# CURRICULUM DIVISION, HEC

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. Mukhtar Ahmed</td>
<td>Executive Director</td>
</tr>
<tr>
<td>Mr. Fida Hussain</td>
<td>Director General (Acad)</td>
</tr>
<tr>
<td>Mr. Rizwan Shoukat</td>
<td>Deputy Director (Curr)</td>
</tr>
<tr>
<td>Mr. Abid Wahab</td>
<td>Assistant Director (Curr)</td>
</tr>
<tr>
<td>Mr. Riaz-ul-Haque</td>
<td>Assistant Director (Curr)</td>
</tr>
</tbody>
</table>

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

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

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

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

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

(Fida Hussain)
Director General (Academics)
CURRICULUM DEVELOPMENT PROCESS

STAGE-I

CURRI. UNDER CONSIDERATION

COLLECTION OF REC

CONS. OF CRC.

PREP. OF DRAFT BY CRC

STAGE-II

CURRI. IN DRAFT STAGE

APPRaisal OF 1ST DRAFT BY EXP. OF COL./UNIV

FINALIZATION OF DRAFT BY CRC

APPROVAL OF CURRI. BY V.C.C.

STAGE-III

FINAL STAGE

PREP. OF FINAL CURRI.

INCORPORATION OF REC. OF V.C.C.

STAGE-IV

FOLLOW UP STUDY

QUESTIONNAIRE

COMMENTS

PRINTING OF CURRI.

REVIEW

STAGE-IV

IMPLE. OF CURRI.

BACK TO STAGE-I

ORIENTATION COURSES

Abbreviations Used:
CRC. Curriculum Revision Committee
VCC. Vice Chancellor’s Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation
REC. Recommendations
Introduction:

National Curriculum Revision Committee

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

Committee Members:

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

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

Committee Members and Curriculum for Computer Science

1. Dr. Shariffullah Khan, Associate Professor, School of Electrical Engg & Computer Science National University of Science & Technology H-12 Islamabad. (Chairperson CS committee)
2. Dr. Imdad Ali Ismaili, Professor & PVC, Institute of Information & Communication Technology, University of Sindh, Allama I.I. Kazi Campus, Jamshoro, Sindh. Member
3. Dr. Hameedullah Kazi, Associate Professor & Chairperson, Dept. of Electrical Engg & Computer Science, ISRA University, Hyderabad, Sindh Member
4. Dr. Abdul Basit Siddiqui, Assistant Professor, Dept. of Software Engg, Member
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Position</th>
<th>Institution and Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>Dr. Syed Asad Raza Kazmi</td>
<td>Assistant Professor, Dept. of Computer Science, Government College University, Lahore.</td>
<td>Foundation University Institute of Engg. &amp; Management Sciences, New Lalazar Rawalpindi</td>
</tr>
<tr>
<td>6.</td>
<td>Dr. Aurangzeb Khan</td>
<td>Director/Assistant Professor, Institute of Engg &amp; Computing Sciences, University of Science &amp; Tech, Bannu.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Dr. Muhammad Abuzar Fahiem</td>
<td>Head, Dept. of Computer Science, Lahore College for Women University, Lahore.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Mr. Asim Munir</td>
<td>Professor / Chairman, Dept. of Computer Science &amp; Software Engg, International Islamic University, H-10, Islamabad.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Dr. Aftab Ahmed Shaikh</td>
<td>Associate Professor &amp; Dean, Faculty of ICT Dept. of Computer Science, Balochistan University of Information Tech. Engg &amp; Management Sciences, Quetta.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Mr. Amjad Hussain Zahid</td>
<td>Assistant Professor, Dept. of Computer Science, Forman Christian College, Ferozepur Road, Lahore.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Name</td>
<td>Position and Institution</td>
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</tr>
<tr>
<td>12.</td>
<td>Dr. Syed Jamal Hussain</td>
<td>Assistant Professor, Dept. of Computer Science, University of Karachi, Karachi.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
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<tr>
<td>13.</td>
<td>Dr. Sehat Ullah</td>
<td>Assistant Professor, Dept. of Computer Science &amp; IT, University of Malakand, Chakdara Dir (Lower).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
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<tr>
<td>14.</td>
<td>Dr. Ayesha Maqbool</td>
<td>Assistant Professor &amp; Coordinator, Dept. of Computer Science, Shaheed Benazir Bhutto Women University</td>
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<tr>
<td></td>
<td></td>
<td>Member</td>
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<tr>
<td>15.</td>
<td>Dr. Arshad Aziz</td>
<td>Professor, Department of Electrical Engineering, Pakistan Navy Engineering College, National University of Science and Technology PNS, Johar, Habib Rehmatullah Road</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Prof. Dr. Aftab Ahmad Malik</td>
<td>Dean, Faculty of Computer Science Engineering, GIK Institute of Engineering &amp; Technology, Topi, Swabi, KPK</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Dr. Ehsan Ullah Munir</td>
<td>Associate Professor / HOD, Dept. of Computer Science, COMSATS Institute of Information Technology (CIIT), Quaid Avenue, Wah Cantt.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Dr. Syed Asif Ali</td>
<td>Associate Professor, Department of Computer Science, Sindh Madrasatul Islam University, Awan-e-Tijarat Road, Karachi-74000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Member</td>
<td></td>
</tr>
</tbody>
</table>
Curricula Consideration

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

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

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

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

Section-I

Computer Science Programme BS (CS)

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

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

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Category</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Computing Courses</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Core Courses</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Supporting Areas Courses</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Computer Science Courses</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Com. Sc. Core Courses</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Com Sc. Supporting Courses</td>
<td>9</td>
</tr>
</tbody>
</table>
A complete detail of BS programme involving programme structure and distribution of credits among various components of programme are discussed in the following pages.

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

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

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

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

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

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

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

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

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

**Programme Structure:**

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

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

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

<table>
<thead>
<tr>
<th>Course Group</th>
<th>Credit hour</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Computing - Core courses</td>
<td>40</td>
<td>31%</td>
</tr>
<tr>
<td>Computing - Supporting areas</td>
<td>12</td>
<td>9%</td>
</tr>
<tr>
<td>Computing - General Education</td>
<td>18</td>
<td>14%</td>
</tr>
<tr>
<td>CS - Core courses</td>
<td>21</td>
<td>16%</td>
</tr>
<tr>
<td>CS – Electives</td>
<td>18</td>
<td>14%</td>
</tr>
<tr>
<td>CS - Supporting courses</td>
<td>9</td>
<td>7%</td>
</tr>
<tr>
<td>University Electives</td>
<td>12</td>
<td>9%</td>
</tr>
</tbody>
</table>
Some knowledge areas in Computer Science Electives Courses are listed below:

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

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

**Eligibility Criteria:**
The eligibility criteria of the curriculum by the last meeting were opened for discussion in the House. It was thoroughly discussed by considering all input streams of BS (Computer Science). The House unanimously recommended the eligibility criteria for admission to BS (Computer Science) as given:
The candidates require intermediate or equivalent qualification. However, the university shall define their selection criteria.

**General Recommendation Regarding Implementation of Programme:**

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

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

<table>
<thead>
<tr>
<th>#</th>
<th>Pre Req</th>
<th>Course Title</th>
<th>Credit hours</th>
<th>Proposed Semester</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>Programming Fundamentals</td>
<td>4 (3+1)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Object Oriented Programming</td>
<td>4 (3+1)</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Data Structure and Algorithms</td>
<td>3 (2+1)</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>Discrete Structures</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>Digital Logic Design</td>
<td>3 (2+1)</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>Operating Systems</td>
<td>4 (3+1)</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>Database Systems</td>
<td>4 (3+1)</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>Software Engineering</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>Data Communications and Computer Networks</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>Human Computer Interaction</td>
<td>3 (2+1)</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>Final year Project</td>
<td>6</td>
<td>7, 8</td>
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</table>

**Total Credit hours** 40

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

Computing courses:

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-Req</th>
<th>Course Title</th>
<th>Credit hours</th>
<th>Proposed Semester</th>
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<tbody>
<tr>
<td>12</td>
<td>MT</td>
<td>-</td>
<td>Calculus and Analytical Geometry</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>MT</td>
<td>-</td>
<td>Probability and Statistics</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>MT</td>
<td>-</td>
<td>Linear Algebra</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>EL</td>
<td>-</td>
<td>Basic Electronics</td>
<td>3 (2+1)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total Credit hours</strong></td>
<td>12</td>
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<table>
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<tr>
<th>#</th>
<th>Code</th>
<th>Pre-Req</th>
<th>Course Title</th>
<th>Credit hours</th>
<th>Proposed Semester</th>
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<tbody>
<tr>
<td>16</td>
<td>EG</td>
<td>-</td>
<td>English Composition and Comprehension</td>
<td>3</td>
<td>1</td>
</tr>
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<td>17</td>
<td>EG</td>
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<td>Technical and Business Writing</td>
<td>3</td>
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<td>Communication Skills</td>
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<td>Islamic Studies / Ethics</td>
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<td>Pakistan Studies</td>
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<td>2</td>
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<td>SS</td>
<td>-</td>
<td>Professional Practices</td>
<td>3</td>
<td>7</td>
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<td>21</td>
<td>CS</td>
<td>-</td>
<td>Introduction to Information and Communication Technologies</td>
<td>3 (2+1)</td>
<td>1</td>
</tr>
<tr>
<td></td>
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<td><strong>Total Credit hours</strong></td>
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Computer Science Courses

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-Req</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Proposed Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>CS</td>
<td>5</td>
<td>Microprocessor and Assembly Language</td>
<td>3 (2+1)</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>CS</td>
<td>-</td>
<td>Theory of Automata</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>24</td>
<td>CS</td>
<td>3</td>
<td>Design and Analysis of Algorithms</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>CS</td>
<td>3</td>
<td>Artificial Intelligence</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td>CS</td>
<td>5</td>
<td>Computer Architecture and Organization</td>
<td>3</td>
<td>4</td>
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<tr>
<td>27</td>
<td>CS</td>
<td>23</td>
<td>Compiler Construction</td>
<td>3 (2+1)</td>
<td>7</td>
</tr>
<tr>
<td>28</td>
<td>CS</td>
<td>9</td>
<td>Information Security</td>
<td>3</td>
<td>7</td>
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<td><strong>Total Credit Hours</strong></td>
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<tr>
<td>#</td>
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<td>Proposed Semester</td>
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<tr>
<td>29</td>
<td>CS</td>
<td>12</td>
<td>Numerical Computing</td>
<td>3 (2+1)</td>
<td>8</td>
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<tr>
<td>30</td>
<td>ST</td>
<td>12</td>
<td>Multivariate Calculus</td>
<td>3</td>
<td>4</td>
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<td>31</td>
<td>ST</td>
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<td>Differential Equations</td>
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<td>5</td>
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Total Credit Hours 9

<table>
<thead>
<tr>
<th>#</th>
<th>Course Title</th>
<th>Credit hours</th>
<th>Proposed Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Computer Graphics</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>33</td>
<td>Digital Image Processing</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>34</td>
<td>Digital Signal Processing</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>35</td>
<td>Computer Vision</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>36</td>
<td>Distributed Computing</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>37</td>
<td>Data and Network Security</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>38</td>
<td>Wireless Networks</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>39</td>
<td>Social Computing</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td>Mobile Application and Development</td>
<td>3 (2+1)</td>
<td>8</td>
</tr>
<tr>
<td>41</td>
<td>Web Design and Development</td>
<td>3 (2+1)</td>
<td>5</td>
</tr>
<tr>
<td>42</td>
<td>Data Warehousing</td>
<td>3 (2+1)</td>
<td>6</td>
</tr>
<tr>
<td>43</td>
<td>Expert Systems</td>
<td>3</td>
<td></td>
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<tr>
<td>44</td>
<td>Artificial Neural Network</td>
<td>3</td>
<td></td>
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<tr>
<td>45</td>
<td>Fuzzy Logic</td>
<td>3</td>
<td></td>
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<tr>
<td>46</td>
<td>Web Engineering</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Fundamentals of Data Mining</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Computational Intelligence</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Multi Agent Systems</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Natural Language Processing</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Game Development</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Logical Paradigms of Computing</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Formal Methods for Software Engineering</td>
<td>3</td>
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</tbody>
</table>
University Elective Courses

<table>
<thead>
<tr>
<th>#</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Proposed Semester</th>
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</thead>
<tbody>
<tr>
<td>101</td>
<td>Financial Accounting</td>
<td>3</td>
<td>4</td>
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<tr>
<td>102</td>
<td>Financial Management</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>103</td>
<td>Human Resource Management</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>104</td>
<td>Marketing</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>105</td>
<td>Economics</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>106</td>
<td>Psychology</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>107</td>
<td>International Relations</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>108</td>
<td>Foreign/Regional Language (French, German, Sindhi, Punjabi, Urdu etc.)</td>
<td>3</td>
<td>7-8</td>
</tr>
<tr>
<td>109</td>
<td>Philosophy</td>
<td>3</td>
<td>6-8</td>
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</table>

Structure of BS (CS) Programme

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Computing Courses</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Core Courses</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Supporting Areas Courses</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Computer Science Courses</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Computer Science Core Course</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Computer Science Supporting Courses</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Computer Science Electives Courses</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>General Education Courses</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>University Elective Courses</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credit Hours</strong></td>
<td><strong>130</strong></td>
</tr>
</tbody>
</table>

- Between 124-136 Credit hours are required for UG Degree
- 51-63 Credit hours should be taken in courses prescribed as major
- 34 Credit hours must be earned taking courses outside the major but within the same school as major
- 30 Credit hours must be earned taking multi-disciplinary courses outside the school of major.
- Regular students are required to take 12 Credit hours, but can take maximum 18 Credit hours if their CGPA is equal or more than 3.5
- Regular graduate students are required to take 9 Credit hours but can take maximum 12 if they meet the above conditions.
Proposed Scheme of Study for BS (CS)
4-Year Programme (8 Semesters)

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

<table>
<thead>
<tr>
<th>Semester 2 (12 Cr. Hrs.)</th>
<th>Cr. Hrs.</th>
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</thead>
<tbody>
<tr>
<td>Object Oriented Programming (Comp. Core)</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>Linear Algebra (Com – Supporting)</td>
<td>3</td>
</tr>
<tr>
<td>Technical and Business Writing(Gen. Edu)</td>
<td>3</td>
</tr>
<tr>
<td>Pakistan Studies(Gen. Edu)</td>
<td>2</td>
</tr>
<tr>
<td>Basic Electronics (Comp. Supporting)</td>
<td>3 (2+1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester 3 (15 Cr. Hrs.)</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Structure and Algorithms(Comp. Core)</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>University Elective I</td>
<td>3</td>
</tr>
<tr>
<td>Digital Logic Design (Comp. Core)</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>Probability and Statistics (Comp. Supporting)</td>
<td>3</td>
</tr>
<tr>
<td>Communication Skills(Gen. Edu)</td>
<td>3</td>
</tr>
<tr>
<td>University Elective II</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester 4 (15 Cr. Hrs.)</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microprocessor and Assembly Language (Comp. Sc. Core)</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>Computer Architecture and Organization (Comp. Sc. Core)</td>
<td>3</td>
</tr>
<tr>
<td>Multivariate Calculus (Comp Sc. Support)</td>
<td>3</td>
</tr>
<tr>
<td>University Elective III</td>
<td>3</td>
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<td>University Elective IV</td>
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**COURSE OUTLINE**

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

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

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

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

Reference Materials:

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

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

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

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

**Reference Materials:**
3. *Ivor Horton’s Beginning Java*, 7/e, Ivor Horton

---

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

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

**Reference Materials:**

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

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

**Reference Materials:**
1. *Digital Fundamentals* by Floyd, 11/e.  

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

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

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

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

Reference Material:

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

Course Outline:

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

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

Course Outline:

Reference Materials:
Computing Supporting Courses for Computer Science Programme

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

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

Reference Materials:

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

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

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

Course Outline:

Reference Materials:

Course Name: Basic Electronics
Prerequisites: None

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

Reference Materials:
1. *University Physics*, Freedman. Young. 10th and higher editions.
Computing General Education

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

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

Reference Materials:

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

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

Reference Material:
Course Name: Communication Skills
Credit Hours: 3
Prerequisites: None

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

Reference Material:

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

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

Reference Material:
1. The Emergence of Pakistan, Chaudary M., 1967
2. The making of Pakistan, Aziz. 1976
Course Name: Professional Practices  
Credit Hours: 3  
Prerequisites: None

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

Reference Material:  
1. Professional Issues in Software Engineering M.F. Bott et al.

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

Course Outline:  

Reference Materials:  
Computer Science Core Courses

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

Course Outline:

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

Reference Materials:

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

Course Outline:
Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene’s theorem, Transducers (automata with output), Pumping lemma and non regular language Grammars and PDA: Context free grammars, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky’s hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Reference Materials:
1. *Introduction to computer theory*, Daniel I. A. Cohen, 2nd Edition
Course Name: Design and Analysis of Algorithms
Credit Hours: 3
Prerequisites: Data Structures and Algorithms

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

Reference Materials:
2. *Algorithms in C++*, Robert Sedgewick

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

Course Outline:

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

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

Reference Materials:  

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

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

Reference Materials:  

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

Course Outline:  
Basic notions of confidentiality, integrity, availability; authentication models; protection models; security kernels; Encryption, Hashing and Digital
Signatures; audit; intrusion detection and response; database security, host-based and network-based security issues; operational security issues; physical security issues; personnel security; policy formation and enforcement; access controls; information flow; legal and social issues; identification and authentication in local and distributed systems; classification and trust modeling; risk assessment

**Reference Materials:**

**Computer Science Supporting Courses**

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

**Course Outline:**

**Reference Materials:**
5. *Numerical Analysis* by Berden, F.

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

**Course Outline:**
Reference Materials:

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

Course Outline:

Reference Materials:
Computer Science Electives

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

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

Reference Materials:

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

Course Outlines:

Reference Material:

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

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

**Reference Materials:**  

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

**Course Outline:**  

**Reference Materials:**  

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

**Course Outline:**
The topics covered will reflect the latest research and development activities in social networking e.g., Service architectures for social networks; Common APIs for popular architectures (Facebook, Open Social, etc.); Open ID and Shibboleth; Linked Data for social networks (FOAF, SKOS, etc); Social network properties and analysis methodologies; Social network interoperability; Social network topologies and ecosystems. Social networks in e-learning, enterprise and media; Identity, privacy and ownership in social networks; Aspects of recommendation engines and information retrieval in social networks; Sentiment classification, opinion extraction, social knowledge acquisition, social group identification and clustering, outlier detection.

**Reference Materials:**
1. *Opinion Mining and Sentiment Analysis (Foundations and Trends(R) in Information Retrieval)* by Bo Pang Lillian Lee  
2. *Introduction to Social Network Theory* by Kadushin, Charles. (Feb 17, 2004).  

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

**Course Outline:**

**Reference Materials:**

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

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

**Reference Materials:**
1. *Web enabled Commercial application development using HTML, DHTML, JAVASCRIPT* by Ivan Bayross. BPS Publications.  

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

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

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

Course outline:

Reference Materials:

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

Course Outline:

Reference Material:
Course Name: Fuzzy Logic System
Credit Hours: 3 (2+1)
Prerequisites: Discrete Structures

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

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

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

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

Reference Materials:
1. Ivon Bayross. Web enabled Commercial application development using HTML, DHTML, JAVASCRIPT, BPS Publications.

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

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

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

**Course Name:** Computational Intelligence  
**Credit Hours:** 3  
**Prerequisite:** Discrete Structures

**Course Outline:**  

**Reference Materials:**  

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

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

Reference Materials:

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

Course outline:

Reference Materials:
1. Daniel Jurafsky and James H. Martin. 2008. *Speech and Language Processing: An Introduction to Natural Language Processing,*
Course Name: Game Development  
Credit Hours: 3  
Prerequisites: Programming Fundamentals, Object Oriented Programming

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

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

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

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

Reference Materials:  
1. Logic in Computer Science Modelling and Reasoning about Systems 2nd Edition Michael Huth, Imperial College of Science, Technology and Medicine, London Mark Ryan, University of Birmingham, 2004  
Course Name: Formal Methods in Software Engineering
Course Structure: Lectures: 3
Credit Hours: 3
Prerequisites: Discrete Structures

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

Reference Materials:
1. Software Reliability Methods, Doron A. Peled, 2001 Springer-Verlag
2. Logic in Computer Science Modelling and Reasoning about Systems 2nd Edition Michael Huth, Imperial College of Science, Technology and Medicine, London Mark Ryan, University of Birmingham, 2004
Curriculum for MS (Computer Science)

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

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

Category wise Credit Hours Distribution

<table>
<thead>
<tr>
<th>Category or Area</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
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<tr>
<td>Electives</td>
<td>18</td>
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<tr>
<td>Thesis</td>
<td>6</td>
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<tr>
<td>Total Credit Hours</td>
<td>30</td>
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</table>

Programme Objectives:

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

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

Among the objectives for students in master’s programmes is entry into the Computer Science field at a relatively high level of responsibility and expertise. Computer Science is such a new and rapidly expanding field that individuals entering with a master’s degree in this field will almost
immediately move to positions with great responsibility. This, in turn, implies the requirement for an advanced level of prior training in both technical and related areas (e.g. communication skills). In all these cases, the master’s degree provides both motivations for the student and a standard for reward by the employer.

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

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

**Eligibility:**

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

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

Courses Requirements:

List of Core Course

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Course Title</th>
<th>Credit hours</th>
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<td>2</td>
<td>CS</td>
<td>Advanced Algorithm Analysis</td>
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</table>

List of Electives Courses:

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

<table>
<thead>
<tr>
<th>Code</th>
<th>Specialization Areas</th>
<th>Crt. Hrs</th>
<th>Code</th>
<th>Specialization Areas</th>
<th>Crt. Hrs</th>
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<td>CS</td>
<td>Software Engineering</td>
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<td>CS</td>
<td>Artificial Intelligence</td>
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<td>CS</td>
<td>Advanced Software Development</td>
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<td>CS</td>
<td>Design of Intelligent Systems</td>
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<td>Topics in Software Engineering</td>
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<td>CS</td>
<td>Machine Learning</td>
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<td>Object Oriented Software Engineering</td>
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<td>Neural Networks</td>
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<td>Software Quality Assurance</td>
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<td>Mathematical Reasoning</td>
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<td>Requirements Engineering</td>
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<td>Decision Support Systems</td>
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<td>Software Architecture</td>
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<td>Computer Vision</td>
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<td>Agent Oriented Software Engineering</td>
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<td>Planning systems</td>
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<td>Software Engineering and Formal Specifications</td>
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<td>Robotics</td>
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<td>Symbolic Computing</td>
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<td>Genetic Algorithms</td>
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<td>Semantic Web</td>
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<td>Computer Architecture and Organization</td>
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<td>Embedded Systems</td>
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<td>CS Multimedia Information Systems</td>
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<td>Parallel and Distributed Systems</td>
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<td>Design Verification</td>
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<td>Integrated Circuit</td>
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<td>Device Development</td>
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<td>Graphics and Visual Computing</td>
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<td>CS</td>
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<td>Dependent Computing</td>
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**Semester 2**

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**Semester 4**

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MS (CS) Core Courses
Course Description

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

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

Reference Materials:

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

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

MS (CS) Elective Courses with Course Details

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

Course Outline:

Reference Materials:
3. Advanced Concepts in Operating Systems by Singhal and Shiviratri

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

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

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

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

Reference Materials:
2. Practical Research Methods, CATHERINE DAWSON, How To Books Ltd, 3 Newtec Place, 2002.

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

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

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

Course Outline:

Reference Material:

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

Course Outlines:

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

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

Reference Materials: 

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

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

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

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

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

Reference Materials:

Course Name: Network Security
Credit Hours: 3
Prerequisites: Data Communications and Computer Networks

Course Outline:
Introduction; Cryptology and simple cryptosystems; Conventional encryption techniques; Stream and block ciphers; DES; More on Block Ciphers; The Advanced Encryption Standard. Confidentiality & Message authentication: Hash functions; Number theory and algorithm complexity; Public key Encryption. RSA and Discrete Logarithms; Elliptic curves; Digital signatures. Key management schemes; Identification schemes; Dial-up security. E-mail security, PGP, S-MIME; Kerberos and directory authentication. Emerging Internet security standards; SET; SSL and IPsec; VPNs; Firewalls; Viruses; Miscellaneous topics.

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

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

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

Reference Materials:

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

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

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

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

Reference Materials:

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

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

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

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

Reference Materials:  
2. Introduction to the Theory of Programming Languages Bertrand Meyer  
3. The Study of Programming Languages, Ryan Stansifer  
4. The Anatomy of Programming Languages, Fischer and Grodzinsky  
5. Concepts of Programming Languages, Sebesta

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

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

Reference Materials:  

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

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

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

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

Reference Material:

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

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

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

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

Reference Materials:

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

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

Reference Materials:
The contents and teaching approach depend on the instructor and the latest trends in the area. Macromedia’s presence on the web can be utilized for information transfer.
Following are some of the new course outlines for MS (CS) Programme suggested by Computer Science Committee.

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

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

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

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

Reference Materials:
1. Pattern Recognition and Machine Learning, Bishop, C., 2006
3. The Elements of Statistical Learning, Hastie, T., Tibshirani, R., and Friedman, J., Neural Networks for Pattern Recognition, 2009Bishop, C., 1995
Course Name: Advanced Optimization methods
Credit Hours: 3
Prerequisites: Discrete Mathematics

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

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

Reference Materials:

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

Course Outline:
A brief history of robotics, types of robots; Potential applications of intelligent systems and robotics; Sensors and Actuators; Sonar, laser scanner, optical encoders; DC motors. Control; Feedback control; Localization and mapping; Dead-reckoning; Triangulation. Kalman filter; Uncertainty grid; Behavior based programming; Robot behaviors. Potential field approach; Behavior based architecture; Recent advances; Multi-robotic systems; Robot evolution.
Reference Materials:
3. *Handbook of Robotics*, Siciliano, Bruno; Khatib, Oussama (Eds.), Springer 2008

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

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

Reference Materials:
Course Name: Fuzzy Systems
Credit Hours: 3
Prerequisites: Discrete Mathematics

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

Reference Materials:
5. Siddique, Nazmul and Adeli, Hojjat, 2013, Computational Intelligence. Wiley.

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

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

Reference Materials:

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

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

**Reference Materials:**  

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

**Course Outline:**  

**Reference Materials:**  
2. *Introduction to Genetic Algorithms*, S.N. Sivanandam, S. N. Deepa  
5. *Genetic Algorithms + Data Structures = Evolution Programs*, Zbigniew Michalewicz
Course Title: Visualization in Medicine
Credit Hours: 3
Prerequisite: Probability and Statistics and Graph Theory

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

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

Reference Material:

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

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

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

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

Reference Materials:

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

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

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

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

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

Course Outline:  
Introduction to Virtual Reality, Human and its environment, I³ diagram for VR (Interaction, Immersion, Imagination), Human centric reference model of VR, Sensory motor interfaces, Motion trackers, Stereoscopic vision(depth perception, stereoscopic image creation, active and passive stereoscopy), Design and evaluation of virtual environments, Application of (Medical, Psychotherapy, Fighting Simulation, Training Simulation, Assembling and Repairing, Biological and Physical Sciences, Collaborative Work, Ergonomic studies, Games VR, Introduction to Augmented Reality.

Reference Materials:  

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

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

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

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

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

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

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

Software engineering therefore requires familiarity with the basic needs and processes in the various application domains, with the principles of good
engineering practice and with the underlying concepts and principles of
computer science. It requires facility in problem analysis, solution design,
program development and documentation. It also requires a basic
understanding of the ways in which humans interact with technological
systems.

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

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

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

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

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

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

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

\(^1\) David Parnas, "Software Engineering Programmes are not Computer Science

\(^2\) David Parnas, "Software Engineering Programmes are not Computer Science
IEEE defines software engineering [IEEE-93] as

“1. The application of systematic, disciplined, quantifiable approach to development, operation, and maintenance of software; that is application of engineering to software.

2. The study of approaches as in 1.”

Software Engineering could also be defined as:

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

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

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

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

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

“The curriculum must provide both breadth and depth across the range of engineering and computer science topics implied by the title and objective of
the programme. The programme must demonstrate that graduates have: the ability to analyze, design, verify, validate, implement, apply, and maintain software systems; the ability to appropriately apply discrete mathematics, probability and statistics, and relevant topics in computer and management sciences to complex software systems.”

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

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

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

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

\textsuperscript{3} Guide to Software Engineering Body of Knowledge, 2004 Edition,
\textsuperscript{4} Software Engineering – Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering, 2004August 23, 2004
\textsuperscript{5} Computing Curriculum 2008—Draft
Software Engineering Degree Programme:

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

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

Duration of Programme:
The committee defined a credit hour as one lecture hour in a course offered in a particular semester. It was agreed that 3 weekly lab hours shall be treated as one credit hour. In normal circumstances a semester comprises 15 to 16 teaching weeks followed by the final examination. It is also recommended that one week may be given to students as preparation week before final exam.

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

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

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

Programme Objective:

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Major Areas</th>
<th>Core/ Required</th>
<th>Elective</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing Foundation</td>
<td>46</td>
<td>21</td>
<td>85 (64%)</td>
</tr>
<tr>
<td>Software Engineering</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting Studies (Math/Science)</td>
<td>12</td>
<td>9</td>
<td>21 (17%)</td>
</tr>
<tr>
<td>General Education</td>
<td>15</td>
<td>12</td>
<td>27 (21%)</td>
</tr>
<tr>
<td>Total</td>
<td>91 (68%)</td>
<td>42 (33%)</td>
<td>133</td>
</tr>
</tbody>
</table>
### Computing-Core Courses-45 Credit Hours

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

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

### Elective Computing and Software Engineering Courses (15/133)

#### Domain Specific Elective Courses (6/133)

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

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

<table>
<thead>
<tr>
<th>Domains</th>
<th>Topics /Component</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 IS</td>
<td>Enterprise Systems Engineering</td>
<td>ERP Systems, SCM Systems, CRM Systems</td>
</tr>
<tr>
<td>2 NS</td>
<td>Net-Centric Systems</td>
<td>Knowledge and skills in Web-based Technologies, Depth in networking, Depth in security</td>
</tr>
<tr>
<td>3 IS</td>
<td>Enterprise Security Architecture</td>
<td>Business issues related to security, Security weaknesses and risk analysis, Cryptography, cryptanalysis, steganography, etc., Depth in networks</td>
</tr>
<tr>
<td>#</td>
<td>Dept</td>
<td>Systems and Systems</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
<td>---------------------</td>
</tr>
<tr>
<td>4</td>
<td>IS</td>
<td>Information Systems and Data Processing</td>
</tr>
<tr>
<td>5</td>
<td>IS</td>
<td>Financial and E-commerce Systems</td>
</tr>
<tr>
<td>6</td>
<td>CE</td>
<td>Fault Tolerant and Survivable Systems</td>
</tr>
<tr>
<td>7</td>
<td>CE</td>
<td>Safety Critical Systems</td>
</tr>
<tr>
<td>8</td>
<td>CE</td>
<td>Embedded &amp; Real time Systems</td>
</tr>
<tr>
<td>9</td>
<td>BI</td>
<td>Bio-medical Systems</td>
</tr>
<tr>
<td>10</td>
<td>SS</td>
<td>Scientific Systems</td>
</tr>
<tr>
<td>11</td>
<td>TE</td>
<td>Telecommunication Systems</td>
</tr>
<tr>
<td>12</td>
<td>AS</td>
<td>Avionic &amp; Vehicular Systems</td>
</tr>
<tr>
<td>14</td>
<td>IE</td>
<td>Industrial Process Systems</td>
</tr>
<tr>
<td>15</td>
<td>ES</td>
<td>Multimedia, game, and entertainment Systems</td>
</tr>
</tbody>
</table>
### Bachelor of Science in Software Engineering: BS (SE)

**Software Engineering Core Courses 15 Credit Hours**

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SE</td>
<td>3,9</td>
<td>Object Oriented Software Engineering</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>SE</td>
<td>9</td>
<td>Software Requirements and Specifications</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>SE</td>
<td>13</td>
<td>Software Architecture Design</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>SE</td>
<td>13</td>
<td>Software Vérification and Validation</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>SE</td>
<td>9</td>
<td>Software Project Management</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

**Software Engineering Elective Computing 15 Credit Hours**

Elective Computing & Software Engineering Courses (15/133)
(The list below is by no means exhaustive. Institutions may add new course)

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SE</td>
<td>9</td>
<td>Software Engineering Economics</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>2</td>
<td>MG</td>
<td>-</td>
<td>Information System Audit</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>9</td>
<td>Business Process Engineering</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>4</td>
<td>SE</td>
<td>7,10</td>
<td>Distributed Computing</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>5</td>
<td>CS</td>
<td>3</td>
<td>Introduction to Soft Computing</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>6</td>
<td>CS</td>
<td>7,10</td>
<td>Real-time systems</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>7</td>
<td>CS</td>
<td>8</td>
<td>Data Warehousing</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>8</td>
<td>CS</td>
<td>8</td>
<td>Data Mining</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>9</td>
<td>CS</td>
<td>4</td>
<td>Artificial Intelligence</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>10</td>
<td>CS</td>
<td>3</td>
<td>Data Security and Encryption</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>CS</td>
<td>14</td>
<td>Secure Software Development</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----</td>
<td>----------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>4</td>
<td>Automata Theory and Formal Languages</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>8</td>
<td>Advance Database Management Systems</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>1,4</td>
<td>Introduction to Bioinformatics</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>33</td>
<td>Bioinformatics Software Engineering</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>2</td>
<td>Web-Engineering</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>9</td>
<td>System Analysis and Design</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>3</td>
<td>Event Driven Programming</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>12</td>
<td>Aspect Oriented Software Design</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>3</td>
<td>Agent Based Computing</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>20</td>
<td>Cloud Computing</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>-</td>
<td>Social Networks</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>-</td>
<td>Intro. to Complex Networks</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>2</td>
<td>Functional Programming</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>2</td>
<td>Mobile Computing</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>9</td>
<td>Formal Methods</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

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

Elective Supporting Courses (9/130) *(The list below is by no means exhaustive. Institutions may add new course)*

| MT  | 1  | Advanced Calculus | 3 |
| MT  | 3  | Numerical and Symbolic Computing | 3 |
| MT  | 3  | Stochastic Processes | 3 |
| Sc  | -  | Physics-II (Mechanics) | 3 |
| Sc  | -  | Bio-Chemistry | 3 |
| Sc  | -  | Biology/ genetics | 3 |
| EE  | 4  | Digital Electronics | 4 (3+1) |
| Sc  | -- | Software Engineering Economics | 3 |
| MT  | -- | Computational Linear Algebra | 3 |
| MT  | -- | Operation Research | 3 |
| MT  | -- | Simulation and Modeling | 3 |
| CS  | -- | Natural Language Processing | 3 |
Computing Requirements-General Education  15 Credit Hours
(Refer to Computing part)

Elective General Education Courses (12/130)
(The list below is by no means exhaustive. Institutions may add new course)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td></td>
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<td>1</td>
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<td>Economics</td>
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<td>Sociology</td>
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<td>Psychology</td>
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<td>SS</td>
<td>International Relations</td>
<td>3</td>
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<tr>
<td>6</td>
<td>HU</td>
<td>Foreign Language (Arabic, French, German, etc.)</td>
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</tr>
<tr>
<td>7</td>
<td>MG</td>
<td>Information System Audit</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>MG</td>
<td>Principles of Management</td>
<td>3</td>
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<td>9</td>
<td>MG</td>
<td>Human Resource Management</td>
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<td>10</td>
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<td>Marketing</td>
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<tr>
<td>11</td>
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<td>Accounting and Finance</td>
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</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Semester-wise 4-Year Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1</td>
</tr>
<tr>
<td>Cr. Hrs.</td>
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<tr>
<td>Cr. Hrs.</td>
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<tr>
<td>Introduction to Computing</td>
</tr>
<tr>
<td>4 (3+1)</td>
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<tr>
<td>Programming Fundamentals</td>
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<td>4 (3+1)</td>
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<td>Discrete Structures</td>
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<td>Physics</td>
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<td>3</td>
</tr>
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<td>English-I (Functional English)</td>
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</tr>
<tr>
<td>Islamic Studies/Ethics</td>
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<tr>
<td>17</td>
</tr>
</tbody>
</table>

| Semester 3               |
| Cr. Hrs. | Semester 4               |
| Cr. Hrs. |                        |
| Software Engineering   | Object Oriented Software |
| 3                  | Engineering             |
| Data Structures and Algorithms | Supporting Elective-II |
| 4 (3+1)            | 3                        |
| Digital Logic & Design | GE/University Elective II|
| 4 (3+1)            | 3                        |
| Linear Algebra       | Introduction to Database Systems |
| 3                  | 4(3+1)                   |
|                      | Pakistan Studies         |
|                      | 2                        |
BS (SE)-Software Engineering (Core)

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

**Course Outline:**
Reference Materials:

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

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

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

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

Reference Materials:

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

Course Outline:
Introduction to the discipline of design, generic design processes, and design management; software product design, including analysis activities such as
needs elicitation and documentation, requirements development activities such as requirements specification and validation, prototyping, and use case modelling; engineering design analysis, including conceptual modelling and both architectural and detailed design; survey of patterns in software design, including architectural styles and common mid-level design patterns.

Reference Materials:

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

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:
BS (SE) - Software Engineering Courses (Electives)

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

Course Outline:

Reference Materials:

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

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

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

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

**Reference Materials:**

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

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

**Reference Materials:**

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

**Course Outline:**
Reference Materials:

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

Course Outlines:

Reference Material:

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

Course Outline:
Fundamentals of networks, Mathematics of Graphs and Networks, Measures and Metrics Degree and eccentricity Centrality, Shortest path between Centrality, Clustering coefficient, Matching index, Large-scale Nature of Networks, Network Models (Erdos-Renyi random, Small-world, Scale-free network models, Calculation of basic measures in networks), Network Modeling tools overview (Pajek, Network Workbench, Gephi, Visone, Cytoscape, Centibin etc.), Evolution of Online Social networks: Facebook, Google+, Twitter, LinkedIn and Beyond, Social Network Analysis, Modeling Software Components as Agents in Networks
Reference Materials:
1. *Networks: An Introduction* by Mark Newman, Oxford University Press, 2010 (latest Ed.)

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

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

Reference Material:

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

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

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

Course Outline:

Reference Materials:  

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

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

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

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

Reference Materials:

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

Course Outline:
Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (Fas), Transition graphs (TGs), NFAs, kleene’s theorem, Transducers (automata with output), Pumping lemma and non regular language Grammars and PDA: Context free grammars, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Push-down Automata, Pumping lemma and non-context free languages, Decidability, Chomsky’s hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Context sensitive Grammars, Defining Computers by TMs.

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

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

Reference Materials: 
1. Introduction to Bioinformatics by T K Attwood, D J Parry-Smith, Samiron Phukan, Pearson Education (Latest edition)  
2. Introduction to Bioinformatics by Arthur Lesk  
3. Algorithms in Bioinformatics by Gary Benson, Roderic Page, Springer  

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

Course Outline:  

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

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

Reference Materials:

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

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

Reference Materials:

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

Course Outline:
Introduction to the course and its importance, history and course format, Introduction to C# or Java, Event-driven programming basics, Maintaining state, On-demand Rendering in event-driven applications, Timer and perpetual tasks, Multithreading and event-driven programming, A "window/frame" as a drawing surface + event-handling unit, Interesting
widgets, GUI design patterns, Performance issues, Gui on mobile devices/smart phones.

Reference Materials:
1. Event Processing in Action, Opher Etzion (Latest Edition)
2. Windows Presentation Foundation Unleashed, Adam Nathan (Latest Edition)

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

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

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

Reference Materials:

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

Course Outlines:
Reference Materials:
1. *Agent-Based and Individual-Based Modeling: A Practical Introduction*, Steven F. Railsback and Volker Grimm (Latest Edition)

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

Course Outline:

Reference Materials:
Course Name: Social Networks
Credit Hours: 3
Prerequisites: None

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

Reference Material:

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

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

Reference Materials:

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

Course Outline:
Types of Mobile Applications How are Users of Mobile Devices (Smartphones) Different from Users of Other Devices? Technologies Involved in Application Development. Differences from Desktop and Server Side Software Development, Software Design Concerns, Stakeholders in mobile applications: manufacturers, network operators, consumers, application developers, content providers, Android Platform Architecture and Application Fundamentals, Android application development tools. User Interface components, Data Storage and Content Providers, Services, Broadcast Receivers, Application Resources and other android structures, Using Android platform APIs, Web applications, Application Testing Framework, Introduction to games for mobile platforms, Introduction to
mobile gaming engines. Overview of game development using a game engine, Apple iOS, Java ME, Windows Phone, Comparison and limitations of popular Cross platform development tools.

Reference Materials:
2. The Busy Coder's Guide to Android Development, Mark Murphy, CommonsWare, LLC. (Latest Edition)

Elective Supporting Courses

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

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

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

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

Reference Materials:
2. Computational Methods of Linear Algebra, G. Sewell, (2/e), (2005) or Latest Edition
Course Name: Operations Research
Credit Hours: 3
Prerequisites: Probability and Statistics

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

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

Reference Materials:

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

Course Outline:

Reference Materials:

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

Course Outline:

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

Reference Materials:
Curriculum for MS Software Engineering, MS (SE)

Eligibility:
1. BS (SE/CS) 4 years degree programme,
   OR
2. Computer Science conversion course two years degree programme referred to as MCS or M.Sc. (Computer Science),
   OR
3. BCS 3-year programme degree applicants may be provisionally admitted in the MS (SE) programme. Candidates will be required to take additional courses to complete credit hour requirement of min. 130 before being formally enrolled in the MS (SE) programme.

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

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

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

Degree Requirements:
In order to obtain MS (SE) degree a student must pass a minimum of:
- i) Four (4) courses (12 credit hours) from the core courses
  AND
- ii) Four (4) courses of 12 credit hours graduate elective courses of which two graduate courses may be taken from other areas.
  AND
- iii) Satisfactorily complete a Research Project Thesis of 9 credit hours.
Core Courses:
Following two courses are considered as core courses for MS (SE) Program

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
<th>Semester</th>
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<tbody>
<tr>
<td>1</td>
<td>SE</td>
<td>Requirements Engineering</td>
<td>3</td>
<td>1-2</td>
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<tr>
<td>2</td>
<td>SE</td>
<td>Software Quality Assurance</td>
<td>3</td>
<td>1-2</td>
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</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>S.No</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Semester</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Software Risk Management</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>2.</td>
<td>Software Measurement and Metrics</td>
<td>3</td>
<td>2-4</td>
</tr>
<tr>
<td>3.</td>
<td>Software Configuration Management</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>4.</td>
<td>Reliability Engineering</td>
<td>3</td>
<td>2-4</td>
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<td>5.</td>
<td>Component Based Software Engineering</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>6.</td>
<td>Design Patterns</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>7.</td>
<td>Complex Networks</td>
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<td>2-4</td>
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<tr>
<td>8.</td>
<td>Agent Based Modelling</td>
<td>3</td>
<td>2-4</td>
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<td>9.</td>
<td>Formal Methods</td>
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<td>2-4</td>
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<td>10.</td>
<td>Software Engineering Ontologies</td>
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<tr>
<td>11.</td>
<td>Semantic based Software Engineering</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>12.</td>
<td>Model Driven Software Development</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>13.</td>
<td>Software Process Engineering</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>14.</td>
<td>Advanced Web Services</td>
<td>3</td>
<td>2-4</td>
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<tr>
<td>15.</td>
<td>Advanced Human Computer Interaction</td>
<td>3</td>
<td>2-4</td>
</tr>
<tr>
<td>16.</td>
<td>Simulation and Modeling</td>
<td>3</td>
<td>2-4</td>
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</table>
Sample Scheme of Study for MS (SE)  
2–year Programme (4 Semesters)  
(30 Credit Hours)

### Semester 1

<table>
<thead>
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<th>Code</th>
<th>Course Title</th>
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<tr>
<td>1</td>
<td>SE</td>
<td>Requirements Engineering</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>SE</td>
<td>Software Quality Assurance</td>
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<tr>
<td>3</td>
<td>SE</td>
<td>Research Methods</td>
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<td>(University Elective I)</td>
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Semester Total 9

### Semester 2

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<tr>
<td>1</td>
<td>SE</td>
<td>Elective II</td>
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<td>Elective III</td>
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<td>SE</td>
<td>Elective IV</td>
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Semester Total 9

### Semester 3

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<th>Cr. Hrs.</th>
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<td>SE</td>
<td>Elective V</td>
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<tr>
<td>2</td>
<td>SE</td>
<td>Thesis (Partial Enrolment)</td>
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Semester Total 6

### Semester 4

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<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
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<tbody>
<tr>
<td>1</td>
<td>SE</td>
<td>Thesis (Full Enrolment)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>SE</td>
<td>Elective VI</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>SE</td>
<td>Semester Total</td>
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</tr>
</tbody>
</table>

Total Credit Hours 30

**Course Descriptions (Core)**

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

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

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

Course Outline:
What Is Software Quality: Quality Assurance, Quality Engineering


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

Risk Identification for Quantifiable Quality Improvement, Software Reliability Engineering.

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

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

Reference Materials:

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

Course Outline:
Risk-Management Discovery, Risk-Management Process, Process steps, inputs, and outputs, Methods and tools, reusable process component. Risk-Management Infrastructure, Training metrics, establishing a baseline for quantitative process improvement, infrastructure, there is no strategic plan in place to institutionalize risk management. Senior managers, engineering
managers, and change agents should benefit from these organizational building blocks.

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

Reference Materials:

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

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

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

Reference Materials:

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

Course Outlines:
Psychologist Loads at the Workplace, Learning From Mistakes, Establishing IT Controls and Compliance, Industry Standards and Framework.

Reference Materials:

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

Course Outlines:

Reference Materials:

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

Course Outline:

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

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

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

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

Reference Materials:


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

Course Outline:
Reference Materials:
1. *Agent-Based and Individual-Based Modeling: A Practical Introduction* by Steven F. Railsback and Volker Grimm, 2011 (latest ed.).

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

Course Outlines:

Reference Materials:

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name &amp; Address</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Prof. Dr. Muhammad Anwar-ur-Rehman Pasha, Chairman, Department of Computer Science &amp; Information Technology, University of Sargodha, Sargodha</td>
<td>Chairperson committee on BS(IT)</td>
</tr>
<tr>
<td>2.</td>
<td>Dr. Imdad Ali Ismaili, Professor &amp; Director, Institute of Information &amp; Communication Technology, University of Sindh, Allama I.I. Kazi Campus, Jamshoro, Sindh.</td>
<td>Member</td>
</tr>
<tr>
<td>3.</td>
<td>Dr. Mansoor-uz-Zafar Dawood, Dean, Faculty of Computer Sciences &amp; IT, Institute of Business &amp; Tech (IBT) Main Ibrahim Hydri Road, Karachi.</td>
<td>Member</td>
</tr>
<tr>
<td>4.</td>
<td>Prof. Dr. Madad Ali Shah, Professor and Head, Department of Electrical &amp; Telecommunication Engineering, Sukkur IBA, Airport Road, Sukkur, Sindh.</td>
<td>Member</td>
</tr>
<tr>
<td>5.</td>
<td>Prof. Dr. Nisar Ahmed Memon, Professor, Dept. of Computer System, Quaid-e-Awam University of Engg Science &amp; Technology, Nawabshah.</td>
<td>Member</td>
</tr>
<tr>
<td>6.</td>
<td>Dr. Mumtaz Hussain Mahar, Professor, Dept. of Computer Science, Shah Abdul Latif University, Khairpur.</td>
<td>Member</td>
</tr>
<tr>
<td>7.</td>
<td>Dr. Saeed Mahfooz, Associate Professor &amp; Chairman, Dept. of Computer Science, University of Peshawar, Peshawar.</td>
<td>Member</td>
</tr>
</tbody>
</table>
The National Curriculum Revision Committee for Information Technology (NCRC-IT) met at HEC Regional Office Lahore on meet again on 10th to 12th June, 2013 and finalized the curricula recommendations. The experts attended were same as in the first meeting.

**The Discipline of Information Technology**

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

![Figure 1: Key Pillars of IT](image)

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

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\(^7\) Curriculum Guidelines for Undergraduate Degree Programs in Information Technology (2008)
IT Programs’ Rational

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

![Figure 2 IT Knowledge Areas and Technologies](image-url)
Vision of Information Technology Education
As defined in cc2008 “Information Technology is very much an integrative discipline; it pulls together the IT pillars of databases, human-computer interaction, networking, programming, and web systems and uses a solid background in each of them to enable graduates to solve all types of computing and informational problems, regardless of their origin. As a discipline, IT emphasizes the pervasive themes of user centeredness and advocacy, information assurance and security, and the management of complexity through abstraction and modeling, best practices, patterns, standards, and the use of appropriate tools.” In the light of this explanation, the curriculum committee formalized the Vision Statement for IT education in Pakistan as follows:

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

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

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

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

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

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

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

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

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

Curriculum for BS Information Technology, BS (IT)

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

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

Structure of BS Information Technology:

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

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Computing Courses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Supporting Areas</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Information Technology Courses</td>
<td></td>
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<tr>
<td></td>
<td>Core</td>
<td>21</td>
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<tr>
<td></td>
<td>Electives</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Supporting</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>General Education Courses</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>University Elective Courses</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Total Credit Hours</td>
<td>136</td>
</tr>
</tbody>
</table>
## Computing — Core Courses (40 Credits Hours)

### Required Computing Courses

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Name</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CMP</td>
<td>-</td>
<td>Programming Fundamentals</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>2</td>
<td>CMP</td>
<td>1</td>
<td>Object Oriented Programming</td>
<td>3*</td>
</tr>
<tr>
<td>3</td>
<td>CMP</td>
<td>-</td>
<td>Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>CMP</td>
<td>3</td>
<td>Data Structures and Algorithms</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>5</td>
<td>CMP</td>
<td>-</td>
<td>Digital Logic Design</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>6</td>
<td>CMP</td>
<td>-</td>
<td>Operating Systems</td>
<td>3*</td>
</tr>
<tr>
<td>7</td>
<td>CMP</td>
<td>-</td>
<td>Database Systems</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>8</td>
<td>CMP</td>
<td>-</td>
<td>Software Engineering</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>CMP</td>
<td>-</td>
<td>Computer Communications and Networks</td>
<td>3*</td>
</tr>
<tr>
<td>10</td>
<td>CMP</td>
<td>-</td>
<td>Human Computer Interaction</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>CMP</td>
<td>-</td>
<td>IT Capstone Project</td>
<td>6 (0+6)</td>
</tr>
</tbody>
</table>

**Total Credit Hours** (40/136)

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

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## IT — Core Courses (21 Credits Hours)

### Required IT Core Courses

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Name</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>IT</td>
<td>-</td>
<td>Web Systems and Technologies</td>
<td>3*</td>
</tr>
<tr>
<td>17</td>
<td>IT</td>
<td>-</td>
<td>Multimedia Systems and Design</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>18</td>
<td>IT</td>
<td>6</td>
<td>Systems and Network Administration</td>
<td>3*</td>
</tr>
<tr>
<td>19</td>
<td>IT</td>
<td>-</td>
<td>Network Security</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>20</td>
<td>IT</td>
<td>-</td>
<td>Cloud Computing</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>21</td>
<td>IT</td>
<td>-</td>
<td>System Integration and Architecture</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Credit Hours** (21/136)

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

---

## IT — Supporting Courses (15 Credits Hours)

### Required Supporting Courses

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Name</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>IT</td>
<td>8,21</td>
<td>IT Project Management</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>IT</td>
<td>9</td>
<td>Internet Architecture &amp; Protocols</td>
<td>3</td>
</tr>
<tr>
<td>25</td>
<td>IT</td>
<td>8</td>
<td>Object Oriented Analysis &amp; Design</td>
<td>3*</td>
</tr>
<tr>
<td>26</td>
<td>IT</td>
<td>7</td>
<td>Database Administration &amp; Management</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>27</td>
<td>IT</td>
<td>-</td>
<td>Information Systems</td>
<td>3 (3+0)</td>
</tr>
</tbody>
</table>

**Total Credit Hours** (15/136)
### General Education (18 Credits Hours)

**Required General Education Courses**

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Name</th>
<th>Cr. Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ENG</td>
<td>-</td>
<td>Functional English (English-I)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>ENG</td>
<td>-</td>
<td>Communication Skills (English-II)</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>ENG</td>
<td>-</td>
<td>Technical Report Writing (English-III)</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>SS</td>
<td>-</td>
<td>Islamic Studies /Ethics</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>SS</td>
<td>-</td>
<td>Pakistan Studies</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>SS</td>
<td>-</td>
<td>Professional Practices</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IT</td>
<td>-</td>
<td>Information &amp; Communication Technologies</td>
<td>(2+1)</td>
</tr>
</tbody>
</table>

**Total Credit Hours (18/136)**

### University Electives (9 Credits Hours)

**University Elective Courses**

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-req</th>
<th>Course Name</th>
<th>Cr. Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>MNG</td>
<td>-</td>
<td>Principles of Accounting</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>MNG</td>
<td>-</td>
<td>Human Resource Management</td>
<td>3</td>
</tr>
<tr>
<td>36</td>
<td>MNG</td>
<td>-</td>
<td>Principles of Management</td>
<td>3</td>
</tr>
<tr>
<td>37</td>
<td>MNG</td>
<td>-</td>
<td>Organizational Behaviour</td>
<td>3</td>
</tr>
<tr>
<td>38</td>
<td>SS</td>
<td>-</td>
<td>Principles of Philosophy</td>
<td>3</td>
</tr>
<tr>
<td>39</td>
<td>SS</td>
<td>-</td>
<td>Principles of Psychology</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>SS</td>
<td>-</td>
<td>Foreign/Regional Language</td>
<td>3</td>
</tr>
<tr>
<td>41</td>
<td>MNG</td>
<td>-</td>
<td>Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>

**IT Electives**

(7 Courses; 21 Credits Hours)

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

<table>
<thead>
<tr>
<th>IT</th>
<th>Course Name</th>
<th>Cr. Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT</td>
<td>Telecommunication Systems</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Routing &amp; Switching</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Network Design and Management</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Network Programming</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Computer Game Development</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Multimedia Technologies</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>3D Modeling &amp; Animation</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Mobile Computing</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Software Agents Technology</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>E-Commerce Applications Development</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Enterprise Application Development</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Distributed Computing</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Mobile Application Development</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Web Engineering</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Data Warehousing</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Business Intelligence and Analytics</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Distributed Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Enterprise Resource Planning Systems</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Information Systems Auditing and Assurance</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Business Process Management</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Knowledge Management</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Artificial Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Formal Methods in Software Engineering</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Software Requirement Engineering</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Software Design and Architecture</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Software Quality Engineering</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Software CASE Tools &amp; Applications</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Software Construction</td>
<td>3</td>
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<tr>
<td>SE</td>
<td>Software Engineering Economics</td>
<td>3</td>
</tr>
<tr>
<td>SE</td>
<td>Design Patterns</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Service-Oriented Architecture</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Computer Graphics</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>IT</td>
<td>Biometric Systems</td>
<td>3</td>
</tr>
</tbody>
</table>
# Proposed Scheme of Study for BS (IT) Model 1

## 4-Year Program (8 Semesters)

(136 Credit Hours)

### Semester 1 (18 Cr. Hrs.)

<table>
<thead>
<tr>
<th>Course Title</th>
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<td>3 (2+1)</td>
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<td>3</td>
</tr>
<tr>
<td>Islamic Studies/Ethics (Gen. Edu.)</td>
<td>2 (2+0)</td>
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### Semester 2 (18 Cr. Hrs.)

<table>
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<td>3</td>
</tr>
<tr>
<td>Digital Logic Design (Comp. Core)</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>Discrete Structures (Comp. Core)</td>
<td>3</td>
</tr>
<tr>
<td>Principles of Psychology (Uni. Elective)</td>
<td>3</td>
</tr>
<tr>
<td>Communication Skills (English-II) (Gen. Edu.)</td>
<td>3</td>
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<td>Probability and Statistics (Comm. Supporting)</td>
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### Semester 3 (19 Cr. Hrs.)

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<tr>
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</tr>
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<tr>
<td>Data Structures and Algorithms (Comp. Core)</td>
<td>4(3+1)</td>
</tr>
<tr>
<td>Computer Communication and Networks (Comp. Core)</td>
<td>3*</td>
</tr>
<tr>
<td>Principles of Accounting (Uni. Elective)</td>
<td>3</td>
</tr>
<tr>
<td>Information Systems (IT – Supporting)</td>
<td>3</td>
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<tr>
<td>Technical and Report Writing (English-III) (Gen. Edu.)</td>
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<td>Linear Algebra (Comp. Supporting)</td>
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### Semester 4 (18 Cr. Hrs.)

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<tr>
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<tr>
<td>Organizational Behaviour (Uni. Elective)</td>
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<td>Internet Architecture &amp; Protocols (IT – Supporting)</td>
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<tr>
<td>Software Engineering (Comp. Core)</td>
<td>3</td>
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<td>Database Systems (Comp. Core)</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>Multimedia Systems and Design (IT Core)</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>Pakistan Studies (Gen. Edu.)</td>
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### Semester 5 (18 Cr. Hrs.)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>IT Elective-I</td>
<td>3</td>
</tr>
<tr>
<td>Operating Systems (Comp. Core)</td>
<td>3*</td>
</tr>
<tr>
<td>OO Analysis &amp; Design (IT – Supporting)</td>
<td>3</td>
</tr>
<tr>
<td>DB Administration &amp; Management (IT – Supporting)</td>
<td>3*</td>
</tr>
<tr>
<td>Web Systems and Technologies (IT Core)</td>
<td>3</td>
</tr>
<tr>
<td>Technology Management (IT Core)</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Semester 6 (18 Cr. Hrs.)</th>
<th>Cr. Hrs.</th>
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</thead>
<tbody>
<tr>
<td>Human Computer Interaction (Comp. Core)</td>
<td>3</td>
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<tr>
<td>Systems and Network Administration</td>
<td>3*</td>
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<tr>
<td>IT Elective II</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective –III</td>
<td>3</td>
</tr>
<tr>
<td>System Integration and Architecture (IT Core)</td>
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<td>IT Project Management (IT – Supporting)</td>
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<tr>
<th>Semester 7 (15 Cr. Hrs.)</th>
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<tbody>
<tr>
<td>Capstone Project Part I (Comp. Core)</td>
<td>3</td>
</tr>
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<td>Data &amp; Network Security (IT Core)</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective IV</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective V</td>
<td>3</td>
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<tr>
<td>Cloud Computing</td>
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<tr>
<th>Semester 8 (12 Cr. Hrs.)</th>
<th>Cr. Hrs.</th>
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<tbody>
<tr>
<td>Capstone Project Part II (Comp. Core)</td>
<td>3</td>
</tr>
<tr>
<td>Professional Practices (Gen. Edu.)</td>
<td>2(2+0)</td>
</tr>
<tr>
<td>IT Elective VI</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective VII</td>
<td>3</td>
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## Proposed Scheme of Study for BS (IT) Model 2

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

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<tr>
<td>IT Elective-I</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective II</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective –III</td>
<td>3</td>
</tr>
<tr>
<td>IT Project Management (IT – Supporting)</td>
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Semester 7 (15 Cr. Hrs.)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Capstone Project Part I (Comp. Core)</td>
<td>3 (0+3)</td>
</tr>
<tr>
<td>Data &amp; Network Security (IT Core)</td>
<td>3</td>
</tr>
<tr>
<td>IT Elective IV</td>
<td>3</td>
</tr>
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<td>IT Elective V</td>
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Semester 8 (12 Cr. Hrs.)

<table>
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<tbody>
<tr>
<td>Capstone Project Part II (Comp. Core)</td>
<td>3</td>
</tr>
<tr>
<td>Professional Practices (Gen. Edu.)</td>
<td>2</td>
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<tr>
<td>IT Elective VI</td>
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<td>IT Elective VII</td>
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BS Information Technology, BS (IT), COURSE CONTENTS

Computing Core Courses:

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

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

Reference Materials:

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

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

Reference Materials:

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

**Course Outline:**  
Please See in BS (CS) Section

**Reference Materials:**  
Please See in BS (CS) Section

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

**Course Outline:**  

**Reference Materials:**  

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

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

**Reference Materials:**

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

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

*Lab assignments involving different single and multithreaded OS algorithms.

**Reference Materials:**

---

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

**Course Outline:**  

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

Course Outline:

Reference Materials:

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

Course Outline:

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

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

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

Reference Materials:
Computing Supporting Elective Courses

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

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:

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

Course Outline:

**Reference Materials:**


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

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

**Reference Materials:**

Contents of General Education Elective Courses

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

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:
4. Communication Skills in English by Prof P N Kharu, Dr Varinder Gandhi Publisher: Laxmi. EAN: 9788131806920

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

Course Outline:

Reference Materials:
2. *Technical English: Writing, Reading, and Speaking* by Pickett and Laster. 8<sup>th</sup> Edition

**ISLAMIC STUDIES**
(Compulsory)

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

Detail of Courses:

**Introduction to Quranic Studies**
1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul-Quran

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

**Study of Selected Text of Holly Quran**
1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

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

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

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

**Selected Study from Text of Hadith**

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

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

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

**Islamic Economic System**
1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce
Political System of Islam
1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

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

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

Reference Books:
1) Hameed ullah Muhammad, “Emergence of Islam”, IRI, Islamabad
2) Hameed ullah Muhammad, “Muslim Conduct of State”
3) Hameed ullah Muhammad, ‘Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,”
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)

Course Name: Ethics
Prerequisites: None

Course Outline:
Follow Institution/University syllabus
Pakistan Studies (Compulsory)

Introduction/Objectives:

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

Course Outline:

1. Historical Perspective
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.

2. Government and Politics in Pakistan
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward

3. Contemporary Pakistan
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books:


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

**Course Outline:**

**Reference Materials:**

**University Elective Courses**

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

**Course Outline:**

**Reference Materials:**

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

**Course Outline:**

**Reference Materials:**

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

**Course Outline:**

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

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:
Course Name: Principles of Psychology
Credit Hours: 3
Prerequisites: None

Course Outline:

Reference Materials:

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

Course Outline:
Institution/Universities follow their approved syllabus

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

Course Outline:

**Reference Materials:**

**Information Technology Core Courses**

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

**Course Outline:**

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

Course Outline:

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

Reference Materials:

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

Course Outline:

Reference Materials:

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

Course Outline:

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

Course Outline:

Reference Materials:

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

Course Outline:
Reference Materials:

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

Course Outline:

Reference Materials:
Contents of Information Technology Supporting Courses

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

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:

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

Course Outline:

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

Course Outline:

Reference Materials:

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

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

Reference Materials:
   Procedures* by Craig S. Mullins, Addison-Wesley Professional; 2nd
2. *Database Systems: A Practical Approach to Design, Implementation and
   Management* by Thomas M. Connolly and Carolyn E. Begg, Addison-
should be avoided)

Contents of Information Technology Elective Courses

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

Course Outline:
Communication Channel and the Communication Network Technologies.
Digital Telephony. Switching and Signaling Systems. Switching Fabric
Interfaces and ICs, Optics and the Future. Cellular Systems. Fixed Wireless
Telecommunication Systems Testing. Embedded Systems Design for
Telecommunications.

Reference Materials:
2. *The Irwin Handbook of Telecommunications* by James Harry Green,
   Communications Fundamentals, Data Networking and the Internet, and
   Next-Generation Networks* by Lillian Goleniewski, Addison-Wesley
Course Name: Routing & Switching
Credit Hours: 3
Prerequisites: Internet Architecture & Protocols

Course Outline:

Reference Materials:
3. CCIE Routing and Switching v4.0 Quick Reference by Brad Ellis, Jacob Uecker and Steven Means, Cisco Press (October 4, 2010). ASIN: B00452V45O

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

Course Outline:

Reference Materials:
Course Name: Network Programming
Credit Hours: 3
Prerequisites: Operating Systems

Course Outline:

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

Course Outline:

Reference Materials:

Course Title: Multimedia Technologies
Credit Hours: 3
Prerequisites:

Course Outline:
What is Multimedia? Text, Multimedia Authoring and Tools, Multimedia Authoring, Multimedia Production, Multimedia Presentation, Automatic Authoring; Editing and Authoring Tools- (Adobe Premiere, Macromedia Director, Macromedia Flash, Dreamweaver), VRML, Handling Images,
Sound, Making Animation and Video, Making Multimedia, Multimedia Skills, Planning and Costing, Designing and Producing, Content and Talent, The Internet and Multimedia, Designing for the World Wide Web, Delivering Multimedia Product. Instructors need to devise a content delivery and Lab work plan using a multimedia Authoring tool in line with the contents of the textbook.

Reference Materials:

Course Name: 3D Modeling & Animation
Credit Hours: 3*
Prerequisites: Multimedia Systems and Design

Course Outline:

Reference Materials:

158
Course Name: Mobile Computing
Credit Hours: 3
Prerequisites: Internet Architecture & Protocols, Web Systems and Technologies

Course Outline:

Reference Materials:

Course Name: Software Agents Technology
Credit Hours: 3
Prerequisites: Web Systems and Technologies

Course Outline:
Reference Materials:

Course Name:  E-Commerce Applications Development  
Credit Hours:  3  
Prerequisites:  Web Technologies

Course Outline:  

Reference Materials:
Course Name: Enterprise Application Development
Credit Hours: 3
Prerequisites: Database Systems

Course Outline:

Reference Materials:

Course Name: Distributed Computing
Credit Hours: 3
Prerequisites: Web Systems and Technologies

Course Outline:
Reference Materials:

Course Title: Mobile Application Development
Credit Hours: 3
Prerequisites: Web Technologies

Course Outline:

Reference Materials:
Course Name: Web Engineering
Credit Hours: 3
Prerequisites: Web Systems and Technologies

Course Outline:

Reference Materials:
6. W3C Online Resources.

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

Course Outline:

Reference Materials:

Course Name: Data Mining
Credit Hours: 3
Prerequisites: Database Systems

Course Outline:
Data-Mining Concepts, Preparing the Data, Data Reduction, Learning From Data, Statistical Methods, Decision Trees and Decision Rules, Artificial Neural Networks, Ensemble Learning, Cluster Analysis, Association Rules, Web Mining and Text Mining, Genetic Algorithms, Fuzzy Sets and Fuzzy Logic, Visualization Methods, Data Mining Tools: Weka, CBA and Yale, etc.

Reference Materials:
Course Name: Business Intelligence and Analytics
Credit Hours: 3
Prerequisites: Data Warehousing, Data Mining

Course Outline:
Business Intelligence Introduction, BI Environment, Business Process and Information Flow, Data Requirements Analysis, Data Warehouses and the Technical BI Architecture, Data Profiling, Business Rules, Data Quality, Data Integration, Deriving Insight from Data, Knowledge Discovery & Delivery, BI User Types and Reports, Installations, Configuring and Maintaining the BI Server, Creating Repositories from Relational Sources, Creating Repositories from OLAP Data Sources, Creating Reports Using Answers and Dashboards.

Reference Materials:

Course Title: Distributed Database Systems
Credit Hours: 3
Prerequisites: Database Systems

Course Outline:

Reference Materials:

**Course Name:** Enterprise Resource Planning Systems  
**Credit Hours:** 3  
**Prerequisites:** Database Systems

**Course Outline:**

**Reference Materials:**

**Course Name:** Information Systems Auditing and Assurance  
**Credit Hours:** 3  
**Prerequisites:** Information Systems

**Course Outline:**
Introduction to Auditing, Assurance and Internal Control, IT Governance and Management, Organization Structure and Responsibilities, Business Continuity Planning, Auditing IT Governance, The Audit Process, Internal Controls, IT Life Cycle Management, Infrastructure Development and

Reference Materials:

Course Name: Business Process Management
Credit Hours: 3
Prerequisites: Object Oriented Analysis and Design

Course Outline:

Reference Materials:
Course Name: Knowledge Management
Credit Hours: 3
Prerequisites: Discrete Structures

Course Outline:

Reference Materials:
Course Name: **Artificial Intelligence**
Credit Hours: 3
Prerequisites: Discrete Structures

**Course Outline:**

**Reference Materials:**
Course Name: Formal Methods in Software Engineering
Credit Hours: 3
Prerequisites: Discrete Structures

Course Outline:

Reference Materials:

Course Name: Software Requirements Engineering
Credit Hours: 3
Prerequisites: Intro. to Software Engineering

Course Outline:
Reference Materials:

Course Name: Software Design and Architecture
Credit Hours: 3
Prerequisites: Programming Fundamentals

Course Outline:

Reference Materials:

Course Name: Software Quality Engineering
Credit Hours: 3
Prerequisites: Intro. to Software Engineering

Course Outline:

Reference Materials:
1. The Certified Software Quality Engineer by Linda Westfall, Quality Press; (September 28, 2009), ISBN-10: 0873897307

Course Name: Software CASE Tools & Applications
Credit Hours: 3
Prerequisites: Intro. to Software Engineering

Course Outline:

Reference Materials:
3. Most popular software CASE tool documentation

Course Name: Software Construction
Credit Hours: 3
Prerequisites: Programming Fundamentals

Course Outline:

Reference Materials:

Course Name: Software Engineering Economics
Credit Hours: 3
Prerequisites: Intro. to Software Engineering/Software Construction

Course Outline:

Reference Materials:

Course Name: Design Patterns
Credit Hours: 3
Prerequisites: Programming Fundamental

Course Outline:

Reference Materials:
1. Design Patterns: Elements of Reusable Object Oriented Software, E. Gamma, R. Helm, R. Johnson, and J. Vlissides, Addison -Wesley Professional, 1995
Course Title: Service-Oriented Architecture  
Credit Hours: 3  
Prerequisites: Programming Fundamentals

Course Outline:

Reference Materials:
3. SOA Design Patterns by Thomas Erl, Prentice Hall PTR; 1st Edition (January 9, 2009)  
Course Name: Computer Graphics
Credit Hours: 3
Prerequisites: Discrete Structures

Course Outline:

Reference Materials:
Program’s Rationale:

A high pace of innovations in technologies for communication, computation, interactivity, and delivery of information introduced invention like the Internet, the World Wide Web, email, bulletin board system, virtual communities, E-commerce, and other online technologies. These inventions brought a paradigm shift in business world - from data processing to information processing - converting industrial society to an “information society.” This paradigm shift not only affected the way scientists conduct their research but also expedite the pace of inventions. As a result Computing becomes a rapidly progressing domain. In recent years, many significant developments have been made and many new concepts have been introduced. For example, “Computational Lens” which articulates a new relationship between computer science and other sciences, “Ternary Computing” dealing with computing for the masses, “e-Science” managing massive experimental data and collaborating via the Net, “Computational Thinking”, “Cloud Computing”, “Biological Computing”, etc. In parallel, the integration of computing in other disciplines introduces new disciplines such as “Computational - x” (e.g., computational mathematics, computational physics, computational finance, etc.) and “x - Informatics” (e.g., bio-informatics, dental-informatics, clinical-informatics, health-informatics, etc.). Many such developments compel IT graduates to update their knowledge to meet the needs of the time. One of the key rationales behind MS(IT) program is the development of a dynamic curricula structure that allows IT graduates to gain a broad technical understanding of current and evolving technologies in the IT field with an emphasis on moving technology from the laboratory to the realm of business development through offering Breadth-Based, Depth-Based, and Integrated Breadth & Depth-Based courses. Students may choose a particular option, which is the most appropriate to their planned future career. Through offering these options, the program develops technically competent, highly productive, and self-motivated professionals in tune with the demands of an ever changing market. The program will groom not only IT professionals, but also experts from other domains offering a unique and comprehensive body of knowledge that exposes the learners to a practical application of information technology within an area of specialization.

Programme Aim:

MS (IT) Programme is aimed to create, expand, disseminate and teach the information technology body of knowledge through academics, applications and research which positively impact society locally, nationally, and internationally.
Programme Objectives:
One of the key objectives of the programme is to produce well rounded individuals who are productive and responsible members of society familiar with the technical concepts and practices in the computing & information technology domains. The program provides graduates with competency and knowledge to take on appropriate professional roles in information technology industry or to pursue further education. Following are the key objectives of the program:

1. Use and apply current technical concepts and practices in the core information technologies.
2. Analyze, identify and define the requirements that must be satisfied to address problems or opportunities faced by individuals or organizations.
3. Identify and evaluate current and emerging technologies and assess their impact on individuals, organizations and society; including ethical, legal and policy issues.
4. Demonstrate independent critical thinking and problem solving skills.
5. Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation.
6. Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology.
7. Recognize the need for continued learning throughout career.

Program Structure:
The Program is designed for full-time students. The program comprises of 33 Cr. Hrs. with 4 core courses, 4 elective courses, and a research thesis of 9 Cr. Hrs. The dynamic structure of the program allows students to choose a particular option, which is the most appropriate for planned future career. Followings are the program details:

Eligibility Criteria:
The Program is designed for full-time students. The program comprises of 33 Cr. Hrs. with 4 core courses, 4 elective courses, and a research thesis of 9 Cr. Hrs. The dynamic structure of the program allows students to choose a particular option, which is the most appropriate for planned future career. Followings are the program details:

1. BS (IT/CS/SE) 4 years degree program or equivalent (minimum 130 Cr. Hrs. with minimum 2.5 CGPA on scale 4.0 or 60% marks);
   OR
2. Computer Science conversion course two years degree program referred to as MCS or M.Sc. (CS) or M. Sc. (IT), (minimum 2.5 CGPA of scale 4.0 or 60% marks);
   OR
3. BCS 3-year program degree applicants may be provisionally admitted in the MS (IT) program. Candidates will be required to take additional courses to complete credit hours requirement of minimum 130 Cr. Hrs. before being formally enrolled in the MS (IT) program.
   Under eligibility criteria 1-3, the university/department may recommend
additional deficiency courses/ transition courses\(^8\), from the BS (IT) curriculum, considering the deficiency of the candidates.

**OR**

4. 16-years education engineering degrees (minimum 2.5 CGPA of scale 4.0 or 60% marks).

Under eligibility criterion 4, candidates will be required to complete the deficiency coursework prior to the MS (IT) coursework to ensure the pre-requisite competency in IT. The deficiency/transition coursework will be determined on the basis of the core IT courses of the BS (IT) degree.

5. Test (University/Institution rules shall be observed).

**Duration:**

Four (4) semesters/terms spread over two (2) calendar years with two semesters/terms a year.

**Degree Requirements:**

Minimum credit hours shall be 30 Cr. Hrs. for MS (Information Technology) program including course work and research thesis/project. In order to obtain MS (IT) degree a student must pass a minimum of:

i. Four (4) core courses (12 credit hours).
   AND

ii. Four (4) courses (12 credit hours) from graduate elective courses.
   AND

iii. Satisfactorily complete a Research Thesis of 6 credit hours.

**Distribution of Courses:**

**Followings are the distribution of total credit hours:**

<table>
<thead>
<tr>
<th>Category or Area</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>12</td>
</tr>
<tr>
<td>Elective</td>
<td>12</td>
</tr>
<tr>
<td>Thesis</td>
<td>6</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>30</td>
</tr>
</tbody>
</table>

---

\(^8\) Transition courses cover essentially undergraduate material mastery of which is crucial for student success in the program. Transition courses are assigned based on an applicant's credentials and will not be counted towards the MS degree program.
### List of Core Courses:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Code</th>
<th>Pre-Req.</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT</td>
<td>*</td>
<td>Advanced Database Management Systems</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>IT</td>
<td>*</td>
<td>Information Security and Assurance</td>
<td>3</td>
</tr>
</tbody>
</table>

### List of Elective Courses:

Universities/Institutions may add courses in this list.

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Pre-Req.</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 IT</td>
<td></td>
<td>*</td>
<td>Mobile and Wireless Networks</td>
<td>3</td>
</tr>
<tr>
<td>2 IT</td>
<td></td>
<td>*</td>
<td>Information Technology Infrastructure</td>
<td>3</td>
</tr>
<tr>
<td>3 IT</td>
<td></td>
<td>*</td>
<td>Telecom Management</td>
<td>3</td>
</tr>
<tr>
<td>4 IT</td>
<td></td>
<td>*</td>
<td>Data Warehousing Trends &amp; Issues</td>
<td>3</td>
</tr>
<tr>
<td>5 IT</td>
<td></td>
<td>*</td>
<td>Data Mining Trends &amp; Issues</td>
<td>3</td>
</tr>
<tr>
<td>6 IT</td>
<td></td>
<td>*</td>
<td>Advanced Business Intelligence and Analytics</td>
<td>3</td>
</tr>
<tr>
<td>7 IT</td>
<td></td>
<td>*</td>
<td>Multimedia Databases</td>
<td>3</td>
</tr>
<tr>
<td>8 IT</td>
<td></td>
<td>*</td>
<td>Information Retrieval</td>
<td>3</td>
</tr>
<tr>
<td>9 IT</td>
<td></td>
<td>*</td>
<td>Cloud Computing</td>
<td>3</td>
</tr>
<tr>
<td>10 IT</td>
<td></td>
<td>*</td>
<td>Mobile &amp; Pervasive Computing</td>
<td>3</td>
</tr>
<tr>
<td>11 IT</td>
<td></td>
<td>*</td>
<td>Enterprise Data Center Design and Methodology</td>
<td>3</td>
</tr>
<tr>
<td>12 IT</td>
<td></td>
<td>*</td>
<td>Data Center Network Design, Implementation, and Security</td>
<td>3</td>
</tr>
<tr>
<td>13 IT</td>
<td></td>
<td>*</td>
<td>Virtualized Data Center</td>
<td>3</td>
</tr>
<tr>
<td>14 IT</td>
<td></td>
<td>*</td>
<td>Advanced Computer Networks</td>
<td>3</td>
</tr>
<tr>
<td>15 IT</td>
<td></td>
<td>*</td>
<td>Network Performance Modeling and Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>16 IT</td>
<td></td>
<td>*</td>
<td>Integrated Services over Packet Networks</td>
<td>3</td>
</tr>
<tr>
<td>17 IT</td>
<td></td>
<td>*</td>
<td>Stochastic Systems</td>
<td>3</td>
</tr>
<tr>
<td>18 IT</td>
<td></td>
<td>*</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>19 IT</td>
<td></td>
<td>*</td>
<td>Knowledge-Based Systems</td>
<td>3</td>
</tr>
<tr>
<td>20 IT</td>
<td></td>
<td>*</td>
<td>Distributed Databases</td>
<td>3</td>
</tr>
<tr>
<td>21 IT</td>
<td></td>
<td>*</td>
<td>Advanced Telecommunication Networks</td>
<td>3</td>
</tr>
<tr>
<td>22 IT</td>
<td></td>
<td>*</td>
<td>Multimedia Databases</td>
<td>3</td>
</tr>
<tr>
<td>23 IT</td>
<td></td>
<td>*</td>
<td>Telecommunication Systems</td>
<td>3</td>
</tr>
<tr>
<td>24 IT</td>
<td></td>
<td>*</td>
<td>Advanced Network Security</td>
<td>3</td>
</tr>
<tr>
<td>25 IT</td>
<td></td>
<td>*</td>
<td>Principles of Multimedia Systems</td>
<td>3</td>
</tr>
<tr>
<td>26 IT</td>
<td></td>
<td>*</td>
<td>Advanced Multimedia Systems</td>
<td>3</td>
</tr>
<tr>
<td>27 IT</td>
<td></td>
<td>*</td>
<td>Distributed System</td>
<td>3</td>
</tr>
</tbody>
</table>
## Sample Scheme of Study for MS (IT) Programme

**2–year Programme (4 Semesters/Terms)**

(30 Credit Hours)

<table>
<thead>
<tr>
<th>Semester/Term 1 (9 Credit Hours)</th>
<th>#</th>
<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT</td>
<td>Advanced Database Management Systems</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>IT</td>
<td>Information Security and Assurance</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>IT</td>
<td>Research Methods (University Elective-I)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Semester Credit Hrs.</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester/Term 2 (9 Credit Hours)</th>
<th>#</th>
<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT</td>
<td>Elective II</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>IT</td>
<td>Elective III</td>
<td>3</td>
<td></td>
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<tr>
<td>3</td>
<td>IT</td>
<td>Elective IV</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Semester Credit Hrs.</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester/Term 3 (6 Credit Hours)</th>
<th>#</th>
<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT</td>
<td>Thesis (Partial Registration)</td>
<td>3</td>
<td></td>
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<tr>
<td>3</td>
<td>IT</td>
<td>Elective V</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Semester Credit Hrs.</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>6</strong></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester/Term 4 (6 Credit Hours)</th>
<th>#</th>
<th>Code</th>
<th>Course Title</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IT</td>
<td>Elective VI</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>IT</td>
<td>Thesis (Full Registration)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Semester Credit Hrs.</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

**Total Credit Hours**

30
Course Outline for MS (IT) Programme (Core)

Course Name: Advanced Database Management Systems  
Credit Hours: 3  
Pre-requisites: Database Management System/Equivalent

Course Outline:

Reference Materials:
4. *Advanced Database Systems* by Carlo Zaniolo, Stefano Ceri (Chapter 5, 6)  

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

Course Outline:

**Reference Materials:**

**Elective Courses for IT**

**Course Name:** Mobile and Wireless Networks  
**Credit Hours:** 3  
**Prerequisites:** Internet Architecture and Protocols

**Course Outline:**

**Reference Materials:**
2. Wireless Communications & Networks by William Stallings, Prentice Hall;
Course Name: Advanced Web Systems & Technologies
Credit Hours: 3
Prerequisites: Web Engineering

Course Outline:


Reference Materials:
2. W3C Online Resources

**Course Name:** Information Technology Infrastructure  
**Credit Hours:** 3  
**Prerequisites:** Computer Communication and Networks

**Course Outline:**

**Reference Materials:**

**Course Name:** Telecom Management  
**Credit Hours:** 3  
**Prerequisites:** Computer Communication and Networks

**Course Outline:**

Reference Materials:

Course Name: Data Warehousing Trends & Issues
Credit Hours: 3
Prerequisites: *

Course Outline:

Reference Materials:
3. WWW Resources

Course Name: Data Mining Trends & Issues
Credit Hours: 3
Prerequisites: Database Management System

Course Outline:
Combining Data Warehousing and Data Mining Techniques for Web Log Analysis Computing Dense Cubes Embedded in Sparse Data. Exploring Similarities Across High-Dimensional Datasets. Pattern Comparison in Data Mining. Mining Frequent Patterns Using Self-Organizing Map. Compression Technique for Vertical Mining Methods. Data Mining Techniques via Multiple Criteria Optimization. Graph-Based Data Mining. Facilitating and Improving the Use of Web Services with Data Mining.

Reference Materials:
Course Name: Advanced Business Intelligence and Analytics
Credit Hours: 3
Prerequisites: Data Mining

Course Outline:

Reference Materials:
Course Name: Multimedia Databases  
Credit Hours: 3  
Prerequisites:  

Course Outline:  

Reference Materials:  

Course Name: Information Retrieval  
Credit Hours: 3  
Prerequisites: None  

Course Outline:  

Reference Materials:

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

Course Outline:

Reference Materials:
Course Name: Mobile & Pervasive Computing
Credit Hours: 3
Prerequisites: Operating Systems, Web Systems and Technologies

Course Outline:

Reference Materials:

Course Name: Enterprise Data Centre Design and Methodology
Credit Hours: 3
Prerequisites: Information Security and Assurance, IT Infrastructure

Course Outline:
Reference Materials:

Course Name: Data Centre Network Design, Implementation, and Security
Credit Hours: 3
Prerequisites: Enterprise Data Centre Design and Methodology

Course Outline:

Reference Materials:
Course Name: Virtualized Data Centre
Credit Hours: 3
Prerequisites: Enterprise Data Centre Design and Methodology

Course Outline:

Reference Materials:
Course Name: Advanced Computer Networks
Credit Hours: 3
Prerequisites: Computer Communication and Networks

Course Outline:

Reference Materials:

Course Name: Network Performance Modeling and Evaluation
Credit Hours: 3
Prerequisites: Computer Communication and Networks

Course Outline:

Reference Materials:

Course Name: Integrated Services over Packet Networks
Credit Hours: 3
Prerequisites: Computer Communication and Networks

Course Outline:

Reference Materials:
Course Name: Stochastic Systems
Credit Hours: 3
Prerequisites: Probability and Statistics

Course Outline:

Reference Materials:

Course Name: Stochastic Processes
Credit Hours: 3
Prerequisites: Stochastic Systems

Course Outline:

Reference Materials:
5. *Stochastic Processes: with Applications to Reliability Theory* by
Course Name: Knowledge-Based Systems
Credit Hours: 3
Prerequisites: Intro to Artificial Intelligence

Course Outline:
Introduction to knowledge-based systems, Logic and automatic reasoning (forward and backward reasoning), Knowledge representation and reasoning models, Bayesian inference and other models of reasoning and decision making under uncertainty, Software lifecycle in knowledge-based systems, Rule-based expert systems, Architecture of a knowledge-based system, Feasibility analysis, Requirements specification and design, Knowledge acquisition and system implementation, Verification and validation.

Reference Material:

Course Name: Distributed Database Systems
Credit Hours: 3
Prerequisites: Network Programming

Course Outline:

Reference Materials:

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

Course Outline:

Reference Materials:

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

**Course Outline:**  

**Reference Material:**

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

**Course Outline:**  
Reference Materials:

Course Name: Advanced Network Security
Credit Hours: 3
Prerequisites: Computer Communication and Networks

Course Outline:

Reference Materials:

Course Name: Principles of Multimedia Systems
Credit Hours: 3
Prerequisites: None

Course Outline:
Introduction to Multimedia and Tools, Graphics and Image Data Representations, Colour in Image and Video, Basics of Digital Audio, Lossless Compression Algorithms, Lossy Compression Algorithms, Image Compression Standards, Basic Video Compression Techniques, MPEG Video Coding MPEG-1, 2, 4-7; Basic Audio Compression Techniques, MPEG
Audio Compression. Latest Compression techniques and Research Trends in Multimedia systems.

Reference Materials:

Course Name: Advanced Multimedia Systems
Credit Hours: 3
Pre-requisites: Multimedia Systems: Theory & Principles

Course Outline:

Reference Materials:
Course Name: **Principles of Soft Computing**
Credit Hours: 3
Prerequisites: **Intro. to Artificial Intelligence**

**Course Outline:**

**Reference Materials:**