing the course, students should be able to:

- Understand the concepts and theory related to software testing.
- Understand different testing techniques used in designing test plans, developing test suites, and evaluating test suite coverage
- Understand the relationship between black-box and white-box testing and know how to apply as appropriate.
- Learn to use automated testing tools in order to measure code coverage.
- Understand how software developers can integrate a testing framework into code development in order to incrementally develop and test code.

Course Contents: Introduction to software quality assurance, The Quality Challenge, Quality Control v/s Quality Assurance, Quality Assurance in Software Projects (Phases), Quality Assurance and Standards, Verification and Validation Planning, Software Quality Assurance (SQA) Plans, Software testing realities, Code coverage, Specification based test construction techniques, Black box, White-box and grey-box testing, Control flow oriented test construction techniques, Data flow oriented test construction techniques, Clean-room approach to quality assurance, Product Quality and Process Quality, Walkthroughs and code inspections, Web testing, Integrating testing into software development process, Test automation.

Recommended Books

1. Crispin, L., & Gregory, J. (2014). *Agile testing a practical guide for testers and agile teams (1st Ed.)*. Upper Saddle River: Addison-Wesley.
2. Homès, B. (2012). *Fundamentals of software testing (Latest ed.)*. Hoboken, NJ: ISTE / Wiley.

Bibliography:

1. Godbole, N. (2007). *Software quality assurance (1st Ed.)*. Oxford, U.K.: Alpha Science International Ltd.

Course Code	Course Title	Credit Hours
CS6853	Open Source Development	3(3+0)

Specializations: Software Engineering, Web Engineering, General Track

Prerequisites: Software Engineering, Object Oriented Analysis and Design, Advance Programming

Course Description: The course Introduces concepts, principles and applications of open source software. Discusses open source software development process. Cover economy, business, and societal and intellectual property aspects of open source software.

Aims and Objectives: Upon successful completion of the course the student will be able to:

- Understand concepts, strategies, and methodologies related to open source software development.
- Understand the business, economy, societal and intellectual property issues of open source software.
- Be familiar with open source software products and development tools currently available on the market.

Course Contents: The origins of the Open Source approach, The Open Source Definition, licenses (MPL, GPL, LGPL, etc.) and their effects; Contrasting and comparing open source vs. traditional development methodologies, a comparison of the Free Software Foundation and the Open Source community; a comparison of Open Source software and proprietary software; benefits, costs, risks; current issues and challenges , Open Source project management tools, Source code management and revision control, the Concurrent Versions System, problem reporting, clearing houses, groupware; major Open Source applications/projects: e.g. office suites, graphical products; major Open Source commercial organizations and their contributions; software development using Open Source methodologies and tools.

Recommended Books

1. Tomlinson, M. (2016). *How to Become an Expert Software Engineer (and Get Any Job You Want): A Programmer's Guide to the Secret Art of Free and Open Source Software Development (Latest ed.)*. Create Space Independent Publishing Platform.

Bibliography

1. Coleman, E. (2013). *Coding freedom (1st Ed..)*. Princeton: Princeton University Press.
2. Raymond, E.S. (2001). *The Cathedral & the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary (Latest ed.)*. O'Reilly Media.

Course Code	Course Title	Credit Hours
CS6861	Machine Learning	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: Statistics and Probability, Linear Algebra, Advanced Programming, Data Structures and Algorithms

Course Description: The aim of the course is to give students a basic understanding of the theory of machine learning, and its techniques and algorithms. Further, the objective of the course is to prepare students to learn machine learning at an advanced level.

Aims and Objectives: After completing this course:

- Students will be able to understand the theory of machine learning at a preliminary level and learn and apply some basic machine learning techniques.

Course Contents: Linear regression with one variable, linear algebra review, linear regression with multiple variables, logistic regression, regularization, neural networks, neural network learning, deep learning, fast nearest neighbor method, machine learning system design, support vector machines, un-supervised learning, dimensionality reduction, anomaly detection, recommender system, large-scale machine learning. Some advanced topics including Markov decision processes, dynamic programming, and deep reinforcement learning.

Recommended Books

1. Bishop, C. (2011). *Pattern recognition and machine learning (Latest ed.)*. Springer.
2. Harrington, P. (2012). *Machine learning in action (5th Ed.)*. Greenwich, CT: Manning.
3. Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2012). *Foundations of machine learning (Latest ed.)*. MIT press.
4. Richert, W. (2013). *Building machine learning systems with python (Latest ed.)*. Packt Publishing Ltd.