**DEPARTMENT OF COMPUTER SCIENCE**
**LAHORE COLLEGE FOR WOMEN UNIVERSITY, LAHORE**

# SELF-ASSESSMENT REPORT
## Ph.D.

Submitted to

**Quality Enhancement Cell,**
**Lahore College for Women University, Lahore**
**Dated: 17th October, 2018**

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# T A B L E  O F  C O N T E N T S

**INTRODUCTION**

The history of the Department of Computer Science dates back to 1996 when it started as a computer center by the grant provided by Ministry of Social Work and Women Development. The Department started ICS classes in 1997 in addition to offering Short Courses and Diploma. The lab facilities were extended with the grant from Punjab Information Technology Board and started BCS classes in 1999. The Department started 4 year BSCS degree program in 2000 and expanded its facilities in 2001 with the funding provided by Higher Education Commission. MSCS degree program was introduced in 2002. The Department was shifted in its new building in 2005. The Department started PhD degree program in 2011.

Currently, the Department is equipped with high speed internet of 400 MB bandwidth supported by fiber backbone, and video conferencing facility. There are total 7 labs (with 40 computers in 3, 35 computers in 2 and 30 computers in 2 labs). Departmental library has more than 15000 books for graduate and postgraduate students. Moreover, the Department has access to international journals and scholarly publications through HEC Digital Library. The syllabi are duly upgraded and modernized to make them abreast with the international standards. The department currently enrolls students for 4 years Bachelor's degree (BS Computer Science), 2 years Master degree (MS Computer Science) and Ph.D. program.

## CRITERION 1: PROGRAM MISSION, OBJECTIVES AND OUTCOMES

**Standard 1-1: The program must have documented measurable objectives that support college and institution mission statements.**

### Mission statements

The Department strives to produce highly skilled professionals who apply specialist skills and knowledge to everyday workplace situations. Besides having highly developed technical abilities they are expected to carry out research and to keep their knowledge continually up-to-date. Most importantly, they are required to have excellent communication skills. To set pace in the field of study, the Department has designed several degree courses that provide balanced coverage of the various aspects of Computer Science. These programs are intended to produce graduates who have acquired:

- Depth and breadth of knowledge in computer science coupled with the capacity to produce feasible and responsible solutions to complex computing problems.
- Literacy in writing, reading, speaking, and listening.
- Critical thinking in interpretation, analysis and evaluation.

- Values by the ability to make reasoned and ethical choices and to accept responsibility for them.
- Interpersonal skills with leadership ability, appreciation for diversity, and the capacity to work effectively with others.
- Life-long learning skills as evidenced by the ability to adapt to innovation and change.

  The core values of the department are:

  - ➡ Quality
  - ➡ Integrity
  - ➡ Character building
  - ➡ Hard work
  - ➡ Respect
  - ➡ Accountability
  - ➡ Objectivity
  - ➡ Transparency
  - ➡ Confidence
  - ➡ Team spirit

Teaching Methodology:

All courses and research work included in the scheme of study are an excellent mix-match of various methods such as lectures, seminars, assignments, workshops, tutorials, quizzes, group discussions, research publications, external linkages and collaborations, research peer review, research proposals and comprehensive knowledge base. This helps the students in developing the ability to collect, recognize and interpret the information through various sources like library and digital library, labs and the internet. This creates originality amongst students enabling them to work hard with sharp learning skills.

## CRITERION 1: PROGRAM MISSION, OBJECTIVES AND OUTCOMES

**Quality Policy of Computer Science Department**:

Our aim is to achieve excellence through provision of quality education. To achieve this commitment, we focus:

- To produce quality post graduates equipped with a wide breadth of knowledge.
- To develop strong critical, analytical and logical thinking in the graduates.
- To establish effective communication and interpersonal skills in the post graduates.

We continually improve the effectiveness of our quality management system through human resource development and active faculty/student participation.

**Table 1: Module Description**

| Name of Programs | Duration | No. of Modules | Total Credit Hrs |
|---|---|---|---|
| Ph.D. (after 18 years of relevant education) | 2 semesters course work + Research | (Course work + Comprehensive Exam + Research Proposal + Final Dissertation Defense) | 18 (Course Work) |

## 1.1: PROGRAM'S OBJECTIVES

### 1.1.1 Ph.D. (After 18 years of education):

In the first year of the program, the students complete course work of 18 credit hours in two semesters. Students securing minimum 3.00 GPA in the course work appear for comprehensive written test and viva voice, and in the third semester the students should submit their synopsis. After the approval of the synopsis from the concerned bodies Ph.D. scholars proceed for their research work. For thesis submission it is compulsory for the students to publish their Ph.D. research work in an HEC recognized journal. As per HEC policy thesis is evaluated from two external foreign examiners and two from any local Universities. Evaluation Reports are submitted and approved in Advance Study and Research Board. After successful defense of the thesis and the approval from the Syndicate, the scholar is awarded Degree of Ph.D.

### 1.1.2 Ph.D. Computer Science Program Objectives:

Following are the learning objectives of the Ph.D. Computer Science program:

1. To produce quality researchers equipped with strong analytical capabilities.
2. To develop a strong and critical reasoning necessary for research.
3. To establish effective communication and interpersonal skills in the students.
4. Identify, develop and focus on a thorough knowledge of a specific research topic dealing with one or more areas.

### 1.1.3 Strategies are based on:

1. Designing the program as per requirements of the students.
2. Develop curriculum according to the need of the program.
3. Regular revision of curriculum to keep them updated with the developing technologies and HEC guidelines.

4. Providing all resources including class room facilities, multimedia, video conferencing room, computers, internet, library and properly equipped laboratories.
5. Updating the knowledge of teachers through workshops and training programs.
6. Encouraging the establishment of linkages at national and international level.
7. Establish liaison with the potential employers and provide economical consultancy services.
8. Develop moral basis of the students to impart concept of team, honesty and discipline through ethical attitudes.

### 1.1.4 Assessment of Educational Objectives of each Program:

**Table 2: Ph.D. Programs Objectives Assessment**

| **OBJECTIVES** **(1)** | **HOW MEASURED** **(2)** | **WHEN MEASURED (FREQUENCY)** **(3)** | **IMPROVEMENT IDENTIFIED** **(4)** | **IMPROVEMENT MADE (CORRECTIVE & PREVENTIVE ACTION)** **(5)** |
|---|---|---|---|---|
| As given in Standard 1.1 | 1 Regular assessment of student knowledge and ability to exhibit the skill by the teacher: | Regular | 1) Regularity of attendees required<br>2) Work based teaching<br>3) Course / curriculum revision to enhance outcomes<br>4) Enhancing communication skills<br>5) Guidance to students | 1) Attendance rules applied more strictly<br>2) Student encouraged to enhance their writing skills<br>3) Course / curriculum revised<br>4) Students are encouraged to attend the national and international workshops /seminars /conferences |
| | i) Class tests | 2 | | |
| | i) Assignment / Presentation | 2 | | |
| | 2. Written examination | Once in a semester | | |
| | 4. Discussions/ tutorial | Twice during each semester | | |
| | 5. Research Thesis | Once in the duration | | |
| | 6. Teaching/ Learning Process Survey (teachers' evaluation by the student) | Once a year conducted by QEC | | |
| | 7. Faculty Survey Form | Once a year | | |
| | 8. Suggestion received from students | As and when recieved | Shortcomings as per survey identified | Teachers are intimated the survey report who make effort to |

| OBJECTIVES (1) | HOW MEASURED (2) | WHEN MEASURED (FREQUENCY) (3) | IMPROVEMENT IDENTIFIED (4) | IMPROVEMENT MADE (CORRECTIVE & PREVENTIVE ACTION) (5) |
|---|---|---|---|---|
| | | | | improve which is monitored in next survey |
| | 9. Students / Quality Assurance Advisor liaison | Once in a year | 1) More time to be spent on the following during teaching:<br>i. Teacher student interaction<br>ii. Personal development topic like ethic, moral & code of conduct<br>iii. Improvement in quality of Research<br>iv. Administrative support | All the improvements identified have been implemented |
| | **New Introductions** | As and when received | 1) Administrative and personal problems of students<br>2) Laboratory facilities | Complaints are addressed immediately |
| | 1. Alumni Survey: | Once a year | Suggestions given by the alumni | Incorporate the feasible suggestions to improve program's outcomes |
| | 2. Latest Research Student Progress Review | Quarterly Progress report after synopsis approval bi-annually to the supervisor | Shortcomings as per progress report identified | Case can be forwarded to HOD/Doctoral committee |
| | 3. Faculty Resume | Once a year | 1. Qualification<br>2. Training | 1) Sent for higher studies<br>2) Internal and external training arranged |

**Standard 1.2:** The program must have documented outcomes for graduating students. It must be demonstrated that the outcomes support the program objectives and that graduating students are capable of performing these outcomes.

**1.2.1. Ph.D. Program Outcomes**:

1. The program will prepare such researchers who will uplift the socio-economic situation of the country.
2. Application of the acquired research experience on a wider scale to solve everyday problems by complying the ethical issues concerned.
3. Acquire the abilities for alliances with relevant public and private sector research organizations.
4. Achieve art of using scientific research for the improvement of community and society and for career development.

**Table 3: Ph.D. Program Outcomes support Program Objectives**

| Program Objectives | Program Outcomes | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | X | X | X | X |
| 2 | X | X | X | X |
| 3 | X | X | X | X |
| 4 | X | X | X | X |

**Table 4: PhD Program Outcomes versus objectives**

| Program Objectives | Program Outcomes | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | * | * | * | * |
| 2 | * | * | * | ◊ |
| 3 | * | * | ◊ | ◊ |
| 4 | * | * | * | ◊ |

**Legend**: * Denotes **Substantial** Contribution to the objectives
◊ Denotes **Moderate** Contribution to the objectives
_ Denotes **No** Contribution to the objectives

**Standard 1.3:** The results of program's assessment and the extent to which they are used to improve the program must be documented.

**1.3.1.a. Actions taken on the basis of assessment:**

1) Syllabus revision
2) Research students' workshops and seminars
3) Labs facility development/ digital library access
4) Faculty development

**1.3.1.b. Strengths of Department:**

i) Teamwork
ii) Work Environment
iii) Well-equipped Labs
iv) Video conferencing room
v) HEC digital library access
iv) Library
v) Internet facility

**1.3.1. c. Weaknesses of Department:**

i) Latest hardware / software facilities
ii) Common room for students

**Standard 1.4:** The department must assess its overall performance periodically using quantifiable measures.

**1.4.1: Performance Measures:**

Computer Science department assesses the overall performance using quantifiable measures e.g. statistical method.

i) Student's enrollment
ii) Student passed out
iii) Attrition rate
iv) Student teacher ratio
v) Number of Publications
vi) Number of projects
vii) Books in Library
viii) Linkages and collaborations with other institutes and organizations
ix) Workshops and seminars
x) Purchase of equipment

**Table 4: Student's enrollment**

| Program | Year of Enrollment | No. of Students |
|---|---|---|
| Ph.D. Computer Science | 2011 | 11 |
| Ph.D. Computer Science | 2012 | 12 |
| Ph.D. Computer Science | 2013 | 14 |
| Ph.D. Computer Science | 2014 | 17 |
| Ph.D. Computer Science | 2015 | 16 |
| Ph.D. Computer Science | 2016 | 16 |
| Ph.D. Computer Science | 2017 | 21 |
| Ph.D. Computer Science | 2018 | 17 |

**ii)**

**Table 4: Student-Faculty Ratio**

| Year | No. of Students | No. of Faculty Members | Student-Faculty ratio |
|---|---|---|---|
| 2017-2018 | | 9 | 2:1 |
| 2015- 2016 | | 8 | 2:1 |
| 2014-2015 | | 6 | 3:1 |
| 2013-2014 | | 6 | 2:1 |
| 2012- 2013 | | 3 | 4:1 |

**iii) Table 5: No. of Students Passed Out**

| Program | Passing out Year | No. of Students |
|---|---|---|
| | 2018 | 4 |
| | 2017 | - |
| | 2016 | - |
| Ph.D. Computer Science | 2015 | - |
| | 2014 | 3 |
| | 2013 | - |
| | 2012 | - |

**IV) Table 6: Percentage of Honor Students & Attrition Rate**

| Year | %age of Honor Students **Criteria:** CGPA 3.75 and above | **Attrition Rate** $\frac{\text{(Admitted – pass out)}}{\text{Admitted}}$ *100 |
|---|---|---|
| 2015 | NA | NA |
| 2014 | NA | NA |

**v) Table 7: Faculty Training, Seminars and workshops (Appendix A)**

| Year | No. Of Trainings, Seminars and workshops |
|---|---|
| 2017 | 4 |
| 2016 | 3 |

**v) Papers Published at National & International Level**

**Table 8: Number of Publications (Appendix B)**

| Year | Papers published |
|---|---|
| 2017 | 16 |
| 2016 | 16 |

**vi) Books in Library**

**Table 7: Linkages with other institutes and industry**

| Year | 2013 |
|---|---|
| No. of linkages | 01 |

- **Research Areas**
  - **Computer Vision, Image Processing**
  - **Software Architecture, Software Engineering**
  - **Data Mining, Big Data, Machine learning**
  - **Information Communication Technologies**

- **Collaborations**

- **Departmental Achievements (others)**

  **International Research Publications by faculty and students**
  **Completion of IT Block**

- **Honors and Awards**

| Year | Awards & Honors |
|---|---|
| 2018 | 10 |
| 2017 | 4 |
| 2016 | 1 |

## CRITERION 2: CURRICULUM DESIGN AND ORGANIZATION

Provide the following information about the program's curriculum:

**PROGRAM Ph.D.**
**Road Map for Ph.D (18 Credit Hours)**
**Scheme of Study for PhD Computer Science 2014-Onwards (18 Credit Hours)**

| Semester I | Semester II |
|---|---|
| Elective 1 | Elective 4 |
| Elective 2 | Elective 5 |
| Elective 3 | Elective 6 |

List of Elective Courses – PhD Computer Science (2014-Onwards)

| | | |
|---|---|---|
| 1. | 3D Modeling and Reconstruction | (CS 701) |
| 2. | Image Compression and Rendering | (CS 702) |
| 3. | Pattern Recognition | (CS 703) |
| 4. | Geographical and Satellite Imaging | (CS 704) |
| 5. | Digital Video Processing | (CS 705) |
| 6. | Computer Visualization and Animation | (CS 706) |
| 7. | Game Theory | (CS 707) |
| 8. | Nano Communication Network | (CS 708) |
| 9. | Optimization Techniques | (CS 709) |
| 10. | Smart Grid | (CS 710) |
| 11. | Data Collection and Analysis Techniques | (CS 711) |
| 12. | Data Warehousing & Data Mining | (CS 712) |
| 13. | Knowledge Management and Information Retrieval | (CS 713) |
| 14. | Advance Requirement Engineering | (CS 714) |
| 15. | Agents based Software Engineering | (CS 715) |
| 16. | Architectures for Software Systems | (CS 716) |

17. Evidence Based Software Engineering (CS 717)

18. Service Oriented Computing (CS 718)

19. Software Engineering Economics (CS 719)

**CS-701 3D Modeling and Reconstruction**
**Credit Hours 3 (3-0)**

| | |
|---|---|
| **Program:** PhD | **Semester:** I |
| **Pre Requisite:** None | **Follow Up:** None |

**Course Description**
The course outlines various aspects of three dimensional geometric modeling and reconstruction approaches. The developments are changing the way we think about 3D data. Today, the primary challenge of 3D modeling is how to synthesize computer-based descriptions for objects. Research in retrieval, recognition, classification of 3D models will follow the same trends as can already be observed for text, images, audio, video, and other media.

**Course Objectives**
The objective of this course is to investigate methods for analysis of 3D data. This objective is motivated by recent developments which have combined to accelerate the proliferation of 3D models.

**Learning Outcomes**
- To be able to synthesize computer-based descriptions for objects.
- Investigate various representations of shape.
- How different representations can be used for analysis and comparison of 3D objects.
- Potential applications for computer-aided design, medicine, electronic commerce, entertainment, and education.
- Get an overview of 3D modeling and reconstruction and to improve the knowledge on surface modeling in graphics.
- Explore the behavior and characteristics of the most popular modeling representations and their uses in design and engineering applications.
- Become familiar with standard ways of creating/reconstructing various shapes and to understand the principles behind the generation of complicated shapes.

**Textbooks**
None

**Reference Books / Material**
- Polygonal Modeling: Basic and Advanced Techniques (Worldwide Game and Graphics Library) (Wordware Game and Graphics Library) by Mario Russo.
- Inspired 3D Modeling and Texture Mapping by Tom Capizzi.
- Computer Vision: From Surfaces to 3D Objects by Christopher W. Tyler.
- 3D Reconstruction from 2D Camera Perspectives: CAD / CAM Applications by M. A. Fahiem and A. A. Shah.

| | |
|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 10%<br>Solution Design: 30%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved**<br>Internet | |
| **Practiced Techniques**<br>Discussions, Presentations, Viva Voce | |

**CS-702 Image Compression and Rendering**
**Credit Hours 3 (3-0)**

| | |
|---|---|
| **Program:** PhD | **Semester:** I |
| **Pre Requisite:** None | **Follow Up:** None |
| **Course Description**<br>Over the last few decades, many good image compression schemes have been developed. The performance of these schemes varies from low to high compression ratios with low to high levels of degradation of the decompressed images.<br>This course provides students with a solid understanding of the fundamentals and the principles of various digital still-image compression and rendering schemes. | |
| **Course Objectives**<br>To be able to handle, efficiently, the huge amount of data associated with images, compression schemes are needed. Image compression is a process intended to yield a compact representation of an image, hence, reducing the image storage/transmission requirements. | |
| **Learning Outcomes**<br>Students will be equipped with the fundamental knowledge that will help them understand various compression techniques in such a way as to optimize their use for a particular application. | |
| **Textbooks**<br>None | |

**Reference Books / Material**

- Digital Image Processing by Gonzalez and Woods.
- Computer Vision: The Modern Approach by Forsyth and Ponce.
- The Computer Image by Watt and Policarpo.
- 3D Computer Graphics by Watt.
- Fundamentals of Computer Graphics by Peter Shirley.
- Realistic Image Synthesis using Photon Mapping by Henrik Wann Jensen.
- Realistic Ray Tracing by Peter Shirley and R. Keith Morley.
- Multiple View Geometry in Computer Vision by Hartley and Zisserman.
- Introduction to Data Compression by Khalid Sayood.

| | |
|---|---|
| **Course Distribution** | Theory: 40%<br>Problem Analysis: 30%<br>Solution Design: 25%<br>Social and Ethical Issues: 5% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

**Technology Involved**
Internet

**Practiced Techniques**
Discussions, Presentations, Viva Voce

## CS-703 Pattern Recognition
## Credit Hours 3 (3-0)

| | |
|---|---|
| **Program:** PhD | **Semester:** I |
| **Pre Requisite:** None | **Follow Up:** None |

**Course Description**
Pattern recognition - the act of taking raw data and making decisions based on the categories of the pattern - has applied to such diverse areas as character recognition, data mining, medical diagnosis, image processing, computer vision, bioinformatics, speech recognition, fraud detection, and stock market prediction. This course will provide underlying principles and various approaches of pattern recognition and decision making processes. The topics include diverse classifier designs, evaluation of classifiability, learning algorithms, and feature extraction and modeling. The goal of this course is to introduce students to the fundamental models of decision making in order to prepare them for applying the associated concepts to information processing.

**Course Objectives**
This course develops a fundamental understanding of adaptive pattern recognition and a basic working knowledge of techniques that can be used in a broad range of applications. Inherent in adaptive patter recognition is the ability of the system to learn by supervised or unsupervised training, or by competition within a changing course environment. The effectiveness of a system depends upon its structure, adaptive properties and specifics of the application. The goal is to gain both a

| |
|---|
| fundamental and working knowledge of different system and the ability to make a good selection when faced with real applications. |
| **Learning Outcomes**<br>By the end of the course students are expected to:<br>• Know the basic principles of pattern recognition theory and the main application domains<br>• Understand the fundamental pattern recognition methods and algorithms<br>• Apply well known algorithms to pilot problems<br>• Select the most efficient algorithm, based on problem requirements<br>• Design the methodology for pattern recognition problems of medium complexity |
| **Textbooks**<br>None |
| **Reference Books / Material**<br>• Pattern Classification by R. O. Duda, P. E. Hart and D. Stork.<br>• Pattern Recognition and Machine Learning by C. Bishop.Statistics and the Evaluation of Evidence for Forensic Scientists by C. Aitken and F. Taroni<br>• Research readings |

| | |
|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

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|---|
| **Technology Involved**<br>Internet |
| **Practiced Techniques**<br>Discussions, Presentations, Viva Voce |

## CS-704 Geographical and Satellite Imaging
## Credit Hours 3 (3-0)

| | |
|---|---|
| **Program:** PhD | **Semester:** II |
| **Pre Requisite:** None | **Follow Up:** None |
| **Course Description**<br>The course intends to provide a comprehensive knowledge about critical issues involved in geographical information systems and satellite imagery. | |
| **Course Objectives**<br>This course would provide the participants with a full understanding of GSI concepts, familiarity with specific functionality to the GSI like spatial analysis, data representations and sources etc. | |

| |
|---|
| **Learning Outcomes**<br>After completing the course students will be able to describe the functional basis of a GSI and perform spatial queries for demographic analysis that allow student to visualize large amounts of complex, spatial data by creating and combining layers of customized maps. They will have a spatial understanding of GIS in their field of interest (fire, crime analysis, etc) |
| **Textbooks**<br>• Fundamentals of Geographic Information Systems by Michael N. DeMers. |
| **Reference Books / Material**<br>• Web GIS: Principles and Applications by Pinde Fu.<br>• Geographic Information Systems and Science by Paul A. Longley, Mike Goodchild, David J. Maguire and David W. Rhind.<br>• Research readings |

| | |
|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

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|---|
| **Technology Involved**<br>Internet |
| **Practiced Techniques**<br>Discussions, Presentations, Viva Voce |

**CS-705 Digital Video Processing**
**Credit Hours 3 (3-0)**

| | |
|---|---|
| **Program:** PhD | **Semester:** II |
| **Pre Requisite:** None | **Follow Up:** None |

**Course Description**
This course provides an introduction to the basic concepts and techniques used in digital image and video processing. Two-dimensional sampling and quantization are studied, and the human visual system is reviewed. The course will start with video formation, perception and representation; video sampling and video sampling structure conversion. Video analysis and enhancement techniques will then be covered including two and three dimensional motion estimation; motion segmentation and tracking, video filtering and restoration. Other advanced topics that will be presented are video compression; video coding standards; video watermarking; error control in video communications and video streaming over internet and wireless IP protocols.

| | |
|---|---|
| **Course Objectives**<br>To be able to understand images, videos and different concepts. | |
| **Learning Outcomes**<br>Students will be equipped with the fundamental knowledge that will help them understand various concepts and techniques. | |
| **Textbooks**<br>None | |
| **Reference Books / Material**<br>• Video Processing and Communications by Yao Wang, Joern Ostermann, and Ya-Qin Zhang.<br>• Digital Video Processing by M. Tekalp.<br>• The Essential Guide to Video Processing by Alan C. Bovik.<br>• Particle Image Velocimetry by Springer | |
| **Course Distribution** | Theory: 40%<br>Problem Analysis: 30%<br>Solution Design: 25%<br>Social and Ethical Issues: 5% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved**<br>Internet | |
| **Practiced Techniques**<br>Discussions, Presentations, Viva Voce | |

**CS-706 Computer Visualization and Animation**
**Credit Hours 3 (3-0)**

| | |
|---|---|
| **Program:** PhD | **Semester:** II |
| **Pre Requisite:** None | **Follow Up:** None |
| **Course Description**<br>Main techniques covered in this course include:<br>• Keyframing, story-boarding,<br>• Kinematics, physically based dynamics modeling,<br>• Motion capture, Scene composition, lighting, and sound track generation<br>Advanced topics such as dynamic simulation of flexible and rigid objects, facial animation, and behavioral/AI based animation are also studied. | |

**Course Objectives**
This course will teach the students about current techniques in computer animation. By the end of the course, the students should:

- have learned the computational methods for modeling of motions in the physical and virtual world,
- be able to storyboard, light, compose, and render an animated sequence,
- be able to read and critically evaluate the current literature in computer animation.

**Learning Outcomes**
On completion of the course, the student should:

- Have a firm understanding of three dimensional computer graphics;
- Be familiar with the basics of computer animation,
- Understand 3D viewing, the 3D viewing pipeline, hidden surface removal, shading and illumination;
- Be ready to study real-time rendering, realistic image synthesis, computer animation and game programming.

**Textbooks**
None

**Reference Books / Material**

- Computer Animation: Algorithms and Techniques by Rick Parent
- After Effects Apprentice by Chris and Trish Meyer.
- Digital Lighting and Rendering by Jeremy Birn.
- Advanced Maya Texturing and Lighting by Lee Lanier.
- Professional Digital Compositing by Lee Lanier.

| | |
|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

**Technology Involved**
Internet

**Practiced Techniques**
Discussions, Presentations, Viva Voce

## CS-707 Game Theory
## Credit Hours 3

| | |
|---|---|
| Program: Ms, PhD | Semester: - |
| Pre Requisite: - | Follow Up: - |

**Course Description**

This course is a rigorous investigation of the evolutionary and epistemic foundations of solution concepts, such as rationalizability and Nash equilibrium. It covers classical topics, such as repeated games, bargaining, and supermodular games as well as new topics such as global games, heterogeneous priors, psychological games, and games without expected utility maximization. Applications are provided when available.

**Course Objectives**

- To understand the importance of competitive and cooperative factors in a variety of decision problems
- To learn how to structure and analyze these problems from a quantitative perspective

**Learning Outcomes**

The essence of game theory is not a set of results - though that surely lies at its foundations - but rather a process - the way in which an argument is constructed, how a puzzle about human behavior is solved. To learn game theory means learning the logical argument that produces a solution, a conclusion, a resolution of a mystery. Therefore the primary objective of this course is to teach how to analyze situations of strategic interaction between agents. Of course in doing so the students will become familiar with the terminology and basic definitions of game theory as well as solution concepts employed in game theory to predict what the outcome of a specific game will be.

**Textbooks**

- **"Algorithmic Game Theory"** by Noam Nisan, Cambridge University Press.

**Reference Books / Material**

- "A Course in Game Theory" by Martin J. Osborne and Ariel Rubinstein, MIT
- "Publicly available solutions for AN INTRODUCTION TO GAME THEORY", by Martin J. Osborene
- Research Papers/Journals.

**Marks Distribution and Grading Model (**Assignment, Quiz, Presentation, Group Discussion, etc., Mid and End Term Papers) Assignments (10), Quiz (10), Mid Term Paper (30), Final Term Paper (50).

**Technology Involved:** Matlab, Microsoft office, Multimedia, Overhead Projector, Web, etc.)

**Practiced Techniques:** Class Room Lecture, Presentation, Workshop, Group Discussion, etc.

## CS-708 Nano Communication Networks
## Credit Hours 3

| | |
|---|---|
| Program: PhD | Semester: Nil |

| Pre Requisite: Nil | Follow Up: Nil |
|---|---|

**Course Description**

*Nano Communication Networks* is a multi-disciplinary area providing a knowledge vehicle for complete coverage of all topics of interest to those involved in all aspects of **nano-scale networking** and **communications**. Theoretical research contributions presenting new techniques, concepts, or analyses, applied contributions reporting on experiences and experiments, and tutorials are discussed.

**Course Objectives**

*Nano Communication Networks* is a part of COMNET (Computer Networks) family of courses within Computer Sciences. The family of topics covers all aspects of networking at **nano-scale communications.**

**Learning Outcomes**

*Nano Communication Networks* course will be committed to the very timely knowledge of all aspects of nano-scale networking and communications.

**Textbooks**

- **"Nanoscale Communication Networks",** Stephen F. Bush, Artech House.
- **"Molecular Communications and Nanonetworks: From Nature to Practical Systems",** Baris Atakan, Springer.

**Reference Books / Material**

- **"Nano Communication Networks", Elsevier Journal.**

**Marks Distribution and Grading Model (**Assignment, Quiz, Presentation, Group Discussion, etc., Mid and End Term Papers) Assignments (10), Quiz (10), Mid Term Paper (30), Final Term Paper (50).

**Technology Involved:** Matlab, Microsoft office, Multimedia, Overhead Projector, Web, etc.)

**Practiced Techniques:** Class Room Lecture, Presentation, Workshop, Group Discussion, etc.

## CS-709 Optimization Techniques
## Credit Hours 3

| Program: PhD | Semester: Nil |
|---|---|
| Pre Requisite: Nil | Follow Up: Nil |

**Course Description**

This course introduces the principal algorithms for linear, network, discrete, nonlinear, dynamic optimization and optimal control. Emphasis is on methodology and the underlying mathematical structures. Topics include the simplex method, network flow methods, branch and bound and cutting plane methods for discrete optimization, optimality conditions for nonlinear optimization, interior point methods for convex optimization, Newton's method, heuristic methods, and dynamic programming and optimal control methods.

**Course Objectives**

The course aims at integrating traditional design methodologies with concepts and techniques of modern optimization theory and practice. In the course the student will learn to create an appropriate mathematical description (a simulation model) of the design problem, to formulate the optimization problem and finally to use numerical optimization techniques and computer support tools in order to solve the problem. The course has an emphasis on system design where “design" is defined in a broad context, and therefore students from diverse disciplines are welcome to attend the course.

**Learning Outcomes**

Upon completion of this course, students will:

Demonstrate knowledge and understanding of the basic ideas underlying optimization techniques;

Demonstrate knowledge and understanding of some of the most common standard optimization models and how they can be solved;

Appreciate some of the power of using the mathematical approach to optimization problems relevant to engineering;

Show logical thinking in problem solving;

Develop mathematical optimization models for a range of practical problems;

Formulate large-scale Linear and Integer Programming problems, input a problem into a computer efficiently, and then solve the problem.

**Textbooks**

- Poompat Saengudomlert, **“Optimization for Communications and Networks”**, Taylor & Francis Group, 22-Sep-2011 - Computers - 208 pages

**Reference Books / Material**

- K.A. Gomez, and A.A. Gomez. Statistical Procedures for Agricultural Research, 2nd ed. New York: John Wiley & Son, 1984.
- William Mendenhall, and R.L. Scheaffer. Mathematical Statistics with Applications. North Scituate: Duxbury Press, 1973.
- Ronald E. Walpole. Introduction to Statistics, 3rd ed. New York: Macmillan Publishing Co.,
- George W. Snedecor, and W. G. Cochran. Statistical Methods, 7th ed. Ames: Iowa State University, 1980.
- Kozak, A, RA Kozak, C Staudhammer and SB Watts (2008) *Introductory Probability and Statistics: Applications for Forestry and the Natural Sciences*. CAB International, Wallingford, Oxfordshire, UK. 448 pp.
- Research Papers/journals.

**Marks Distribution and Grading Model (**Assignment, Quiz, Presentation, Group Discussion, etc., Mid and End Term Papers) Assignments (10), Quiz (10), Mid Term Paper (30), Final Term Paper (50).

**Technology Involved:** Matlab, Microsoft office, Multimedia, Overhead Projector, Web, etc.)

| **Practiced Techniques:** Class Room Lecture, Presentation, Workshop, Group Discussion, etc. |
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**CS-710 Smart Grid**
**Credit Hours 3**

| Program: MS, PhD | Semester: |
|---|---|
| Pre Requisite: Game Theory | Follow Up: |

**Course Description**

Learn about the intelligent energy grid that supports today's green-energy initiatives. Study real-world value propositions, business perspectives and solution scenarios from business economics and technical practicalities points of view. Discover the evolution of today's power-distribution grid and the potential benefits from dynamically applying intelligence for improved efficiencies. This course lays a solid technical foundation for business professionals and a contemporary overview for technical staff; it is ideal for proposal staff, product developers, system managers and urban planners.

**Course Objectives**

This course is a survey course to provide an overview of the smart grid. After successfully completing this course, a student will have gained an understanding of:

a. The various aspects of the smart grid, including
- o Technologies
- o Components
- o Architectures
- o Applications

b. How a smart grid can be designed to meet the needs of a utility, including
- o Meeting a utility’s objectives
- o Helping to adopt new technologies into the grid
- o Creating a framework for knowledgeable power engineers to operate the grid more effectively

c. The issues and challenges that remain to be solved

The course is not designed to teach student how:
- To become power engineers
- To determine the best ways to manage the grid

**Learning Outcomes**

The learning objectives of this course include understanding the main issues of smart grid development and the critical technologies that underpin such development, their basic principles, physical constraints, and technological potentials, with a hope to facilitate attendees explore research opportunities in this area.

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| **Textbooks**<br>**"Algorithmic Game Theory" by Noam Nisan, Cambridge University Press** |
| **Reference Books / Material**<br>• "A Course in Game Theory" by Martin J. Osborne and Ariel Rubinstein, MIT<br>• "Publicly available solutions for AN INTRODUCTION TO GAME THEORY", by Martin J. Osborene<br>• Research Papers/journals. |
| **Marks Distribution and Grading Model (**Assignment, Quiz, Presentation, Group Discussion, etc., Mid and End Term Papers) Assignments (10), Quiz (10), Mid Term Paper (30), Final Term Paper (50). |
| **Technology Involved:** Matlab, Microsoft office, Multimedia, Overhead Projector, Web, etc.) |
| **Practiced Techniques:** Class Room Lecture, Presentation, Workshop, Group Discussion, etc. |

**CS-711 Data Collection and Analysis Techniques**
**Credit Hours 3**

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|---|---|
| Program: PhD | Semester: |
| Pre Requisite: | Follow Up: |
| **Course Description**<br>The course is designed to study current advancements in data collection and analysis techniques for machine learning and vision algorithms. | |
| **Course Objectives**<br>The course will aim to teach students the importance of performance characterization of algorithms with main focus on vision algorithms (such as edge detection, corner detection, blob detection, descriptors, image matching algorithms and application specific algorithms for example, panorama stitching, tracking, navigation etc). It will cover conventional methods such as ROC curves, Precision-Recall curve, sensitivity-specificity graphs, F-measure and Accuracy. The main focus will be to understand the application of above mentioned performance metric s and their limitations. The course will also discuss statistical methods commonly used in other domains such as Null hypothesis testing using parametric methods and non-parametric methods. Parametric methods include chi-square test, T-tsets etc. Whereas, non-parametric methods include ANOVA, McNemar's test, signed tests etc. Furthermore, the importance of using sufficiently large amount of data will be discussed which will also include the use of synthetic and real data. | |
| **Learning Outcomes**<br>Upon completion of this course, students will: | |

- Select appropriate analytical tools for performance characterization of algorithms
- Identify the appropriate amount of data for performance comparisons
- Be able to use tools for different statistical tests such as Excel, SPSS, WEKA etc.

**Textbooks / Reference Books / Material**


- Charles R. Hicks, Kenneth V. Turner. Fundamental Concepts in the Design of Experiments, 5th ed. New York: Oxford University Press, 1999.
- R. Mead, R.N. Curnow, and A.M. Hasted. Statistical Methods in Agriculture and Experimental Biology, 2nd ed. London: Chapman & Hall, 1993.
- K.A. Gomez, and A.A. Gomez. Statistical Procedures for Agricultural Research, 2nd ed. New York: John Wiley & Son, 1984.
- William Mendenhall, and R.L. Scheaffer. Mathematical Statistics with Applications. North Scituate: Duxbury Press, 1973.
- Ronald E. Walpole. Introduction to Statistics, 3rd ed. New York: Macmillan Publishing Co.,
- George W. Snedecor, and W. G. Cochran. Statistical Methods, 7th ed. Ames: Iowa State University, 1980.
- Kozak, A, RA Kozak, C Staudhammer and SB Watts (2008) *Introductory Probability and Statistics: Applications for Forestry and the Natural Sciences*. CAB International, Wallingford, Oxfordshire, UK. 448 pp.
- Research Papers/journals.


**Marks Distribution and Grading Model (**Assignment, Quiz, Presentation, Group Discussion, etc., Mid and End Term Papers) Assignments (10), Quiz (10), Mid Term Paper (30), Final Term Paper (50).

**Technology Involved:** WEKA (a public domain machine learning tool box), Microsoft office, SPSS, Multimedia, Overhead Projector, Web, etc.)

**Practiced Techniques:** Class Room Lecture, Presentation, Workshop, Group Discussion, etc.

## CS-712 Data Warehousing & Data Mining

| **Program:** PhD | **Semester: II** |
|---|---|
| **Prerequisite**: Calculus, probability theory, and linear algebra. Knowledge of graphs and basic algorithms is an advantage. | **Follow Up:** |

**Course Description**

Data Warehouse: (a) Data Model for Data Warehouses. (b) Implementing Data Warehouses: data extraction, cleansing, transformation and loading, data cube computation, materialized view selection, OLAP query processing. Data Mining: (a) Fundamentals: data mining process and system architecture, relationship with data warehouse and OLAP systems, data pre-processing. (b) Mining Techniques and Applications.

**Course Objectives**

The aim of the course is to provide a basic but comprehensive introduction to data warehousing and data mining. By the end of the course, students will be able to build models, choose algorithms, implement and evaluate them.

**Learning Outcomes**

- Understanding concepts of data warehouse and data mining
- Learn the techniques and also to implement them

**Textbooks**
Reading material will be provided during the session.

**Reference Books / Material**

Article by Susan Gallas comparing Kimball and Inmon approaches for DW: http://www.dmreview.com/master.cfm?NavID=198&EdID=1400

The Data Warehouse Lifecycle Toolkit - Expert methods for designing, developing, and deploying Data Warehouses, Ralph Kimball, Laura Reeves, Margy Ross, Warren Thornthwaite, ISBN 0-471-25547-5

The OLAP Report: www.olapreport.com

Microsoft Online resource: http://msdn.microsoft.com/library/default.asp?url=/library/en-us/olapdma...

SQL Server Tutorials www.microsoft.com

Microsoft SQL Server 2005 Analysis Services Step by Step by Reed Jacobson published by Microsoft Press; ISBN 0-7356-2199-3

DM Review: www.dmreview.com

Building the Data Warehouse, W.H. Inmon, John Wiley & Sons, ISBN 0-764-59944-5

Jiawei Han and Micheline Kamber: *Data Mining: Concepts and Techniques*, 2nd ed., Morgan Kaufmann Publishers, 2006.

Pang-Ning Tan, Michael Steinbach, Vipin Kumar: *Introduction to Data Mining*, Addison-Wesley, 2006.

T. Hastie, R. Tibshirani, J. H. Friedman: *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer-Verlag, 2001.

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|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours |

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|---|---|
| | ***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions, Poster Presentation, Seminar | |

**CS-713 Knowledge Management and Information Retrieval (KMIR)**

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|---|---|
| **Program:** PhD | **Semester: II** |
| **Pre Requisite:** | **Follow Up:** |

**Course Description**
Introduction to Knowledge and Knowledge Management Concepts, Knowledge Modeling, Introduction to Information Retrieval, Information Retrieval Models, Retrieval Evaluation, Query Languages and Operations, Document Processing, Search Techniques.

**Course Objectives**
It has become recognized that knowledge of products, processes, management, and technologies is one of the most important assets of the modern corporation. To gain maximum benefit, this resource must be effectively managed. This includes knowledge capture, storage, and dissemination. Since knowledge is often embodied in textual documents, information storage and retrieval form a central part of the techniques for knowledge management. Information retrieval has also become one of the most important technologies used in conjunction with the Internet, in the form of search engines.

**Learning Outcomes**

- Students will be able to understand information retrieval models
- Students will also be able to understand query languages and operations

**Textbooks**
Readings will be available during the session.

**Reference Books / Material**

*T.H. Davenport and L. Prusak:*
Working Knowledge, Harvard Business School Press, 2000.

*R. Baeza-Yates and B. Ribeiro-Neto:*
Modern Information Retrieval, ACM Press, Addison Wesley, 1999.

*A. Tiwana:*

Knowledge Management Toolkit, The: Practical Techniques for Building a Knowledge Management System, Prentice Hall, 1999.

*S.I. Tannenbaum and G.M. Alliger:*
Knowledge Management: Clarifying the Key Issues, IHRIM, 2000.

*W. Applehans, A. Globe, and G. Laugero:*
Managing Knowledge: A Practical Web-Based Approach, Addison-Wesley, 1998.

*R. K. Belew:*
Finding Out About, Cambridge University Press, 2000.

*M.W. Berry and M. Browne:*
Understanding Search Engines, Society for Industrial and Applied Mathematics, 1999.

*W. Frakes, R. Baeza-Yates:*
Information Retrieval: Data Structures and Algorithms, Prentice Hall, 1992.

*A. G. Taylor:*
The Organization of Information, Libraries Unlimited, 1999.
*ACM Special Interest Group on Information Retrieval (SIGIR)*
http://www.acm.org/sigir

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| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions, Poster presentations | |

## CS-714 Advance Requirement Engineering

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|---|---|
| **Program:** PhD | **Semester: 1** |
| **Pre Requisite:** | **Follow Up:** |
| **Course Description** | |

Requirements engineering (RE) plays a fundamental role within the systems development process. The goal of this course is to bring in the concepts, methods and techniques needed in the eliciting, analyzing, documenting, validating, and managing requirements for complex information systems. It explains how requirements engineering fits into a broader systems development process, and provides an understanding of the main challenges in requirements engineering nowadays.

**Course Objectives**

The students will learn how to:

- Identify stakeholders and their influence on the system requirements.
- Specify functional requirements using different modeling methods.
- Identify and classify non-functional requirements, influences and constraints.
- Negotiate and prioritize requirements.
- Validate requirements.
- Document and trace requirements using computer-based tools.
- Manage changing requirements and establish traceability of changes.
- Practice the different roles in the requirement engineering process, by working in groups.
- Analyze the practical use of the latest scientific contributions within the RE subject.

**Learning Outcomes**

Students will be able to understand

- state-of-the-art for research & practice in Requirements Engineering.
- Role of RE in software and systems engineering
- Current techniques, notations, methods, processes and tools used in RE
- Breadth of skills needed for RE, and the many disciplines on which it draws
- Contextual factors & practicalities that affect the success of various approaches to RE
- Methodological issues for RE research
- Current research issues and the direction of the field
- Awareness of the literature

**Textbooks**

No textbook adequately covers the course's range of topics, so a diversity of bibliographic elements (books, journals and conference proceedings) will be used. Reading materials will be delivered on each session.

**Reference Books / Material**

- Richard H. Thayer, Sidney C. Bailin, " Software requirements engineering"
- Sommerville, I. and Kotonya, G. (1998), Requirements Engineering: Processes and Techniques, John Wiley & Sons, Inc.
- D. Norman, The Psychology of Everyday Things, Basic Books/Harper-Collins, 1988. (ISBN 0-465-06709-3).

| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20% |
|---|---|

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|---|---|
| | Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions | |

## CS-715 Agents based Software Engineering

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|---|---|
| **Program:** PhD | **Semester: 1I** |
| **Pre Requisite:** Principles of software engineering, Object oriented analysis and design with UML | **Follow Up:** |

**Course Description**

The course begins with an overview of the agent systems and software agents. Then we focus on agent system architecture and infrastructure from a software engineering viewpoint, including:

- Requirements for agent-based systems
- Modeling and design of agent-based systems
- Development process for agent-based systems

**Course Objectives**

Agent-based systems are software products that not only do things as specified but also have knowledge to do their job and can do it in a cooperative, coordinative and competitive way.

- What are myths and realities of the agent-based systems?
- How to develop an agent-based system for a particular task?
- How to evolve from object-oriented development to agent-based systems?
- How to incorporate and share knowledge among software agents?

**Learning Outcomes**

- will have an understanding of the agent system terminology and development process of agent-based systems.
- will have learned techniques to design agent-based system.
- will know how to modify architecture of the current software systems and re-structure them to be agent-based.

**Textbooks**

No textbook adequately covers the course's range of topics, so a diversity of bibliographic elements (books, journals and conference proceedings) will be used. Reading materials will be delivered on each session.

**Reference Books / Material**

- *Multiagent Systems : A Modern Approach to Distributed Artificial Intelligence*, Gerhard Weiss, Edt., 1st edition, (648 pages) MIT Press, (July, 2000). ISBN: 0262731312.
- *Readings in Agents*, M.N. Huhns and M.P. Singh, Edts., (523 p.) Morgan Kaufmann Publishers, (January1998). ISBN: 1-558-60495-2.
- *Heterogeneous Agent Systems*, V. S. Subrahmanian, Piero Bonatti, Jurgen Dix, Thomas Eiter and Fatma Ozcan, (640 p.) 1st edition, MIT Press, (June, 2000). ISBN: 0-262-19436-8.
- An Introduction to MultiAgent Systems, Michael Wooldridge, 2nd edition (June 22, 2009). ISBN: 0470519460
- Agent-Based Software Engineering by Michael Wooldridge

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|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

**Technology Involved** (Multimedia, Overhead Projector, etc.)
Multimedia

**Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)
Lecture, Workshop, Group discussions

## CS-716 Architectures for Software Systems

| **Program:** PhD | **Semester: I** |
|---|---|
| **Pre Requisite:** | **Follow Up:** |

**Course Description**
Software architecture represents the gross-level structure of software intensive systems and includes the early design decisions that impact the quality of the overall system. Software architecture is generally considered to play a fundamental role in coping with the inherent difficulties of the development of large-scale and complex software systems. A common assumption is that architecture design can support the required software system qualities such as robustness, adaptability, reusability and maintainability. This course teaches the basic concepts, methods and techniques for designing software architectures.

**Course Objectives**
Concepts and methodologies for the systematic analysis, development, evolution, and reuse of software architectural design. Common software architectural styles, elements and connectors. Decomposition and composition of software functionality. Non-functional requirements as criteria for analyzing trade-offs and selecting among architectural design alternatives. State of the practice and art.

**Learning Outcomes**
Architectures for Software Systems aims to teach students how to design, understand, and evaluate systems at an architectural level of abstraction. By the end of the course students will be able to:

- Understand the influence of architectural drivers on software structures.
- Understand the technical, organizational, and business role of software
- architecture.
- Identify key architectural structures (styles, patterns, tactics, etc.).
- Understand the principles of good architectural documentation and presentation.
- Understand the impact that COTS has on architectural designs.
- Generate architectural alternatives in a given context and choose among them.
- Understand how formal notations can be used to specify architectures.
- Evaluate the fitness of an architectural design in meeting a set of system requirements and balancing quality tradeoffs.
- Be aware of the future trends in software architecture.

**Textbooks**
Reading material will be provided during the session.

**Reference Books / Material**

*Software Architecture: Perspectives on an Emerging Discipline*, by Mary Shaw and David Garlan, Prentice Hall 1996

*Software Architecture in Practice, Second Edition*, by Len Bass, Paul Clements, and Rick Kazman, Addison-Wesley 2003

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|---|---|
| *Documenting Software Architectures: Views and Beyond, Second Edition,* by Clements, et al. Addison-Wesley 2011<br>*Architecting Software Intensive Systems: A Practitioner's Guide,* by Anthony J. Lattanze, Taylor and Francis/Auerbach 2008 | |
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 10%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions | |

**CS-717 Evidence Based Software Engineering**

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| **Program:** PhD | **Semester: II** |
| **Prerequisite**: | **Follow Up:** |
| **Course Description**<br>Course is based on Evidence based software engineering. This course will require research work produced through empirical study of any of software engineering areas. The empirical study on existing industry practices will be highly recommended. The research will be conducted by selecting any of the following empirical research methods. | |
| **Course Objectives**<br>This course provides details about evidence based software engineering where facts are collected, synthesized, evaluated and reported by employing a combination or research approaches in a systematic manner. The course highly focused on systematic way of finding facts about the area of interest. The course involves techniques coming from social science, human and behavioral studies and psychology. | |

**Learning Outcomes**

- will have an understanding of what evidence based software engineering is.
- will have learned techniques to conduct , analyze, evaluate and report facts by producing a chain of evidence.

**Textbooks**

Reading material will be provided during the session.

**Reference Books / Material**


- Dyba, T., Kitchenham, B. A. and Jrgensen, M. (2005), `Evidence-based software engineering for practitioners', IEEE Software 22(1)
- Oates, B. J. (2005), Researching information systems and computing, Sage Publications Limited. 9
- Runeson, P., Host, M., Rainer, A. and Regnell, B. (2012), Case Study Research in Software Engineering: Guidelines and Examples, Wiley.
- Yin, R. K. (2008), Case Study Research: Design and Methods, Vol. 5, 4 edn, Sage Publications, Inc.
- http://www.dur.ac.uk/ebse/
- Kitchenham, B.A.; Dyba, T.; Jorgensen, M.; Evidence-based software engineering. Proceedings. 26th International Conference on Software Engineering (ICSE 2004), p273-281. 23-28 May 2004.
- Preliminary guidelines for empirical research in software engineering by Barbara A. Kitchenham
- Ethical Issues in Empirical Studies of Software Engineering by Janice Singer and Norman G. Vinson
- Writing good software engineering research papers by Mary Shaw
- Five Misunderstandings about Case Study Research by Bent Flyvbjerg
- Cruzes, D. S. and Dyb_a, T. (2011), `Research synthesis in software engineering: A tertiary study', Information and Software Technology
- Dyb_a, T., Dingsyr, T. and Hanssen, G. K. (2007), Applying systematic reviews to diverse study types: An experience report, in `First International Symposium on Empirical Software Engineering and Measurement.
- Dyb_a, T., Kitchenham, B. A. and Jrgensen, M. (2005), `Evidence-based software engineering for practitioners', IEEE Software.
- Kitchenham, B. and Charters, S. (2007), Guidelines for performing systematic literature

reviews in software engineering, Technical Report EBSE 2007-001, Keele University and Durham University Joint Report.

- Perry, D. E., Sim, S. E. and Easterbrook, S. M. (2004), Case studies for software engineers, in `Proceedings of the 26th International Conference on Software engineering (ICSE'04)', IEEE.
- Runeson, P. and H□ost, M. (2009), `Guidelines for conducting and reporting case study research in software engineering', Empirical Software Engineering.
- Seaman, C. B. (1999), `Qualitative methods in empirical studies of software engineering', IEEE Transactions on Software Engineering 25(4).
- Kitchenham, B., Brereton, P., Budgen, D., Turner, M., Bailey, J. and Linkman, S. (2009), `Systematic literature reviews in software engineering systematic literature review', Information and Software Technology 51(1).
- McLeod, L., MacDonell, S. G. and Doolin, B. (2011), `Qualitative research on software development: a longitudinal case study methodology', Empirical Software Engineering 16(4)
- Mandi_c, V., Markkula, J. and Oivo, M. (2009), `Towards multi-method research approach in empirical software engineering', Product-Focused Software Process Improvement
- Wood, M., Daly, J., Miller, J. and Roper, M. (1999), `Multi-method research: an empirical investigation of object-oriented technology', Journal of Systems and Software.
- Cruzes, D. S. and Dyb_a, T. (2011), `Research synthesis in software engineering: A tertiary study', Information and Software Technology.

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| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions, Poster Presentation, Seminar | |

## CS-718 Service Oriented Computing

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| **Program:** PhD | **Semester: I** |

| **Pre Requisite:** | **Follow Up:** |
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**Course Description**
Service-oriented architectures and computing have emerged as the core of the next generation of information systems. This course focuses on analysis and design of information systems with a service-oriented perspective.

**Course Objectives**

- To understand the concept of software services
- To understand paradigm shift and the significance of software services based architectures
- To understand SOA, SaaS and cloud computing
- To understand technologies involved in developing service based systems

**Learning Outcomes**

By the end of the course students should be able to:

- Understand Service-oriented Architectures and Models
- Know about Service description, discovery, composition, and aggregation
- Understand Interactions between Service providers, consumers, brokers and aggregators
- Appreciate Service-Level Agreements and Contracts for Service Provision
- Evaluate Service-oriented technologies and their potential for business transformation.

**Textbooks-**
Reading material will be provided before the session or in the session.

**Reference Books / Material**

- Erl, T. (2004), Service-Oriented Architecture: A Field Guide to Integrating XML and WebServices, Prentice Hall
- Erl, T. (2005), Service-Oriented Architecture (SOA): Concepts, Technology, and Design, Prentice Hall
- Huhns, M. and Singh, M. P. (2005), `Service-oriented computing: key concepts and principles', IEEE Internet Computing 9(1)

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|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |

**Technology Involved** (Multimedia, Overhead Projector, etc.)
Multimedia

**Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)
Lecture, Workshop, Group discussions, The course will involve a group project or individual

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| project that analyzes and design a real world system. |

## CS-719 Software Engineering Economics

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| **Program: P**hD | **Semester: II** |
| **Pre Requisite**: | **Follow Up:** |

**Course Description**

The course will cover the aspects of software quality management including total quality management (TQM), quality management activities including quality assurance, quality planning and quality control, process based quality, quality assurance and standards, approaches to software quality, product and process standards, software process improvement (SPI), quality models, GQM approach, cost of quality, cost of repair, software metrics including measurement, metrics and its indicators, process metrics, product metrics and quality metrics.

- Measurement of software products
- Measurement of software processes
- Software quality

**Course Objectives**

**Learning Outcomes**

- 

**Textbooks**

Reading material will be provided during the session.

**Reference Books / Material**

- Software Metrics: A Rigorous and Practical Approach (2nd ed.) (638p.) ISBN 0-534-95425-1 (1998)
- N.E. Fenton and S.L. Pfleeger, PWS Publishing, Metrics and Models in Software Quality Engineering (2nd ed.) (528 pages), ISBN 0-201-72915-6 (2002)
- Stephen H. Kan, Addison-Wesley, Software Metrics: A Guide to Planning, Analysis, and Application (312p.), ISBN 0-8493-1661-8 (2004)
- C. Ravindranath Pandian, Auerbach Publications, CRC Press Company, Goal/Question/Metric Method: A Practical Guide for Quality Improvement of Software Development (216 p.)
- CMMI and Project Quality Management
- Chemuturi, Murali (2010). Software Quality Assurance: Best Practices, Tools and Techniques for Software Developers. J.Ross Publishing.

| | |
|---|---|
| **Course Distribution** | Theory: 50%<br>Problem Analysis: 20%<br>Solution Design: 20%<br>Social and Ethical Issues: 10% |
| **Marks Distribution** | ***Mid Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 30 Marks, 02 hours<br>***End Term*** Test: 05 Marks, Assignment: 05 Marks, Paper: No Choice, 50 Marks, 03 hours |
| **Technology Involved** (Multimedia, Overhead Projector, etc.)<br>Multimedia | |
| **Practiced Techniques** (Class Room Lecture, Workshop, Group Discussion, Survey, etc.)<br>Lecture, Workshop, Group discussions, Poster Presentation, Seminar, Survey | |

**Standard 2.1:** The curriculum must be consistent and supports the program's documented objectives.

➡ Ph.D. Computer Science program contents/courses meet the program objectives as shown in the table.

**Table 9: Ph.D. Courses versus Program Objectives**

| Courses/Groups of Courses | Objectives | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| CS- 701 | X | X | X | X |
| CS- 702 | X | X | X | X |
| CS- 703 | X | X | X | X |
| CS- 704 | X | X | X | X |
| CS- 705 | X | X | X | X |
| CS- 706 | X | X | X | X |
| CS- 707 | X | X | X | X |
| CS- 708 | X | X | X | X |
| CS- 709 | X | X | X | X |
| CS- 710 | | | X | X |
| CS- 711 | X | X | X | X |
| CS- 712 | | X | X | X |
| CS- 713 | | X | X | X |
| CS- 714 | X | X | X | X |
| CS- 715 | X | X | X | X |
| CS- 716 | X | X | X | X |
| CS- 717 | X | X | X | X |
| CS- 718 | X | X | X | X |
| CS- 719 | | | X | X |

**Standard 2.2:** Theoretical background, problems analysis and solution design must be stressed within the program's core material.

**Program: Ph.D. Computer Science**

The modules of all the programs adequately address:

1) Problem solving

2) Solution design
3) Application of the theoretical knowledge

- Great emphasis of the program is on problem solving strategies and design of solution. The product of the task results in the application of the theoretical knowledge in the applied fields of natural sciences.
- All the modules provide adequate and practical application of the knowledge in different specializations with the exploitation of advance techniques.

**Table 13**: **Elements of Courses**

| Elements | No of Courses |
|---|---|
| Theoretical background | 19 |
| Problem solving | 19 |
| Solution design | 19 |

**Standard 2.3:** The curriculum must satisfy the core requirements for the program, as specified by the respective accreditation body.

The curriculum satisfies both the core requirements of credit hours and criteria of admission lay down by Lahore College for Women University and HEC and are in par with the international standards.

**Standard 2.4:** The curriculum must satisfy the major requirements for the program as specified by the respective accreditation body.

The curriculum satisfies major requirements of the program. No formal accreditation with any professional body. The programs and curriculum have the approval of Board of Studies.

**Standard 2.5:** The curriculum must satisfy general education, arts, and professional and other discipline requirements for the program, as specified by the respective accreditation body/council.

The curriculum satisfies general education disciplines requirements. No formal accreditation with any professional body but it fulfills all the necessary/basic requirements of the accreditation body. The programs and curriculum have the approval of Board of Studies and Lahore College for Women University.

| Programs | Maths & Basic Sciences | Computing Topics | General Education | Others |
|---|---|---|---|---|
| PhD | - | 6 * 3 | - | - |
| | | | | |

Table A.1 Minimum Requirements for Each Program
(Program Semester Credit hours)

**Standard 2.6:** Information technology component of the curriculum must be integrated throughout the program.

This requirement is fulfilled by all the courses as well.

**Standard 2.7:** Oral and written communication skills of the student must be developed and applied in the program.

Oral and written communication skills of the student are developed by the structurally designed courses for English, seminars, question answers, presentations and by the class participation of the students.

## CRITERION 3: LABORATORIES AND COMPUTING FACILITIES

**Standard 3.1:** Laboratory manuals/documentation/instructions for experiments must be available and readily accessible to faculty and students.

➡ The Ph.D. program has no exclusive requirements of labs manuals.

**Standard 3.2:** There must be adequate support personnel for instruction and maintaining the laboratories:

➡ Faculty members themselves are responsible for instructions and tutorial related to the practical. Laboratory staff is responsible for the maintenance of hardware and software and other equipment.

**Standard 3.3:** The university computing infrastructure and facilities must be adequate to support program's objectives:

➡ The computing infrastructure of the Computer Science department is adequate. There are 7 computer labs with adequate computers for the use of the students. Mostly PhD research students are tightly bundled with research supervisor in faculty room with personal laptops.

## CRITERION 4: STUDENT SUPPORT AND ADVISING

**Standard 4.1:** Courses must be offered with sufficient frequency and number for students to complete the program in a timely manner:

➡ The strategy for programs (courses) offering is controlled. The Ph.D. courses are offered minimum once a year.

**Standard 4.2:** Courses in the major area of study must be structured to ensure effective interaction between students, faculty and teaching assistants:

➡ The effective student/faculty interaction in programs taught by more than one faculty members is streamlined by coordination of these faculty members and the commonality is maintained through any curriculum which is adopted for the particular module.

➡ The programs are structured to ensure effective interaction between students, faculty and the Head of Department. The students requiring extra help are provided services through tutorials, questions and answers. Questions are encouraged by the faculty from the students. Seminars are arranged where the students are free to discuss the topics relating to the program. The students are free to interact with the class in charge and Head of department in case of any shortcoming.

**Standard 4.3:** Guidance on how to complete the program must be available to all students and access to academic advising must be available to make course decisions and career choices:

➡ The students are provided guidance regarding the completion of the programs and having access to qualified faculty as well as student counseling. The students are encouraged to bring forward their suggestions and complaints through a complaint box which is maintained in the Institute. The students once in semester carry-out the teacher's evaluation. Furthermore, the weekly work plan and the course outlines are made available to the students in the beginning of the semester.

The counseling is availed at the Student counseling center of the university which deals with various issues.

## CRITERION 5: PROCESS CONTROL

**Standard 5.1:** The process by which students are admitted to the program must be based on quantitative and qualitative criteria and clearly documented. This process must be periodically evaluated to ensure that it is meeting its objectives:

**Ph.D. Computer Science Program**

The program is divided in 2 semesters each year.

Eligibility Criteria:

Minimum CGPA 3.0 (out of 4.0in the Semester System) or First Division (in the Annual System) in M. Phil / MS /Equivalent degree in Computer Science. Equivalence must be from HEC. Entry Test with 60% passing criterion.

**Standard 5.2:** The process by which students are registered in the program and monitoring of students' progress to ensure timely completion of the program must be documented. This process must be periodically evaluated to ensure that it is meeting its objectives:

- Advertisements are made in leading newspapers and on Lahore College for Women University website. The student academic progress is monitored regularly by the regular written examination system. The process of registration and monitoring are reviewed once in a year three months before the date of admission.
- Students requiring admission in Ph.D. Computer Science program who have qualified from private universities are required to give equivalence certificates/ NOC as per rules of Lahore College for Women University.

**Standard 5.3:** The process of recruiting and retaining highly qualified faculty members must be in place and clearly documented. Also processes and procedures for faculty evaluation, promotion must be consistent with institution mission statement. These processes must be periodically evaluated to ensure that it is meeting its objectives:

- The standards are clearly indicated in the University act/statues which is followed. Qualifications which are required for each subject are kept in mind. The criteria for recruiting are qualification, experience which is judged through analysis of CVs, written test and personal interviews as stipulated in university's act/statues. The input of the students for maintaining the quality of the teachers is done by evaluating the teachers regularly once in a semester by the students. The results of these studies are sent to the teachers who are asked to improve and in extreme cases, replacements are made.

**Standard 5.4:** The process and procedures used to ensure that teaching and delivery of course material to the students emphasizes active learning and that course learning outcomes are met. The process must be periodically evaluated to ensure that it is meeting its objectives:

- There are process and procedure to ensure that the teaching and delivery of the program material to the students emphasizes active learning. For instance, exercises, tasks, activities, assignments and research assignments based on practicality of the knowledge are given to the students and research thesis is initiated at the end of the program. Process is monitored and assessed regularly through monthly progress reports.

**Standard 5.5:** The process that ensures that graduates have completed the requirements of the program must be based on standards, effective and clearly documented procedures. This process must be periodically evaluated to ensure that it is meeting its objectives

- The semester rules have been adopted by the department according to the rules provided by the examination. Head of Department ensure their compliance.
- This operation is reviewed once a year and is documented.

## CRITERION 6: FACULTY

**Standard 6.1:** There must be enough full time faculty members who are committed to the program to provide adequate coverage of the program areas/courses with continuity and stability. The interests and qualifications of all faculty members must be sufficient to teach all courses, plan, modify and update courses and curricula. All faculty members must have a level of competence that would normally be obtained through graduate work in the discipline. The majority of the faculty must hold a Ph.D. in the discipline:

- There is adequate full time faculty which provides adequate coverage of the program with continuity and stability. The interest and the qualifications of all faculty members are pre-judged and monitored for each course forming a part of the program. The level of competency of the faculty members are evaluated at time of induction and monitored during teaching.

**Table 4.6: Faculty Distribution by Program Areas**

| Program Area of Specialization | Courses in the Area and Average | Number of faculty Members in Each | Number of Faculty with Ph. D Degree |
|---|---|---|---|

| | | Area | |
|---|---|---|---|
| **Computer Vision/Image Processing** | **CS-701 – CS-706** | **5** | **5** |
| **Networking/ICT** | **CS-707 – CS-710** | **3** | **3** |
| **Software Engineering / Software Architecture** | **CS-711 – CS-719** | **1** | **1** |
| **Data Mining, Machine Leering, Big Data Analysis** | **CS-701 – CS-706** | **5** | **5** |

**Standard 6.2:** All faculty members must remain current in the discipline and sufficient time must be provided for scholarly activities and professional development. Also, effective programs for faculty development must be in place:

All the faculty members remain current in the disciplines and sufficient time is provided for scholarly activities and professional development. The newly inducted faculty is given enough time to familiarize with the working environment of the Institute. During this time, they are monitored. Faculty is provided with centralized training by Registrar's office through DFDI at university, National Academy for Higher Education (NAHE) at HEC and other independent organizations / institutions. They are encouraged to attend international seminars. Some of the faculty members had opportunity to get training and research experiences from foreign universities/institutions.

**Standard 6.3:** All faculty members should be motivated and have job satisfaction to excel in their profession:

The faculty members are regularly motivated and efforts are made to provide job satisfaction so that they excel in their profession**.**

## CRITERION 7: INSTITUTIONAL FACILITIES

**Standard 7.1:** The institution must have the infrastructure to support new trends in learning such as e-learning

**Academic Building:** (Dedicated/Owned)

1. Class rooms: 00
2. Computer Lab: 01

3. Conference Room: 01
4. Video Conferencing Room: 01
5. H.O.D Office: 01
6. Staff Room: 01
7. Shared faculty offices 08

- Department building is fully equipped with all latest new technology.
- Projectors are used in the labs.
- Internet facility is available throughout department.
- Access to HEC digital library.

**Standard 7.2:** The library must possess an up-to-date technical collection relevant to the program and must be adequately staffed with professional personnel:

- 3000 of up-to-dated books are available in the library that covers all the areas of programs.
- Institute provides services of digital library.
- Common Science library is also available for books borrowing.

**Standard 7.3:** Class-rooms must be adequately equipped and offices must be adequate to enable faculty to carry out their responsibilities:

- 1 lab, 1 conference room and 1 video conferencing room.
- Office of Head of department, 1 staff room and shared faculty offices

## CRITERION 8: INSTITUTIONAL SUPPORT

**Standard 8.1:** There must be sufficient support and financial resources to attract and retain high quality faculty and provide the means for them to maintain competence as teachers and scholars:

- Teachers are recruited on the basis of criterion established by the University.
- Existing faculty is sent to different courses of teaching organized to update the knowledge.
- Research incentive award by the university

**Standard 8.2:** There must be an adequate number of high quality graduate students, research assistants and Ph.D. students:

**In 2018**

| | |
|---|---|
| Ph.D. Students | 17 |

**Standard 8.3:** Financial resources must be provided to acquire and maintain Library holdings, laboratories and computing facilities:

➡ Budget for Laboratory equipment is 0.1 Million