Minutes

of the

17th Meeting of the Board of Studies

Faculty of Engineering Sciences

held on

7th and 15th August 2018

through VLC

Bahria University Islamabad

Contents

Minutes of the 17th Meeting of the Faculty Board of Studies Engineering Sciences held on 7th & 15th August 2018 by VLC

Attendance:

BUIC

Present

• Prof. Dr. Muhammad Najam ul Islam	Dean ES	Chair
• Prof. Dr. Tahseen Ullah Khan	HOD(E&ES)	Member
• Prof. Dr. Atif Raza Jafri	HOD(EE)	Member
• Prof. Dr. Faisal Bashir	HOD(CS)	Member
• Senior Associate Prof. Dr. Awais Majeed	HOD(SE)	Member
• Senior Assistant Prof.Dr.Khalid Javed	HOD(CE)	Member

BUKC

Present

• Prof. Dr. Nargis Yasmeen	HOD (E&ES)	Member
• Senior Associate Prof. Dr. Humera Farooq	HOD(CS)	Member
• Associate Prof. Dr. Sohaib Ahmed	HOD(SE)	Member
• SeniorAsstt. Prof. Dr. Rizwan Iqbal	HOD(CE)	Member
• Dr.Najam Muhammad Amin	Acting HOD(EE)	Member

BULC

• Asstt Prof. Mr Farhan Saeed Sherazi	HOD(CS&IT)	Member

In Attendance

• Prof. Dr. Muhammad Zafar	E&ES	BUIC
• Mr.Raees Ahmad	E&ES	BUIC

Proceedings

Preliminaries

1. FBoS-ES meeting took place on two days; in first session, with the quorum complete, the proceedings commenced at 1200 hrs, with recitation from the Holy Quran on 7th August, 2018.

2. The second session of FBoS took place on 15th August, 2018, with the quorum complete; the proceedings commenced at 1030 hrs, with recitation from the Holy Quran and continued till 1500 hrs.

3. In his opening remarks, the Chair stressed the importance of participation in the proceedings while staying focused on the point under deliberation.

New Items:

Item 1701: MS(Software Engineering)-Revision of Curriculum

Sponsor: HODs(SE) BUIC & BUKC — Referral Authority: Inter-Campus Committee

Summary of the Case

Revision of curriculum is a continuous process. The Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs). The revised curriculum of MS (Software Engineering) has been issued by HEC in 2018. Following committee has review and updated the MS(SE) curriculum:

1. Dr. Awais Majeed - HoD, SE-IC
2. Dr. Sohaib Ahmed - HoD, SE-KC
3. Dr. Tamim A Khan - Professor, SE-IC
4. Dr. Osama Rehman - Sr. AP, SE-KC

After, due consideration and deliberation the committee has revised the roadmap of MSSE program offered at BU in accordance with HEC guidelines.
The committee presented its recommendations, which were deliberated by the house in detail. With minor changes, the recommendations were approved in line with NCRC's revised roadmap.
The revised roadmap of BS(SE) program is attached at Appendage 1701 .

Decision 1701
The agenda item is approved and forwarded to ACM for consideration.

Item 1702: Revision of MS (Engineering Management) Roadmap

Sponsor: HOD SE BUIC — Referral Authority: Inter Campus Committee

Summary of the Case

Bahria University launched MS – Engineering Management Program at Islamabad campus in the Software Engineering department in Spring 2016. The faculty members of Management Sciences department at Islamabad campus are actively involved in the MS – EM program. The revision of curriculum was due in 2018. The revised curricula of MS (Engineering Management) was presented after due deliberation in DBOS. The following committee has review and updated the MS (EM) curriculum:

1. Dr. Awais Majeed - HoD, SE-IC
2. Dr. Ismail Ramay, Professor MS-IC
3. Dr. Tamim A Khan - Professor, SE-IC
4. Dr. Zahoor Sarwar – Sr. Associate Professor, SE-IC
5. Dr. Abdul Baseer Qazi – Sr. Assistant Professor, SE-IC
6. Dr. Farrukh Jalil - Sr. AP, MS-IC

Discussion

The chair recommended the following changes:

The course codes for the core courses of the program to 500 level.
Addition of elective courses in two sub-domains.
Review of course offering in the initial two semesters.

HOD-SE discussed the recommendations with committee mentioned above; and the revised curriculum and roadmap was presented in the FBoS during the second session. The revised curriculum was recommended by the house to be presented in the next ACM (Appendage 1702).

Decision 1702

The agenda item is recommended for consideration of ACM.

Item 1703: Addition/Correction of Course Codes in the Unified Course Code Book

Sponsor: HOD(EE)BUKC Referral Authority: DBOS EE BUIC

Summary of the Case

The course code book published in 2018 has following issues:

1. Duplicated course codes for Electrical Machine Course.
2. Microprocessor/Microcontroller based system Lab course code is missing.
3. The Engineering Drawing & CAD and Workshop Practice course codes are EEL-121 & EEL- 112 respectively. The course codes and credit hours (0+1) show that they are lab based course hence the CMS system has no provision of midterm and sessional marks entry.

It is recommended that old course code of Electrical Machine EEN-219 should be removed from the unified course code book. Course code of Microprocessor/Microcontroller based system Lab course code should be added Engineering Drawing & CAD and Workshop Practice courses should be registered in CMS as lab courses instead of theory courses.

Discussion

The house recommended that duplicate course codes corrections can be made through Letter/MEMO to the concerned directorate, and there is no need to forward the agenda item to the ACM. Moreover, the revised curriculum shall help resolving the issue of missing course codes.
The house suggested the department to write a letter to exam department to resolve the issue at serial number 3 of agenda item. The student advisors of the departments should also take care of the lab and theory components while registering / adding a course in the campus management system (CMS).

Decision 1703

The department is to write letter to Exam & IT Directorates to address the issue and pass on instructions to concerned students advisor. Point dropped.

Item 1704: Course Assessment Report (CAR) for direct and indirect assessment of CLOs and PLOs

Sponsor: HOD(EE)BUKC Referral Authority: DBOS EE BUKC

Summary of the Case

For Outcome based education (OBE) system implementation in BEE Program, there is a requirement to have comprehensive assessment report that helps in the assessment of Course learning outcomes (CLOs) and program learning outcomes (PLOs) on course level and to have a complete record of each course to ensure the completion of continuous quality improvement (CQI) cycle. Following are the guidelines for compilation of CAR (Course Assessment Report).

Discussion:

Considering the commonalities of contents in the Engineering Programs offered at BU and the implementation process at department level, the Chair suggested that the departments should prepare the common format for CAR either at campus or university level. The suggestion was supported by the house. HOD SE at KC was assigned the task to review the CARs at Karachi Campus and come up with a unified or common CAR. The same task was assigned to HOD CE at Islamabad Campus. HOD CE at Islamabad Campus was assigned to compile the CARs and share with HODs by 30 August 2018. The recommendations of the HODs were endorsed by FBoS through email and the house approved the CARs to be used by the departments' w.e.f. Fall'2018 Appendage 1704.

Decision 1704:
The revised course assessment reports are approved to be used by the Engineering departments w.e.f. Fall'2018.

Item 1705: Policy For Registering/Completing Deficiency Course in MS Degree Programs – Faculty of Engineering Sciences

Sponsor: HOD(EE)BUKC Referral Authority: DBOS EE BUKC

Summary of the Case
The domains in FoES are overlapping and there are several commonalities in the BS curriculum. BU follows the HEC / accreditation bodies' guidelines for admission in the MS Programs. Due to commonalities, the applicants are eligible for admission in the relevant programs. An applicant with BS-IT program can apply for MS-CS, MS-SE program, computer engineering graduate can apply for MS-EE, MS-T&N etc. There are certain core courses of each discipline, that must be studied before and / or during the PG programs. These courses are listed as pre-requisite courses for each MS Program and are approved with the curriculum of each MS Program. The applicant must have already studied these courses or should pass at BU with UG class to qualify for MS program. Dean – ES in the previous FBoS asked HoDs to work on the issue at program level in their respective departments, and HoD-EE-KC was assigned to study and compile the requirements for all programs. The compiled list was reviewed in both sessions of the FBoS.

Discussion
The chair asked HoDs to formulate SOP in their respective DBOSs for the implementation of agenda item and submit till 28th August. The finalized proposal for SOP is attached at appendage 1705.

Decision 1705
The agenda item is recommended for consideration of ACM.

Item 1706: Revision of Curriculum – MS (CS) Program

Sponsor: HOD (CS)BUIC Referral Authority: DBOS CS BUIC

Summary of the Case
A committee comprising of the following members was constituted by HoD CS BUIC to align the roadmap/curriculum of the MSCS program in accordance with the latest HEC guidelines issued in Spring 2018.

a. Prof. Dr. Imran Siddiqi
b. Snr. Asst. Prof. Dr. Asfand-e-yar
c. Snr. Asst. Prof. Dr. Sumaira Kausar
d. Snr. Asst. Prof. Dr. Samabia Tehseen
e. Snr. Asst. Prof. Dr. Sabina Akhtar

In this regard, the committee reviewed the existing curriculum and presented revised road map of the program in DBoS. Key changes are listed as follows:

1. The eligibility criteria for the program is updated with inclusion of pre-requisite courses
2. 4 core courses in revised MSCS program instead of 2 in existing roadmap
3. Total degree credit hours are revised to 30 (33 in existing roadmap).
4. Course on Deep Learning is added to the list of electives.

Discussion

HOD CS BUIC presented and iterated the case. The agenda item was deliberated in length in FBoS and house recommended to discuss agenda item in respective DBOSs of CS BULC and CS BUKC and submit

report in a week. The revised roadmap duly endorsed by all three departments of Computer Science at BU was approved by the house and is attached at Appendage 1706.

Decision 1706

The revised curriculum of MS-CS program is recommended for consideration at next ACM.

Item 1707: Revision of Curriculum – MS Information Security Program

Sponsor: HOD(CS) BUIC Referral Authority: DBOS CS BUIC

Summary of the Case

A committee comprising of the following members was constituted by HoD CS BUIC to align the roadmap/curriculum of the MSIS program in accordance with the latest HEC guidelines issued in Spring 2018.

a. Assoc. Prof. Dr. Moneeb Gohar
b. Snr. Asst. Prof. Dr. Shagufta Henna
c. Snr. Asst. Prof. Dr. Kashif Naseer

In this regards, the committee reviewed the existing curriculum and presented revised road map of the program in DBoS. The key changes are listed as follows:

1. 4 core courses in revised MSIS program instead of 5 in existing roadmap
2. Total degree credit hours are revised to 30 (33 in existing roadmap).
3. Course on Block chain Technology is added to the list of electives.

Discussion

The sponsor presented the revised roadmap. The chair suggested adding more elective courses to avoid frequent changes in the roadmaps. The revised road-map of MSIS is attached as Appendage 1707

Decision 1707

The FBoS forwarded the agenda to ACM for approval.

Item 1708: Mapping of Department Vision & Program Mission on University Vision and Mission

Sponsor: HOD(EE)BUIC Referral Authority: DBOS EE BUIC

Summary of the Case

The OBE frame work along with PEOs, PLOs and their mapping is accepted in 31st ACM. Although the Departmental Vision and BEE Program mission is in line with University Vision and Mission, but it is not represented in mapping tablet in ACM.

Currently the mapping table is as under:

Program Educational Objectives	Department Vision	Program Mission
1. Professional Employment	✓	✓
2. Technical Competence	✓	✓
3. Professional Growth	✓	✓
4. Social Engagement	✓	✓

In addition to above mentioned mapping table, following mapping table should also be included in OBE implementation framework of BEE program.

	University Vision	University Mission
Department Vision	✓	
Program Mission		✓

Discussion

HOD CE BUKC supported the agenda item while rest of the house suggested few changes which were later incorporated by the sponsor. The chair suggested addition of rationale for both the tables to give a better understanding. The revised mappings of vision and mission were presented in the second session of the FBoS and are attached at Appendage 1708.

Decision 1708

The mapping of departmental & university's vision and mission are approved. (Appendage 1708)

Item 1709: Design and approval of forms to evaluate PEOSs, PLOs & CLOs

Sponsor: HOD(EE) BUIC Referral Authority: DBOS EE BUIC

Summary of the Case

With reference to 14th meeting of FBOS the

1. The **Alumni Survey form, Summery of Alumni Survey form** and **Employer survey forms** are designed to evaluate PEOs.
2. The **Internship survey and Exit survey form, Exit Survey summery forms** are designed to evaluate PLOs.
3. The **Course evaluation form, Subject Domain Specialist (SDS) report, course update form, Course Evaluation forms** are designed to Evaluate and review The CLOs.

Discussion

The sponsor presented the agenda item. After detailed discussion and arguments, board suggested designing similar and consolidated forms in same departments across the campuses. The Chair constituted following committee to finalize the forms accordingly and send its report till August 30, 2018:

1. Dr. Abdul Baseer Qazi – SE BUIC (Committee Head)
2. Dr. Juniad Imtiaz – EE BUIC
3. Engr. Muhammad Saim – CE BUIC

The committee shared its recommendations with stake holders through email and the hard work of the committee in short time was appreciated by the members.

Decision 1709

The forms to evaluate PEOs, PLOs, and CLOs are approved and placed at Appendage 1709.

Item 1710: Same Course Code for Microprocessors/Microcontroller Based System and MPI

Sponsor: HOD(EE) BUIC Referral Authority: DBOS EE BUIC

Summary of the Case

The (CEN 321) Microprocessors & Interfacing course is being offered in BEE as well as BCE and BSE programs. In 27th ACM, EE road map was revised and the Microprocessor/Microcontroller Based

System (CEN-321) replaced the Microprocessors & Interfacing course. However, no change has been made in the offering of Microprocessors & Interfacing course in BCE & BSE.

The updated road map is applicable to the students of Fall-2016 and onwards entries. Hence, this course of Microprocessor/Microcontroller Based System will be offered from Spring-2019.

Following recommendations were suggested by the sponsor:

1. There will be two courses in the university with same course code.
2. The course code of Microprocessor/Microcontroller Based System is required to be changed along with course code for Lab course related to Microprocessor/Microcontroller Based System.
3. The proposed course codes are CEN-322 and CEL-322 for course and lab respectively.

Decision 1710

The departments of FoES at all three campuses must offer courses as per course code book issued by the examination directorate. The anomalies in the existing courses should be intimated to Exam and IT directorate through a letter and should also be addressed in the revised roadmaps.

Item 1711: To add Elective course in PhD roadmap

Sponsor: HOD(EE)BUIC — Referral Authority: DBOS EE BUIC

Summary of the Case

In EE department at BUIC, Communications is one of the four major areas in which PhD is being offered. DBOS of EE-BUIC was convinced that following courses must be added to the existing PhD roadmap.

1. Internet of Things: Architecture and protocols
2. Principles of 5G and IoT Communication

Course outlines of the recommended courses are attached at Appendage 1711.

Discussion

The chair suggested to address the issue while reviewing the MS-EE roadmap due in next FBoS as PhD students can also enroll in 700 or plus level courses with MS students as per approved roadmaps of PhD programs in FoES.

Decision 1711

Point dropped.

Item 1712: Proposed revised roadmap of BEE 2018.

Sponsor: HOD(EE)BUIC — Referral Authority: DBOS EE BUIC

Summary of the Case

The revised curricula of BEE was approved by the National Curriculum Review Committee (NCRC) in 2017 and issued by HEC on its website in 2018. Dean – ES asked both the EE departments at KC and IC to review and revise in consultation with each other.

Discussion

EE BUIC and BUKC reviewed the revised roadmap and presented their recommendations, which were deliberated by the house in detail. The departments had agreed on the curricula, however roadmap (offering of courses in semesters 4, 5, and 6) was not agreed upon. Dean – ES asked the HoDs to resolve the issue at the earliest taking him in loop as well. The roadmap was reviewed accordingly with all stake holders agreeing to revisions.

Decision 1712

The revised agenda item is recommended and forwarded to ACM for consideration Appendage 1712.

Item 1713: PhD program in Geo-Physics – Launch Proposal

Sponsor: HOD(E&ES)BUIC | Referral Authority: DBOS E&ES BUIC

Summary of the Case

Geophysics is a leading discipline of modeling the Earth and is a major tool or technology of exploring the natural resources. PhD programs in Geology and Environmental Sciences are already being conducted at the E&ES, BUIC whereas PhD Geophysics program is currently offered at E&ES, BUKC. The department desires to start PhD Geophysics program from Fall 2019 semester in line with the approved PhD program in Geophysics for E&ES, BUKC. Therefore, the agenda item containing the Feasibility, Curricula/Roadmap and list of available Faculty for starting the PhD program was presented to FBoS for discussion.

Discussion

The sponsor iterated and presented the agenda item, which was deliberated by the house in detail. The sponsor supported the agenda item by stating that same program is being offered in BUKC. The Chair asked HOD E&ES BUKC to review the Curricula/roadmap and give her feedback in week. Dean – ES also suggested to review the seminar course of '3' Credit Hours course and either to reduce the credit hours or change the contents of the said course. Moreover the industrial affiliation of the visiting faculty members should also be added.

Minor changes were recommended by other members, which were incorporated by the sponsor as well.

Decision 1713

The case of PhD Geo-Physics is recommended for consideration of ACM (Appendage 1713).

Item 1714: Approval of BS Thesis rules for Earth and Environmental Sciences Department

Sponsor: HOD(E&ES)BUIC | Referral Authority: DBOS E&ES BUIC

Summary of the Case

During the Self Academic Audit for the BS programs of E&ES Department, conducted on 27th April 2018, it was found that there were not any thesis rules and standards for BS students formally approved from the FBOS and ACM. The practices and the procedures for the BS Thesis being followed at the department have been documented and presented before the board for approval and further processing.

Draft for BS Thesis Rules is attached at Appendage 1714.

Discussion

The house deliberated the agenda item in length; various aspects of the draft came under discussion. After detailed discussion and arguments house suggested consulting HEC guidelines for thesis/project for BS programs of Environmental Sciences, Geology and Geo-Physics. Dean-ES , HoD EES,IC and Prof. Dr. Muhammad Zafar were asked to revise the proposed draft, which was later shared with EES-Karachi Campus. The revised rules for BS Project & Thesis for E&ES department were agreed upon by all stake holders.

Decision 1714

The BS Project & BS Thesis rules for E&ES department are approved. The EES departments at IC and KC are to implement w-e-f Spring 2019.

Item 1715: Approval of Departmental Vision and Mission of Earth and Environmental Sciences Department.

Sponsor: HOD(E&ES)BUIC Referral Authority: DBOS E&ES BUIC

Summary of the Case

Self-academic audit for the BS programs of Earth & Environmental Sciences Department was carried out on 27th April 2018. The assessment team included

1. Prof. Dr. M. Najam ul Islam - Dean Engineering and Sciences
2. Mr. Fazal Wahab - Director Quality Assurance
3. Dr. Nergis Yasmeen- HOD E&ES BUKC
4. Ms. Sobia Shujaat - Deputy Director Quality Assurance.

The assessment team suggested revisiting the Vision and Mission of the department. Revised Vision and Mission by DBOS are attached at Appendage 1715.

Discussion

The sponsor iterated the agenda item and deliberated by the house in detail. The house suggested few changes in Departmental Vision which were incorporated.

Decision 1715

The approved vision and mission of the E&ES department are placed at Appendage 1715.

Item 1716: Approval of course catalog of BS program of Earth & Environmental Sciences Department

Sponsor: HOD(E&ES)BUIC Referral Authority: DBOS E&ES BUIC

Summary of the Case

During the Self Academic Audit for the BS programs of E&ES Department, conducted on 27th April 2018, it was suggested that the Course Catalogues for all 3 BS programs should be prepared. The suggested Course Catalog by DBOS for BS Geology, Geophysics and Environmental Sciences were presented before FBOS for approval.

Discussion

The Chair commented that Course Catalogues should be approved at Departmental Board of Studies on the recommendations of the Cluster Heads. ACM approves the curricula and roadmap, while FBoS may consider minor changes in the course outlines and roadmaps. The detailed course outlines should be considered at department level. The house agreed with the comments of the chair.

Decision 1716

The catalogues are to be approved by DBoS with the recommendations of Cluster Heads. Point dropped.

Item 1717: Increase in Remuneration for Invigilation Duties

Sponsor: HOD(CS)BULC Referral Authority: DBOS CS BULC

Summary of the Case:

Final term exam time has been extended to 150 minutes from 120 minutes; however remuneration for the retrospective is unchanged. The agenda proposed for increasing the Invigilation Remuneration which is presently Rs.600/ for morning 1st & 2nd session, Rs.800/ for 3rd session and Rs.1500/ for Weekend duty.

Discussion
HoD CS BUIC and HOD E&ES BUIC supported the agenda item while rest of the house suggested that status quo to be maintained.

Decision 1717
Point dropped by majority vote.

Item 1718: Remuneration for Proposal Evaluation of FYP

Sponsor: HOD (CS)BULC Referral Authority: DBOS CS BULC

Summary of the Case:
Proposal Evaluation carries a significance importance for Final Year Projects. Faculty is seen to be meticulously engaged in the evaluation of FYP Proposals and thus work beyond their normal teaching workload. It has been further observed that it takes at least 01 hour in evaluating a proposal during proposal presentation. However, at present there exists no remuneration model for the faculty engaged in FYP Proposal Evaluation. Whereas, there do exist remuneration policies for invigilation duties. The agenda thus proposes that a remuneration of PKR 1500/- may be given to faculty for FYP Proposal evaluation

Discussion:
The sponsor reiterated the agenda item: HOD CS, E&ES and CS BUKC supported the agenda item while HOD SE BUIC commented that it's a once in a year activity and it is not necessary to pay FMs for every activity addition to pay.

Decision 1718:
The Chair constituted the following committee to analyze and work on cash inflow/outflow and payment model of FYP and MS thesis considering other HEIs as well and devise the mechanism for BU – FoES:

1. Dr. Humera Farooq – HOD (CS), KC – Chair
2. Mr. Farhan Sherazi – HOD(CS), LC
3. Dr. Khalid Javed HOD(CE), IC
4. Mr. Faraz Humayun, CH(EE), KC
5. Mr. Raees Amjad- FM(E&ES, IC

The committee is to prepare its report and send to Dean – ES by October 15, 2018.

Item 1719: Revised Objectives and Outcomes of combined BS Programs

Sponsor: HOD (E&ES) BUKC Referral Authority: DBOS E&ES BUKC

Summary of the Case:
DBOS E&ES proposed combined objectives and outcomes for all BS programs offered in the department of E&ES – KC.

Objectives:

1. To gain required basic knowledge of the Earth sciences and Environmental sciences.
2. To apply applied sciences in exploration, quantification and environmental assessment of natural resources of the planet earth.
3. To develop effective technical / professional communication and presentation skills.

4. To establish a strong linkage between relevant industries, academic institutions and research organizations.
5. To prepare ecofriendly operators / professionals as per Quality, Health, Safety, Environment (QHSE) standards.
6. To meet emerging industrial demand in term of skills, software's & work ethics.

Outcomes:

1. Understand core concepts and applications of Earth & Environmental Sciences.
2. Ability to identify, formulate and quantitatively resolve the environmental issues.
3. Make individuals to observe, record, and interpret the model by processing the uncertainties.
4. Effectively communicate and present their scientific knowledge and applied research at national and international forums.
5. Cope up with the relevant industrial demands and strengthen the out-source linkages.
6. Perform professional and ethical responsibilities with true spirit.

Discussion:
The sponsor presented the agenda item. The Chair commented that every program has its unique Outcomes and Objectives and this is the only way programs can be differentiated. The Chair asked HOD E&ES BUIC to share departmental data with his counterpart at BUKC. Both the departments sent the consolidated program-wise objectives and outcomes, which were approved by the FBoS.

Decision 1719
The Objectives and Outcomes of BS-Geo-Physics, and BS-Environmental Sciences are approved and placed at Appendage 1719.

Item 1720: Mapping of Department Vision & Program Mission on University Vision and Mission

Sponsor: HODs (CE) BUIC & BUKC — Referral Authority: DBOSs CE BUIC & BUKC

Summary of the Case:
Mapping of BCE program mission, program educational objectives to university is missing in the OBE implementation frame work accepted in 31st ACM.

Currently the mapping table is as under:

Program Educational Objectives	Program Mission	University Vision
PEO – 1	✓	✓
PEO – 2	✓	✓
PEO – 3	✓	✓
PEO – 4	✓	✓

Discussion:
The sponsor iterated and presented the agenda item .The house suggested few changes which were later incorporated by the sponsor. The chair suggested addition of rationale for both the tables to give a better understanding. The revised mappings of vision and mission were presented in the second session of the FBoS and are attached at Appendage 1720.

Decision 1720
The mapping of departmental & university's vision and mission are approved. (Appendage 1720)

Item 1721: Mapping of PEOs on Department Vision & Program Mission & Approval of KPIs.

Sponsor: HODs (SE) BUIC & BUKC Referral Authority: DBOSs SE BUIC & BUKC

Summary of the Case:

- The BSE program's educational objectives (PEOs) are derived based on the philosophy and mission of BSE program which synergies itself with the department's vision. Mapping of PEOs with Department's vision and program mission in the following table demonstrates this concept:

Program Educational Objectives	Department Vision	Program Mission
Graduates should demonstrate competence to apply Software Engineering knowledge & practices in various phases of software/system development life cycle in their respective professional career.		✓ The mission of Bachelor of Software Engineering program is to prepare technically strong Software Engineers who can contribute effectively towards the nation, society and the world at large through effective problem solving skills, application of engineering knowledge, leadership and healthy lifelong learning attitude.
5. Graduates should demonstrate an ability to *work as a member and/or leader in a team* with a *strong sense of societal context*, *professional ethics and effective communication skills* in professional practice.	✓ Department of Software Engineering aims to be recognized *as a leader in Software Engineering education* and research	✓ The mission of Bachelor of Software Engineering program is to prepare technically strong Software Engineers who can

	through *excellence in modern education* and targeted research in emerging areas of Software Engineering.	contribute effectively towards the nation, society and the world at large through effective problem solving skills, application of engineering knowledge, leadership and healthy lifelong learning attitude.
Graduates should demonstrate sustained learning by pursuing life-long learning through graduate studies, professional development or managerial/leadership skills.	✓ Department of Software Engineering aims to be recognized as a leader in Software Engineering education and research through excellence in modern education and targeted research in emerging areas of Software Engineering.	✓ The mission of Bachelor of Software Engineering program is to prepare technically strong Software Engineers who can contribute effectively towards the nation, society and the world at large through effective problem solving skills, application of engineering knowledge, leadership and healthy lifelong learning attitude.

- Similarly, the Department's vision and program mission is in line with University's vision and mission. This mapping is shown in the following table:

	University Vision	**University Mission**
Department Vision Department of Software Engineering aims to be recognized as a leader in Software Engineering education and research through *excellence in modern education and*	✓ To become an internationally recognized university that *contributes towards*	To remain committed to the attainment of *highest standards in teaching, learning and research,* at par with the international

targeted research in emerging areas of Software Engineering.	*the development of nation through excellence in education and research.*	standards.
Program Mission The mission of Bachelor of Software Engineering program is to *prepare technically strong Software Engineers who can contribute effectively towards the nation, society and the world* at large through effective problem solving skills, application of engineering knowledge, leadership and healthy lifelong learning attitude.	✓ To become an internationally recognized university that *contributes towards the development of nation through excellence in education* and research.	✓ To remain committed to the attainment of highest standards in teaching, learning and research, at par with the international standards.

KPIs for PEO assessment:

PEOs	KPI	PLO Mapping
Graduates should demonstrate competence to apply Software Engineering knowledge & practices in various phases of software/system development life cycle in their respective professional career.	50% of the employers are satisfied in terms of technical competence of the graduates. 50% of the graduates are satisfied in terms of appropriateness of the curriculum with respect to their professional needs.	PLO 1: Engineering Knowledge PLO 2: Problem Analysis PLO 3: Design/Development of Solutions PLO 4: Investigation PLO 5: Modern Tool Usage
Graduates should demonstrate an ability to work as a member and/or leader in a team with a strong sense of societal context, professional ethics and effective communication skills in professional practice.	50% of the employers are satisfied with the ethical conduct, management and communication skills of the graduates.	PLO 6: The Engineer and Society PLO 7: Environment and Sustainability: PLO 8: Ethics: PLO 9: Individual and Team Work PLO 10: Communication PLO 11: Project Management
Graduates should demonstrate sustained learning by pursuing life-long learning through graduate studies, professional development or managerial/leadership skills.	15% of graduates have enhanced their skills through postgraduate studies or technical & professional education.	PLO 12: Lifelong Learning

Discussion:
The sponsor presented the agenda item .Board suggested minor changes which were incorporated.
Decision 1721
The mapping of departmental & university's vision and mission are approved.

Closing of the Meeting

There being no further points, the Chair brought the meeting to close, thanking the participants for their wholehearted participation in both sessions.

Prof. Dr. M. Najam-ul-Islam
Dean (ES), Head FBoS
01 October, 2018

Distribution:

BUHQ:	Rector, Pro-Rector, Registrar DAA
BUIC:	DG BUIC, DIC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BUKC:	DG BUKC, DKC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BULC:	DLC, HOD(CS)

Appendages:

Appendage 1701

Roadmap MS in Software Engineering
Proposed for Spring 2019 and onward

Vision Statement of the Department:

Department aims to be recognized as a leader in software Engineering education and research through excellence in education and targeted research themes in emerging areas of software Engineering disciplines.

Mission Statement of the Program

The mission of the Masters of Science (Software Engineering) program is to equip students with theoretical and applied knowledge of software engineering for that is helpful in the design & development of complex software systems. Moreover, it is aimed to prepare students to enhance further in their careers in industry or academia through advanced software engineering knowledge in both applied and research domain.

Admission Criteria

Sixteen years of education in a relevant computing discipline (Software Engineering, Computer Science, IT, Computer Engineering, Information Systems & Informatics) with a minimum 130 Cr Hrs and CGPA of 2.5/4.0 or 50% marks (annual system). Students will be required to complete deficiency courses if required.

Additionally, applicants must provide HEC verification of all academic degrees and transcripts.

Program Educational Objectives

1. Prepare graduates who can critically apply concepts, theories and practices to provide creative solutions of complex computing problems.
2. Prepare graduates with a theoretical software engineering background and applied research needed to enter a doctorate program in Computing or pursue a research career in Industry.
3. Prepare graduates who are able to join an appropriate and respectable level position in a computing related field and to maintain their professional skills in rapidly evolving field.

Learning Outcomes of the Degree Program

The MS SE program offers the following learning outcomes by which students are:

- Able to demonstrate an understanding of advanced knowledge of the practice of software, from vision to analysis, design, validation, and deployment
- Able to tackle complex engineering problems and tasks, using contemporary engineering principles, methodologies, and tools
- Able to understand research aspects of software engineering and its relevant domain
- Able to communicate effectively, in both oral and written forms

Semester Wise Breakdown of Courses

Semester 1

Course Code	Course Title	Credits
SEN 522	Advanced Software System Architecture	3
SEN 558	Advanced Requirement Engineering	3
ESC 701	Research Methodology	3
	Total	**9**

Semester 2

Course Code	Course Title	Credits
SEN 547	Software Testing and Quality Assurance	3
	Elective I	3
	Elective II	3
	Total	**9**

Semester 3

Course Code	Course Title	Credits
	Elective III	3
	Elective IV	3
ESC 600	Thesis I / (Elective V)	3
	Total	**9**

Semester 4

Course Code	Course Title	Credits
ESC 600	Thesis II / (Elective VI)	3
	Total	**3**

Total Credit Hours: 30

CORE COURSES

S. No.	Course Code	Course Title	Credits
1	SEN 522	Advanced Software System Architecture	3
2	SEN 547	Software Testing and Quality Assurance	3
3	SEN 558	Advanced Requirement Engineering	3
4	ESC 701	Research Methodology	3

DOMAIN ELECTIVE COURSES

S. No.	Course Code	Course Title	Credits
5	SEN 523	Automated Software Engineering	3
6	SEN 546	Software Metrics	3
7	SEN 601	Advanced Software Project Management	3
8	SEN 602	Agile Software Development Methods	3
9	SEN 603	Complex Networks	3
10	SEN 720	Advanced Human-Computer Interaction	3
11	SEN 723	Formal Methods and Specifications	3
12	SEN 754	Advanced Web Computing System and Application	3
13	SEN 755	Service-Oriented Computing	3
14	SEN 756	Advanced Usability Engineering	3
15	SEN 758	Component-based Software Engineering	3

16	SEN 759	Software Re-Engineering	3
17	SEN 760	Complex Adaptive Systems	3
18	SEN 762	Advanced Big Data Analytics	3
19	SEN 763	Advanced Software Engineering	3
20	SEN 764	Ontology Engineering	3
21	SEN 774	IoTs: Architecture, Protocols & Applications	3

Note: (Minimum 2 of the above courses)

GENERAL ELECTIVE COURSES

S. No.	Course Code	Course Title	Credits
21	CSC 504	Ubiquitous Computing	3
22	CSC 521	Advanced Design and Analysis of Algorithm	3
23	CSC 704	Advanced Cryptography	3
24	CSC 708	Advanced Simulation and Modeling	3
25	CSC 711	Advanced Artificial Intelligence	3
26	CSC 719	Machine Learning	3
27	CSC 720	Advanced Operating Systems	3
28	CSC 741	Advanced Natural Language Processing	3
29	CSC 744	Advanced Computer Graphics	3
30	CSC 746	Advanced Data Mining	3
31	CSC 750	Advanced Neural Networks	3
32	CSC 751	Pattern Recognition	3
33	CSC 753	Distributed Databases	3
34	CSC 759	Agent-based Modeling	3
35	CSC 760	Advanced Data Warehousing	3
36	CSC 764	Computer Vision	3
37	CSC 765	BioMedical Image Analysis	3
38	CSC 781	Cloud Computing	3
39	SEN 604	Blockchain Technologies	3
40	DSC 704	Deep Learning	3
41	CEN 707	Advanced Distributed Systems	3
42	CEN 720	Advanced Computer Architecture	3
43	CEN 745	Advanced Digital Image Processing	3
44	GSC 700	Advanced Engineering Mathematics	3
45	EET 702	Advanced Network Security	3

Note: (Minimum 2 of the above courses)

Course outlines

Course Title: Advanced Software System Architecture
Course Code: SEN 522
Credit Hours: 3

Course Description:
The course teaches how large, complex software systems are designed and their system level architecture and class level object oriented designs are developed. There is a special emphasis on the study of architectural and design patterns: the core of solutions to commonly occurring design problems; representations of design/architecture; architectural assessment; product lines; architecture extraction; and refactoring. A very special focus will be given to the architectural patterns and state of the art software architectures related to the evolving technology spectrum. In this regard, novel concepts such as workflows, Service Oriented Architecture (SOA), Web 2.0 and Cloud Computing and large scale distributed systems will also be discussed. Students will be given assignments based on different case studies. Students will also be required to read suggested research papers and compile their original ideas in (at least one) research paper(s)/report(s).

Reference Books:

- Bass, L, Clements, P., & Kazman, R. (2012). *Software Architecture in Practice*. 3rd Edition. Pearson Education Inc.
- Duggan, D. (2012). *Enterprise Software Architecture & Design: Entities, Services & Resources*. John Wiley & Sons Publishers.
- Fairbanks, G.H. (2010). *Just Enough Software Architecture: A Risk Driven Approach*. Marshall & Brainerd Publishers.

Course name: Software Testing and Quality Assurance
Course Code: SEN 547
Credit Hours: 3

Course Description:
This course takes off by providing an overview of fundamental notions of software testing and quality assurance techniques used to build and check quality in software systems. A particular emphasis is placed on quantitative assessment of software quality and quality control using software testing techniques. The students would not only be introduced with the theoretical background of these concepts but they would also be given hands on experience of applying these concepts.

Once, a sound background is updated, students are focused on advanced concepts such as slicing, test suite reduction techniques, test case prioritization, TMMI, etc. The students are given a sound understanding of ISO 9001:2008 and CMMI where they are able to practically implant these in their respective organizations. This course introduces the student fundamental notions of software quality and the techniques used to build and check quality in software systems.

A particular emphasis is placed on quantitative assessment of software quality and quality control using software testing techniques. The students would not only be introduced with the theoretical background of these concepts but they would also be given hands on experience of applying these concepts. The assignments would be planned carefully to enhance students' learning of applying the learned concepts from a practical standpoint. The assignments are planned carefully to enhance students' learning of applying the learned concepts from a practical standpoint.

Reference Books:

- Myers, G. J., Sanders, C., & Badgett, T. (2015). *The Art of Software Testing*, 3rd Edition, John & Willey Inc.

- Laporte, C. Y., & April, A. (2018). *Software Quality Assurance*, Wiley.

Course Title: Advanced Requirements Engineering
Course Code: SEN 558
Credit Hours: 3

Course Description:
This course exposes students to the problem of determining and specifying what a proposed software system should do, why and for whom the system is needed; not how the system should do it, which is the topic of downstream software engineering activities such as design and coding. There are some nontechnical aspects of the course, with respect to communication and negotiation with multiple stakeholders. Most of the course covers technical approaches to the requirements problem, such as techniques for eliciting stakeholder goals and requirements, notations and models for documenting and specifying requirements, and techniques for analyzing requirements. The course is a practical guide to Requirements engineering and upon completion of this course, the students will be able to:

- Understand how to analyze a system and its scope, stakeholders etc. Knowledge of techniques available to ensure competence in complete and efficient elicitation requirements
- Understand the different types of documentation options available at different levels of the requirements process and the content required
- How to write good quality natural language requirements, some common issues associated with writing them and possible tools to assist in consistency
- How to ensure a good requirements management process, considering grouping, visualization and movement and traceability of requirements through the process
- To know how to apply the learned concepts, knowledge, and techniques to solve real world problems
- Understanding the need for research on selected topics in requirements engineering.

Reference Books:

- Dick, J., Hull, E., & Jackson, K. (2017). *Requirements engineering*. Springer.
- Hatley, D., Hruschka, P., & Pirbhai, I. (2013). *Process for system architecture and requirements engineering*. Addison Wesley.
- Hofmann, H. F. (2013). *Requirements engineering: a situated discovery process*. Springer Verlag.

Course name: Research Methodology
Course Code: ESC 701
Credit Hours: 3

Course Description:
This course presents a basic understanding of the principles involved in the research. RM, as compared to any other engineering courses, is not a subject that one may master it by securing a good grade but it comes with experience. this course, however, introduces the basic logic and principal involved. it will give you an understanding of the research and your role to effectively and synergistically participate in it. Students shall be able to take on independent research tasks and will be able to produce one IEEE style conference paper.

Broadly, the course covers the following aspects:

- Research types and 'The scientific method of research'
- Literature Review – Searching & Review
  - Forward and backward literature search
  - Organization of literature
  - Different between an annotated bibliography and comprehensive literature review
- Research Design and Methods
- Choosing a research problem & Supervisor (MS, Ph.D.)
- Formulating the research question, identifying variables and generating a hypothesis
- Introduction to bibliographic management tools and brief introduction on Latex
- Writing the literature review, Plagiarism and ways to avoid it
  - Introduction to 'Turnitin' or any other plagiarism detection tool
- Formulating the research question, identifying variables and generating a hypothesis
- Sampling: Selection of samples
- Data Analysis, Interpretation and presentation
- Thesis Manuscript writing and tool utilization (e.g. latex)
- Writing a research proposal for funding/grants
- Publishing Research in Conferences, Journals, and Paper Reviewing
- Planning & Delivering Scientific Presentation

Reference Books:

- Bryman, A. & Bell, E. (2011). *Business Research Methods*. 3rd Edition, Oxford University Press.
- Wieringa, R.J. (2014). *Design Science Methodology for Information System & Software Engineering.* Springer
- Stappleton, N. (2013). *Advancing Research Methods with New Technologies.* Information Science Reference.
- Wayne, C. B., Colomb, G.G., & Willams, J. M. (2009). The craft of Research, Third Ed (Chicago Guides to Writing, Editing, and Publishing).

Course name: **Automated Software Engineering**
Course Code: SEN 523
Credit Hours: **3**

Course Description:

Introduction to Automated Software Engineering, What is Automation, Automation in SE, Why, When and Limitations, When to and when not to automate, Automated Software Project Management, Automated Communication Management, Automated Software Quality Management and Quality Audit, Automated Requirement Management, Automated Requirement Management, Requirement Traceability, Automated Quality Assurance and Testing, Software Quality Assurance and Testing, Automated Test Case Generation, Automated Configuration and Change Management, Examples of CASE TOOL, SPM, SQM, SQA, REM and CCM CASE TOOL.

Reference Books:

- Stanev, I., Grigorova, K. (2012). *Knowledge Based Automated Software Engineering*. Cambridge Scholars Publishing.
- Storr, A., & Jarvis, D. H. (2013). *Software Engineering for Manufacturing Systems: Methods and CASE tools*. Chapman & Hall.

Course name: **Software Metrics**
Course Code: SEN 546
Credit Hours: **3**

Course Description:
This course offers state of the art knowledge of software measurements and best practices with emphasis on the value of software measurement as a set of pragmatic methodologies and tools for both software engineers and software project management. After completing this course student will have a good understanding of nature and problems associated with software measurement and experimentation, software measurement planning and implementation (incl. data collection and analysis), software size measurement (Function Point counting, etc.), software cost estimation (COCOMO II model and tool, etc.), software resource, process, and product (i.e., product structure, complexity, quality, and reliability) measurement.

Reference Books:

- Fenton, N., & Bieman, J. (2014). *Software Metrics: A rigorous and practical approach*, 3rd Edition, CRC Press.
- Nicolette, D. (2015). *Software Development Metrics*. Manning Publications.

Course name: **Advanced Software Project Management**
Course Code: SEN 601
Credit Hours: **3**

Course Description:
This course deals with managing information technology and software development projects. It is not restricted to project managers but encompasses the art and science of using teamwork to meet project goals. The team includes the project manager, lead developers, software engineers, supporting functions, business experts and other stakeholders. Therefore, this course is directed to students across a wide range of backgrounds and interests. The student will learn how to conceptualize, initiate, plan and execute a successful project. Students will participate in a competitive team effort to propose a major design project.

Students will be able to:

- recognize the principles of general management theory which transfer to project management
- apply techniques for successfully managing a project throughout its life cycle
- interpret the processes and knowledge areas in the Project Management Institute's Project Management Body of Knowledge
- formulate the determination of success as a measurable organizational value
- consider the human side of projects including participation in a team project
- understand the propositions of software design by the legendary Fred Brooks

Reference Books:

- Marchewka, J. (2012). *Information Technology Project Management*, 4th Edition. John Wiley & Sons.
- Brooks, F. (2010). *The Design of Design: Essays from a Computer Scientist*, Pearson Education.
- Fairley, R. E. (2011). *Managing and Leading Software Projects*. John Wiley & Sons.

Course name: **Agile Software Development Methods**
Course Code: SEN 602

Credit Hours: 3

Course Description:

In software problem areas that require exploratory development efforts, those with complex requirements and high levels of change, agile software development practices are highly effective when deployed in a collaborative, people centered organizational culture. This course examines agile methods, including Extreme Programming (XP), Scrum, Lean, Crystal, Dynamic Systems Development Method and Feature Driven Development to understand how rapid realization of software occurs most effectively. The ability of agile development teams to rapidly develop high quality, customer valued software is examined and contrasted with teams following more traditional methodologies that emphasize planning and documentation. Students will learn agile development principles and techniques covering the entire software development process from problem conception through development, testing, and deployment, and will be able to effectively participate in and manage agile software developments as a result of their successfully completing this course. Case studies and software development projects are used throughout.

Reference Books:

- Maximini (2015). *The Scrum Culture: Introducing Agile Methods in Organization.* Springer.
- Ashmore & Runyan (2014). *Introduction to Agile Methods*. Pearson Education Inc.

Course name: Complex Networks
Course Code: SEN 603
Credit Hours: 3

Course Description:

This course covers theory and modeling of real world networks such as a computer, social, and biological networks where the underlying topology is a dynamically growing complex graph. Many phenomena in nature can be modeled as a network. Researchers from many areas including biology, computer science, engineering, epidemiology, mathematics, physics, and sociology have been studying complex networks of their field. Scale free networks and small world networks are well known examples of complex networks where power law degree distribution and high clustering are their respective characteristic feature. These networks have been identified in many fundamentally different systems. Complex networks display non trivial topological features that require an in depth study.

Reference Books:

- Barabasi, A. (2016). Network Science, Cambridge University Press.
- Gros, C. (2015). Complex and Adaptive Dynamical Systems, Springer.

Course name: Advance Human Computer Interaction
Course Code: SEN 720
Credit Hours: 3

Course Description:

The aim of this course is to provide extensive guideline to the students for the design of computer technology, and how computer technology can be made more usable by people. It takes research oriented approach to providing students with specialized human computer interaction (HCI) knowledge as they grapple with designing, prototyping and testing a device or software application to solve a problem. The main topics covers

including human factors, interaction design, cognitive aspects, social and emotion interaction, interfaces, prototyping and construction, data gathering, designing HCI experiments, evaluation studies. Upon completion of this course, students will be able to:

- Comprehend different approaches used in human computer interaction domain
- Understand and analyze different kinds of interfaces
- Understand cognitive aspects for designing and testing a device or software application
- Apply HCI techniques and methods to the design of software

Reference Books:

- Mackenzie, S. (2013). *Human Computer Interaction: An Empirical Research Perspective*. Elsevier Ltd.
- Rogers, Y., Sharp, H., & Preece, J. (2011). *Interaction Design: Beyond Human Computer Interaction*. 3rd Edition, John Wiley & Sons.
- Cipolla Ficarra, F. V. (2014). *Advanced Research and Trends in New Technologies, Software, Human Computer Interaction, and Communicability*. IGI Global.
- Kurosu, M. (2013). *Human Computer Interaction: Human Centered Design Approaches*. Springer.
- Purchase, H. C. (2013). *Experimental Human Computer Interaction. A Practical Guide with Visual Examples*.

Course name: Formal Methods and Specifications
Course Code: SEN 723
Credit Hours: 3

Course Description:

As more complex computational systems are used within critical applications, it is becoming essential that these systems are formally specified. Such specifications are used to give a precise and unambiguous description of the required system. While this is clearly important in critical systems such as industrial process management and air/spacecraft control, it is also becoming essential when applications involving E commerce and mobile code are developed. In addition, as computational systems become more complex in general, the formal specification can allow us to define the key characteristics of systems in a clear way and so help the development process. Formal specifications provide the basis for verification of properties of systems. While there are a number of ways in which this can be achieved, the model checking approach is a practical and popular way to verify the temporal properties of finite state systems. Indeed, such temporal verification is widely used within the design of critical parts of integrated circuits, has recently been used to verify parts of the control mechanism for one of NASA's space probes, and is now beginning to be used to verify general Java programs.

Upon completing this module, a student will understand: the principles of standard formal methods, such as Z; the basic notions of temporal logic and its use in relation to reactive systems; the use of model checking techniques in the verification of reactive systems; be aware of some of the current research issues related to formal methods.

Reference Books:

- Alagar, V. S. , & Periyasamy, K. (2011). *Specification of Software Systems*, 2nd Edition, Springer.
- Monin, J. (2012). *Understanding Formal Methods*, Springer.

Course name: Advanced Web Computing System and Application
Course Code: SEN 754

Credit Hours: 3

Course Description:

The course aims to enable students to understand the emerging trends in the Web application development. It will enable students to understand the core issues related to the development of systematic, cost effective and quality Web application.

Reference Books:

- Keig, A. (2013). *Advanced Express Web Application Development*. Packt Publishing Ltd.
- Velasquez, J. D., Jain, L. C. (Eds.) (2010). *Advanced Techniques in Web Intelligence 1*. Springer.

Course name: Service Oriented Computing
Course Code: SEN 755
Credit Hours: 3

Course Description:

This course covers architectures for Web applications based on the classical publish, find, and bind triangle, but formulates it at a higher level. It considers sophisticated approaches for the description, discovery, and engagement of Web services. This course emphasizes Web service composition. Key topics include semantics, transactions, processes, agents, quality of service, compliance, and trust.

Reference Books:

- Griffiths, N., & Chao, K. (Eds.) (2010). *Agent based Service oriented Computing*, Springer.
- McDonald, N. (2016). *High Performance Service oriented Computing*.

Course name: Advanced Usability Engineering
Course Code: SEN 756
Credit Hours: 3

Course Description:

The course objective is to introduce a product's design considerations that should be taken into account right from the beginning of the product inception. Subsequently, evaluation based upon usability principles will be discussed.

Reference Books:

- Rebelo, F., & Soares, M.M. (Eds.) (2013). *Advances in Usability Evaluation*. Taylor & Francis Group.
- Richter, M., & Fluckiger, M. (2014). *User Centered Engineering: Creating Products For Humans*. Springer.
- Spiliotopoulos, T., Papadopoulou, P., Martakos, D., Kouroupetroglou, G. (2010). *Integrating Usability Engineering For Designing The Web Experience: Methodologies and Principles*. IGI Global.
- Garcia Ruiz, M. A. (2013). *Cases on Usability Engineering: Design And Development Of Digital Products*.

Course name: Component based Software Engineering
Course Code: SEN 758
Credit Hours: 3

Course Description:

The course focuses on an approach to software development based on extensive use of pre existing standard (or customizable) components. It also illustrates how a repository of reusable candidate components can be integrated into a typical evolutionary process model. The Component based Software Engineering process involves identifying candidate components; qualify each component interface and adapting components.

Reference Books:

- Lau, K., & Di Cola, S. (2017). An Introduction to Component based Software Development, Vol 3, World Scientific.
- Bruegge, B. & Dutoit, A. H. (2009). *Object Oriented Software Engineering: Using UML, Patterns, and Java*, 3rd Edition, Prentice Hall.

Course name: Software Re engineering
Course Code: SEN 759
Credit Hours: 3

Course Description:

This course covers software re-engineering techniques and tools that facilitate the evolution of legacy systems. This course is broken into three major parts. In the first part, the course discusses the terminology and the processes pertaining to software evolution. In the second part, the course provides the fundamental re-engineering techniques to modernize legacy systems. These techniques include source code analysis, architecture recovery, and code restructuring. The last part of the course focuses on specific topics in software re-engineering research. The topics include software refactoring strategies, migration to Object Oriented platforms, quality issues in re-engineering processes, migration to network centric environments, and software integration. Students would learn:

- Introduction to software re-engineering
- Program comprehension
- Software re-engineering techniques in source code transformation and refactoring strategies
- Software metrics & quality
- Re engineering economics
- Techniques for the migration of legacy systems into network centric environments
- Software integration issues and enabling technologies in web enabled and distributed environments.

Reference Books:

- Birchall, C. (2016). *Re engineering Legacy Software*. Manning Publications.
- Ryan,C. (2012). *Automatic Re-engineering of Software Using Genetic Programming*. Springer.

Course name: Complex Adaptive System
Course Code: SEN 760
Credit Hours: 3

Course Description:
The main goal of the course is to understand Complex Adaptive Systems theory and its relation to the socio technical systems around us. The course primarily integrates theories and methodologies from human factors and human computer interaction to provide design guidelines and recommendations. Moreover, the course provides a road map for all steps in system design process including conception, analysis, design, and implementation consideration for complex adaptive system. Secondary goal is for the student to learn about the basics of Agent Based Modeling and its significant realization in real world examples.

Reference Books:

- Wilensky, U., & Rand, W. (2015). *An Introduction to Agent Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo.* MIT Press.
- Hou, M., Banbury, S., & Burns, C. (2014). *Intelligent Adaptive Systems: An Interaction Centered Design Perspective*, CRC Press.

Course name: Advanced Big Data Analytics
Course Code: SEN 762
Credit Hours: 3

Course Description:
This course shall provide the fundamental knowledge to equip students being able to handle those challenges. This discipline inherently involves many fields. Because of its importance and broad impact, new software and hardware tools and algorithms are quickly emerging. A data scientist needs to keep up with these ever changing trends to be able to create a state of the art solution for real world challenges.

This Big Data Analytics course shall first introduce the overview applications, market trend, and the things to learn. Then, students shall be introduced fundamental platforms, such as Hadoop, Spark, and other tools, such as IBM System G for Linked Big Data. Afterward, the course will introduce several data storage methods and how to upload, distribute, and process them. This shall include HDFS, HBase, KV stores, document database, and graph database. The course will go on to introduce different ways of handling analytics algorithms on different platforms. Then, students shall introduce visualization issues and mobile issues on Big Data Analytics. Students will then have a fundamental knowledge of Big Data Analytics to handle various real world challenges. Course will also focus on large scale machine learning methods that are foundations for artificial intelligence and cognitive networks. The course will discuss several methods to optimize the analytics based on different hardware platforms, such as Intel & Power chips, GPU, FPGA, etc. The lectures will conclude with the introduction of the future challenges of Big Data, especially on the ongoing Linked Big Data issues which involve graphs, graphical models, spatiotemporal analysis, cognitive analytics, etc.

Reference Books:

- EMC Education Services (2015), *Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data*, Wiley.
- Provost, F., & Fawcett, T. (2013). *Data Science for Business: What You Need to Know about Data Mining and Data Analytic Thinking*, O'Reilly Media.

- Foreman, J.W. (2013). *Data Smart: Using Data Science to Transform Information into Insight*, Wiley.

Course name: Advanced Software Engineering
Course Code: SEN 763
Credit Hours: 3

Course Description:

This course defines a systematic approach to software development using the object oriented paradigm. The student should be able to fully understand the fundamental concepts, benefits, and applicability of object orientation. The student should gain application experience of the concepts through the use of an object oriented analysis and design methodology and software development in an object oriented language.

Reference Books:

- Dogru, A.H., & Bicer, U. (2010). *Modern Software Engineering Concepts and Practices: Advanced Approaches*. Information Science Reference.
- Ocboa, S. F., & Roman, G. (Eds.) (2009). *Software Engineering: Expanding the Frontiers of Software Technology*. Springer.

Course name: Ontology Engineering
Course Code: SEN 764
Credit Hours: 3

Course Description:

The course will provide students with a theoretical and practical understanding of leading edge solutions for the Semantic Web. It will introduce students to the W3C standard Web Ontology Language, OWL, and its underlying Description Logics. It will provide students with experience using a set of established patterns for developing OWL ontologies and help them to learn to avoid the major pitfalls in using OWL. It will give them an opportunity to become familiar with a widely used environment for developing and an API for applying OWL ontologies and making use of reasoning services accessible via both.

Ontologies provide rich, expressive vocabularies of terms describing a domain (e.g. medicine, astronomy, music etc.) They are key to the development of the next generation of the Web, support a number of activities such as information exchange, data integration, and search. This unit will provide an introduction to OWL, a standardized language for the representation of ontologies. It will cover the syntax and semantics of the language; authoring ontologies (including the use of standard design patterns); the use of reasoning and the use of ontologies in applications.

Reference Books:

- Keet, M. (2014). Lecture Notes Ontology Engineering. Department of Computer Science, University of Cape Town, South Africa.
- Allemang, D. & Hendler, J. (2011). Semantic Web for the Working Ontologist. 2nd Edition, Elsevier Inc.
- De Pablos, Ordonez (2013). Advancing Information Management through Semantic Web Concepts and Ontologies. IGI Global.
- Sheth, A. (2013). Semantic Web Ontology and Knowledge Based Enabled Tools, Services and Applications. IGI Global.
- Duchame, B. (2013). Learning SPARQL.O‟ Reilly.

Course Title: IoTs: Architecture, Protocols & Applications

Course Code: SEN 774
Credit Hours: 3

Course Description:
This course aims at building the necessary background and foundation about IoTs. Basic IoT concepts covering architecture, PHY and MAC layer protocols along with enabling technologies (i.e., machine 2 machine communication) are the essential part of this course. Some advanced application of IoTs such as smart city, smart grid, and smart homes is also discussed. Main goal of this course is to teach different theories, concepts and building blocks involved in IoTs architectures for developing smart applications.

Reference Books:

- Waher, P. (2015). *Learning Internet of Things*, Packt Publishing.
- Lea, P. (2018). *Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security*, Packt Publishing.

Course name: Ubiquitous Computing
Course Code: CSC 504
Credit Hours: 3

Course Description:
This course will teach the basics of ubiquitous computing (also known as pervasive computing) as well as the basics of research, including reading research papers, speaking and presentation, formulating research questions, and empirical investigation.

Reference Books:

- Poslad, S. (2011). *Ubiquitous Computing: Smart Devices, Environments and Interactions*, Wiley.
- Krumm, J. (2016). *Ubiquitous Computing Fundamentals*, CRC Press.
- Kuniavsky, M. (2010). *Smart Things: Ubiquitous Computing User Experience Design*, Elsevier.

Course name: Advanced Design and Analysis of Algorithm
Course Code: CSC 521
Credit Hours: 3

Course Description:
This course introduces students to advanced concepts for designing and analyzing algorithms. The effect of data structures on program design is investigated. The uses of data structures and algorithms in a variety of application areas are covered. The focus is on algorithmic thinking, performance guarantees and boundary cases, and efficient solutions to practical problems. Advanced topics will cover a selection of modern algorithms, many of which come from real world applications.

Reference Books:

- Sedgewick, R., & Flajolet, P. (2013). *An Introduction to the Analysis of Algorithms*, 2nd Edition, Addison Wesley.
- Vrajitou, D., & Knight, W. (2014). *Practical Analysis of Algorithms*, Springer.
- Kozen, D.C. (2012). *The Design and Analysis of Algorithms*, Springer.

Course name: Advanced Cryptography
Course Code: CSC 704
Credit Hours: 3

Course Description:

This course focuses on modern cryptography. It includes building blocks such as one way functions, pseudo random number generation, encryption, and digital signatures, protocols and applications such as information security, secure network communication, secure cloud computing, and privacy preserving data analytics. Fundamental security properties, cryptographic constructions, and their applications are emphasized.

Reference Books:

- Katz, J., Lindell, Y. (2014). *Introduction to Modern Cryptography*, 2nd Edition, CRC Press.
- Ferguson, N., Schneier, B., & Kohno, T. (2011). *Cryptography Engineering: Design Principles and Practical Applications*, by Niels Ferguson, Bruce Schneier and Tadayoshi Kohno, Wiley Publishing Inc.

Course name: Advanced Simulation and Modeling
Course Code: CSC 708
Credit Hours: 3

Course Description:

As simulation is increasingly applied to more complex applications, exploiting efficiencies in model design and model execution becomes a challenging task. The aim of this course is to provide students with the ability to model, simulate and analyze complex systems within a reasonable time. This course is divided into three parts and covers advanced techniques in simulation model design, model execution, and model analysis. A selection of model design techniques such as conceptual models, declarative models, functional models, constraint models, and multi models will be discussed. Model execution techniques include discussion of serial and parallel discrete event simulation algorithms. For model analysis, topics include input output analysis, variance reduction techniques and experimental design. Present concepts of computer based modeling and simulation applicable to various domains of engineering and science. Provide theoretical concepts, methods, and hands on experience with object oriented modeling and simulation. Students are expected to gain a solid foundation and associated experience for a computer based toolset for constructing, simulating and analyzing models of complex systems.

Reference Books:

- Zeigler, B.P., & Sarjoughian, H.S. (2011). *Guide to Modelling and Simulation of Systems of Systems*, 2nd Edition, Springer.
- Murin, J., Kompis, V., & Kutis, V. (2010). *Computational Modelling and Advanced Simulations*, Springer.
- Sokolowski, J.A., & Banks, C.M. (2011). *Principles of Modelling and Simulation: A Multidisciplinary Approach*. Wiley.

Course name: Advanced Artificial Intelligence
Course Code: CSC 711
Credit Hours: 3

Course Description:

This course will present advanced topics in Artificial Intelligence (AI). It will begin by defining the term "software agent" and discussing how software agents differ from programs in general. We will then take a look at those problems in the field of AI that tend to receive the most attention. Different researchers approach these problems differently. In this course, we will focus on how to build and search graph data structures needed to create software agents, an approach that you will find useful for solving many problems in AI. Students will also learn to "break down" larger problems into a number of more specific, manageable sub problems.

Reference Books:

- Zhongci, S. (2011). *Advanced Artificial Intelligence*, World Scientific.
- Bibel, W. et al. (2014). *Fundamentals of Artificial Intelligence: An Advanced Course*, Springer Berlin Heidelberg.

Course Title: **Machine Learning**
Course Code: **CSC 719**
Pre Requisite: **None**

Course Description:

This course is an overview of concepts and techniques in machine learning, beginning with topics such as classification and linear regression and ending up with more recent topics such as boosting, support vector machines, hidden Markov models, and Bayesian networks. The course will give the student the basic ideas behind modern machine learning methods. Salient contents of the course are: Introduction to Machine Learning, Concept learning, Decision tree learning, Linear models for regression, Linear models for classification, Artificial neural networks, Kernel methods, Sparse kernel machines, Mixture models and the EM algorithm, Evaluation, Combining multiple learners, Support vector machines, Bayesian networks.

Reference Books:

- Kelleher, J.D., Namee, B.M., & D'Arcy, A. (2017). *Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies.* MIT Press, 1st Edition, 2017.
- Chapmann, J. (2017). *Machine Learning: Fundamental Algorithms for Supervised and Unsupervised Learning With Real World Application*, 2nd Edition, 2017.

Course name: Advanced Operating System
Course Code: CSC 720
Credit Hours: 3

Course Description:

The operating systems course is of prime importance in the curriculum of any graduate or undergraduate program in computer science. This course deals with advanced concepts with relevance to the graduate level study. It has been designed using references of similar courses being offered at accredited universities. The intention is to deliver the state of art operating system concepts ranging from embedded microkernels to popular platforms like LINUX, SOLARIS, Windows 2000 and XP. The focus will be on the internals, architecture, device driver writing and the distributed processing support on multi processor systems. An effort will be made to conduct the course in such a way that the students get a research orientation. For this purpose, the state of the art research articles will be reviewed and areas of further research will be identified. In some cases, we may be able to come up with research papers.

Reference Books:

- Silberschatz, A., Gagne, G., & Galvin, P.B. (2013). *Operating System Concepts*, 9th Edition, Wiley.
- Tanenbaum, A.S., & Bos, H. (2014). *Modern Operating Systems*, 4th Edition, Pearson.

Course name: Advanced Natural Language Processing
Course Code: CSC 741
Credit Hours: 3

Course Description:

This course offers an in depth coverage of methods for Natural Language Processing. We will present fundamental models and tools to approach a variety of Natural Language Processing tasks, ranging from syntactic processing to semantic processing, to final applications such as information extraction, human machine dialogue systems, and machine translation. The flow of the course is along two main axes: (1) computational formalisms to describe natural language processes, and (2) statistical and machine learning methods to acquire linguistic models from large data collections.

Reference Books:

- Thanaki, J. (2017). *Python Natural Language Processing: Advanced machine learning and deep learning techniques for natural language processing*, Packt Publishing.
- Rodgrigues, M., & Teixeria, A. (2015). *Advanced Applications of Natural Language Processing for Performing Information Extraction*, Springer.

Course name: Advanced Computer Graphics
Course Code: CSC 744
Credit Hours: 3

Course Description:

This course is intended to provide a advanced level introduction to modern computer graphics. Students will study some of the basic background of 3D computer graphics in the areas of geometry, physical simulation and rendering. The course is intended to bring students up to the research frontier, and prepare them for further work in the field. As such, at least half the material in the course will go over topics of current research interest, such as the physical simulation and coupling of solids and fluids, and pre computation based methods for real time rendering. Topics to be covered include, but are not limited to: Introduction to Basic Ray Tracing and BRDFs, Global Illumination and Monte Carlo Rendering, Recent Developments in Fast Offline Rendering, Image Based and Real Time Rendering, Data Driven Methods, Signal processing and low dimensional and data sparse methods, Imaging and Computational Photography, Basic Geometric Concepts, Meshes and Subdivision Surfaces, Finite Elements and Numerical Integration for Animation, Fluid Simulation and Reduced Order Models, Inverse Kinematics and Rigid Body Dynamics.

Reference Books:

- Hughes, J.F. et al. (2014). *Computer Graphics: Principles and Practices*, 3rd Edition, Addison Wesley Professional.
- Pharr, M., & Humphreys, G. (2010). *Physically Based Rendering – From Theory to Implementation*, 3rd Edition, Morgan Kaufmann.
- Ganovelli, F., & Corsini, M. (2014). *Introduction to Computer Graphics: A Practical Learning Approach*, CRC Press.

Course name: Advanced Data Mining
Course Code: CSC 746
Credit Hours: 3

Course Description:

The objective of the course is to create awareness amongst the students about different aspects of data warehousing. The course will also introduce students to the basic concepts and techniques of data mining. The aim is to develop skills of using recent data mining software for solving practical problems and to gain experience of doing independent study and research.

Reference Books:

- Han, J. & Kamber, M. (2011). *Data Mining Concepts & Techniques*, 3rd Edition, Elsevier.
- Roiger, R. J. (2017). *Data Mining: A Tutorial Based Primer*, 2nd Edition, CRC Press.
- Benson, J. (2015). *Advanced Data Mining*, Clanrye International.

Course name: Advanced Neural Networks
Course Code: CSC 750
Credit Hours: 3

Course Description:

Neural networks provide a model of computation drastically different from traditional computers. Typically, neural networks are not explicitly programmed to perform a given task; rather, they learn to do the task from examples of desired input/output behavior. The networks automatically generalize their processing knowledge into previously unseen situations, and they perform well even when the input is noisy, incomplete or inaccurate. These properties are well suited for modeling tasks in ill structured domains such as face recognition, speech recognition, and motor control. This course will cover basic neural network architectures and learning algorithms, for applications in *pattern recognition, image processing,* and *computer vision*.

Reference Books:

- Russell, R. (2018). *Neural Networks: Easy Guide to Artificial Neural Networks*, CreateSpace Independent Publishing.
- Story, B. (2017). *Neural Networks for Beginners: An Easy To Use Manual for Understanding Artificial Neural Network Programming*, CreateSpace Independent Publishing.

Course name: Pattern Recognition
Course Code: CSC 752
Credit Hours: 3

Course Description:

Pattern recognition techniques are concerned with the theory and algorithms for putting abstract objects, e.g., measurements made on physical objects, into categories. Typically, the categories are assumed to be known in advance, although there are techniques to learn the categories (clustering). Methods of pattern recognition are useful in many applications such as information retrieval, data mining, document image analysis and recognition, computational linguistics, forensics, biometrics, and bioinformatics.

Reference Books:

- Bishop, C.M. (2016). *Pattern Recognition and Machine Learning*, Springer.
- Murty, M.N., & Devi, V.S. (2011). *Pattern Recognition: An Algorithmic Approach*, Springer.
- Duda, R.O., Hart, P.E., & Stork, D. G. (2012). *Pattern Classification*, 2nd Edition, John Wiley & Sons Inc.

Course name: Distributed Databases
Course Code: CSC 753
Credit Hours: 3

Course Description:

This course outlines the advanced data models including conceptual database design, concurrency control techniques, recovery techniques, query processing and optimization, integrity and security, client Server architecture, distributed database systems. It also includes the current trends in database systems, database technologies, machines and modeling.

Reference Books:

- Öszu, T., & Valduriez, P. (2011). *Principles of Distributed Database Systems*, 3rd edition, Springer.
- Rahimi, S. K. (2014). *Distributed Database Management Systems: A Practical Approach*, Wiley India Private Limited.

Course name: Agent based Modeling
Course Code: CSC 759
Credit Hours: 3

Course Description:

This course will guide students through the research process of agent based modeling in the engineering and social sciences: formulating a research question, specifying a model, creating a simulation and interpreting the output. During the course, students will be helped to build a model using NetLogo, acquiring basic and intermediate programming skills. Moreover, this course will provide the students with the basic insights into Complex Adaptive Systems (CAS) theory and its main modeling tool, Agent Based Modeling. Many different and seemingly contradictory properties of CAS, such as Adaptiveness and Robustness, Path dependency and Evolution, Chaos and Stability etc. will be discussed using socio technical examples and Agent Based computer simulations.

Reference Books:

- Railsback, S.F., & Grimm, V. (2012). *Agent Based and Individual Based Modeling: A Practical Introduction*, Princeton and Oxford: Princeton University Press.
- Wilensky, U., & Rand, W. (2015). *An Introduction to Agent Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo.* MIT Press.

Course name: Advanced Data Warehousing
Course Code: CSC 760
Credit Hours: 3

Course Description:

This course will be an introduction to data mining and Data Warehousing (Taught Course). The course will be taught through lectures, with class participation expected and encouraged. There will be frequent reading and practical assignments to supplement the lectures. The core focus of the subject will be on learning data mining & DW techniques.

Reference Books:

- Vaisman, A., & Zimanyi, E. (2014). *Data Warehouse Systems: Design and Implementation*, Springer.
- Krishnan, K. (2013). *Data Warehousing in the Age of Big Data*, Elsevier.

Course name: Computer Vision
Course Code: CSC 764
Credit Hours: 3

Course Description:

The goal of computer vision is to make computers understand and interpret visual information. Computer vision systems bring together imaging devices, computers, and sophisticated algorithms for solving problems in areas such as industrial inspection, medicine, document analysis, autonomous navigation, and remote sensing.

Reference Books:

- Szeliski, R. (2011). *Computer Vision: Algorithms and Applications*, Springer.
- Prince, S.J.D. (2012). *Computer Vision: Models, Learning, and Inference*, Cambridge University Press.
- Forsyth, D. A., & Ponce, J. (2011). *Computer Vision: A Modern Approach*, Pearson.
- Solomon, J. (2015). *Numerical Algorithms: Methods for Computer Vision, Machine Learning, and Graphics*, A K Peters/CRC Press.
- Slavio, J. (2017). *Deep Learning and Artificial Intelligence: A Beginners' Guide to Neural Networks and Deep Learning*, CreateSpace Independent Publishing.

Course name: Bio Medical Image Analysis
Course Code: CSC 765
Credit Hours: 3

Course Description:

The course covers different aspects of biomedical imaging including topics on image formation and reconstruction, processing, analysis and interpretation. The course aims to offer the student an understanding of the generic concepts underpinning the physical processes of imaging, and their practical realizations in specific imaging modalities and imaging systems.

Reference Books:

- Birkfellner, W. (2016). *Applied Medical Image Processing: A Basic Course*, 2nd Edition, CRC Press.
- Dougherty, G. (Ed.) (2011). *Medical Image Processing: Techniques and Applications*, Springer.

Course name: Cloud Computing
Course Code: CSC 781
Credit Hours: 3

Course Description:

Cloud Computing has transformed the IT industry by opening the possibility for infinite or at least highly elastic scalability in the delivery of enterprise applications and software as a service (SaaS). Amazon Elastic Cloud, Microsoft's Azure, Google App Engine, and many other Cloud offerings give mature software vendors and new start ups the option to deploy their applications to systems of infinite computational power with practically no initial capital investment and with modest operating costs proportional to the actual use. The course examines the most important APIs used in the Amazon and Microsoft Cloud, including the techniques for building, deploying, and maintaining machine images and applications. We will learn how to use Cloud as the infrastructure for existing and new services. We will use open source implementations of highly available clustering computational environments, as well as RESTFul Web services, to build very powerful and efficient applications. We also learn how to deal with not trivial issues in the Cloud, such as load balancing, caching, distributed transactions, and identity and authorization management. In the process, we will also become very familiar with the Linux operating system.

Reference Books:

- Rafaels, R. J. (2015). *Cloud Computing: From Beginning to End*, CreateSpace Independent Publishing.
- Marinescu, D.C. (2013). *Cloud Computing Theory and Practice*, Elsevier.
- Erl, T., Puttini, R., & Mahmood, Z. (2013). *Cloud Computing: Concepts, Technology & Architecture*, Prentice Hall.

Course Title: Blockchain Technologies
Course Code: SEN 604
Credit Hours: 3
Course Description:

Bitcoin Protocol and Consensus: A High Level Overview, Bitcoin and Blockchain History: From the Cypher punk Movement to JPMorgan Chase, Bitcoin Mechanics and Optimizations: A Technical Overview, Bitcoin IRL: Wallets, Mining, and More, Ethereum & Smart Contracts: Enabling a Decentralized Future, Game Theory and Network Attacks: How to Destroy Bitcoin, Crypto economics and Proof of State, Distributed Systems and Alternative Consensus, Scaling Blockchain: Cryptocurrencies for the Masses, Enterprise Blockchain: Real World Applications, Anonymity: Mixing and Altcoins, Blockchain Hype and the Future.

Reference Books:

- Narayanan, A., Bonneau, J. Felten, E., Miller, A., & Goldfeder, S. (2016). *Bitcoin and Cryptocurrency Technologies*. Princeton.
- Fleming, S. (2017). Blockchain Technology: Introduction to Blockchain Technology and its impact on Business Ecosystem.

Course Title: Deep Learning
Course Code: DSC 704
Pre Requisite: Machine Learning

Course Description:

The objective of this course is to acquaint the students with the state of the art deep learning techniques to solve different learning problems. Students will learn to design as well as implement deep neural network architectures (through hands on tasks) to solve various recognition problems.

Salient contents of the course are: Introduction to neural networks, activation functions and back propagation; Convolutional Neural Networks: History, Convolution, Pooling, CNNs for classification, Deep learning Software, CNN Architectures; Sequence Modeling: Recurrent and Recursive Nets: Long Short Term Memory models and variants, Language modeling and image captioning, Unsupervised learning: Restricted Boltzmann Machines and Auto encoders; Case Studies.

Reference Books:

- Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning (Adaptive Computation and Machine Learning series)*, The MIT Press, 2016.
- Patterson, J., & Gibson, A. (2017). Deep Learning: A Practitioner's Approach, O'reilly.

Course name: Advanced Distributed System
Course Code: CEN 707
Credit Hours: 3

Course Description:

This course aims to make the students become familiar with the advanced topics in distributed systems, starting with a basic model of distributed computation, followed by an algorithmic description of logical clocks, snapshot

recording, message passing and group communication, and how to reach to a consensus. The course will also focus on Multiagent Systems as a design tool for Complex Adaptive Systems. More emphasis will be on algorithms of leader selection and agreement. Distributed models of decision making of agents such as Swarm Intelligence and Game Theory will also be explored. The course will also focus on Systems side of the domain, with System Modeling, Clustering and Virtualization, Computing Clouds, Grids, P2P, and The Future Internet (IoT).

Reference Books:

- Kshemkalyani, A.D. (2011). *Distributed Computing: Principles, Algorithms, and Systems*, Cambridge University Press.
- Hwang, K., Fox, G.C., & Dongarra, J. (2013). *Distributed and Cloud Computing: From Parallel Processing to the Internet of Things*, Elsevier Science.
- Vlassis, N. (2007). *A Concise Introduction to Multiagent Systems and Distributed Artificial Intelligence*.

Course name: Advanced Computer Architecture
Course Code: CEN 720
Credit Hours: 3

Course Description:

This course builds on the computer architecture concepts. It covers advanced features in state of art CPUs and their design and evaluation. The topics covered include instruction set design, microprogrammed CPU design, pipelining, instruction level parallelism, high speed memory systems, storage systems, interconnection networks, and multiprocessor architectures. The fault tolerance, real time systems, and multimedia systems along with case studies of Intel Pentium 4, SunSparc and DEC Alpha are introduced. The new domains like multi core processors and use of programmable hardware for ASIC or FPGA designs are also discussed.

Reference Books:

- Hennessy, J.I., & Patterson, D.A. (2011). *Computer Architecture: A quantitative approach*, 5th Edition, Morgan Kauffman Series.
- Harris, D., & Harris, S. (2012). *Digital Design and Computer Architecture*, 2nd Edition, Morgan Kauffman Series.
- Hwang, K. (2011). *Advanced Computer Architecture, Parallelism, Scalability, and Programmability*, 2nd Edition, McGraw Hill publication.

Course name: Advanced Digital Image Processing
Course Code: CEN 745
Credit Hours: 3

Course Description:

The goal of this course is to understand digital image processing beyond just the fundamental or introductory level, to choose appropriate image processing algorithms to achieve a desired result, to properly implement such algorithms using modern computing tools such as MATLAB, and to correctly interpret and present the results. The course would also cover the study of research topics of current interest in image processing and analysis.

Reference Books:

- Woods, R. E., & Gonzales, R.C. (2016). *Digital Image Processing*, 3rd Edition, Pearson.

- Burger, W., & Burge, M.J. (2013). *Principles of Digital Image Processing: Advanced Methods*, Springer.
- McAndrew, A. (2015). *A Computational Introduction to Digital Image Processing*, 2nd Edition, Chapman and Hall/CRC.

Course name: Advanced Engineering Mathematics
Course Code: GSC 700
Credit Hours: 3

Course Description:
This unit provides students with the advanced knowledge and skills required at Engineering Technologist level to solve mathematical problems typically encountered in a civil engineering design office. Students will learn to appraise problems and choose possible solutions as part of the process involved in achieving a satisfactory resolution to a problem through the study of real world cases. Topics include vectors, matrix algebra, calculus, and statistics.

Reference Books:

- Kreyszig, E. (2011). *Advanced Engineering Mathematics*, 10th Edition, Wiley.
- Zill, D. G. (2016). *Advanced Engineering Mathematics*, 6th Edition, Jones & Barnett Learning.

Course name: Advanced Network Security
Course Code: EET 702
Credit Hours: 3

Course Description:
Organizations today are linking their systems across enterprise wide networks and virtual private networks (VPNs), as well as increasing their exposure to customers, competitors, browsers, and hackers on the Internet. Each connection magnifies the vulnerability to attack.

This course provides the fundamental knowledge students need to analyze risks to networks and systems. Students learn the steps to take in order to select and deploy the appropriate countermeasures to reduce exposure to network threats.

Reference Books:

- Kaufman, C., Perlman, R., & Speciner,M. (2016) *Network Security: Private Communication in a Public World*, by, Prentice Hall.
- Stalling, W. (2016). *Cryptography and Network Security: Principles and Practice*, Pearson Education.

Appendage 1702

Department of Software Engineering, Islamabad Campus

Roadmap for the

Master of Science in Engineering Management

(Applicable from Spring 2019)

Table of Contents

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Introduction

Department of Software Engineering is offering Masters degree in Engineering Management (MS-EM). The main aim of this program is to equip graduates with essential Engineering processes management skills that are needed in industry to enable them to perform in a global engineering environment. These skills would include:

- Decision and Risk Analysis
- Systems Modelling, Design and Optimization
- Engineering Project Management
- Supply Chain and Logistics Engineering
- Quality Engineering
- Information and Knowledge management
- Manufacturing and Maintenance Management
- Energy Systems Design and Planning
- Technology Management

1. Communication Systems and Technology Management

- Understanding of Global Business Dynamics

The program will follow a multi-disciplinary approach enabled through a flexible curriculum realized by a keen and thoughtful collaboration within Engineering, Management and Social disciplines of Bahria University (BU).

Program Aims, Objectives and Expected Benefits

Every day, business leaders make critical decisions on managing their organizations without truly understanding the second- and third-order effects of those decisions. At the same time, accomplished engineers produce ideas on changing the world through innovation, but aren't able to navigate barriers to their implementation from business leaders and government.

In a world of increasing speed of change and technology evolution, the challenges facing today's international society are increasingly complicated—and so are the solutions required to meet them. While creating such systemic solutions requires expertise in traditional business, management, and engineering practices, effective leadership must adopt cross-discipline approaches to support true collaboration and minimize the tendency toward reductionist rather than holistic solutions.

Successful leaders must understand and manipulate the inter-relationships between engineering, business, and policy considerations in order to achieve solutions that will meet technical and financial requirements while adhering to governance and policy constraints.

Program Aims and Objectives

Engineering management incorporates the leadership skills and concepts from engineering, business, and governance to develop and manage real solutions to complicated, evolving problems. The individuals that work in this field are systems thinkers who view problems and solutions through a holistic lens, striving to create a systems solution that incorporates evolution and adaptation as a key attribute, rather than struggling simply to interface individually engineered components.

This program would aims to:

- Approach each phase of the solution life cycle with the ultimate goal of balancing the risks, needs, and desires of the stakeholder community and producing a successful, sustainable system.
- Develop an educational experience that prepares successful leaders for the real world of emerging problems, evolving technologies, and growing complexity in the global community.

The proposed program would bear following objectives:

- Emphasizing, developing and applying big-picture thinking to manage critical challenges around the world
- Concentrating less on technical and mathematical components than a typical engineering degree, while providing fundamental systems engineering skills
- Extending benefits students from various backgrounds—including consulting, healthcare, government, and finance—not just engineers
- Providing unique opportunities to participate in and contribute to cutting-edge research and industry innovation

Benefits to the Society

The proposed program would immerse the students at the intersection of policy, business strategy and leadership, and engineering, providing them with the critical skills they need to address the global challenges of today and pioneer the solutions of tomorrow.

Students will not only strengthen their existing skill sets, but also develop new competencies that were previously outside of their scope of knowledge. They will leave the program with a practical toolset that that can be adapted to various industries and applications, allowing them to work seamlessly across areas of expertise and placing them in high demand in a growing marketplace.

Admission Requirements

Applicants must follow all the requirements laid down for MS programs in BU, which include:

1. Bachelor degree or its equivalent in Engineering or relevant scientific and technological field from an accredited institution.
2. Cumulative minimum baccalaureate grade point average of 2.5.
3. Official transcript(s) for all post-secondary coursework.
4. BU admission test or NTS-GAT (General) with at least 50% or more.

Additionally, applicants must provide HEC verification of all academic certificates / degrees.

Degree Requirement

Thirty-three semester hours of approved graduate work within one of two options would require students to complete this degree in not less than two years and not more than three years.

The students would also require to either freeze a semester through written application should they require a semester leave within the course of their degree.

Option 1

This option is based on a successful completion of 33 semester hours of graduate-level coursework without thesis option. The curriculum consists of four core courses and seven additional courses within specializations (as Technology Management, Systems Management, and Engineering Management) selected from an approved list of electives.

Option 2

This option is based on a successful completion of 27 semester hours of graduate-level coursework and 6 hours of thesis research. The curriculum consists of four core courses and five additional courses within specializations (as Technology Management, Systems Management, and Engineering Management) selected from an approved list of electives.

Students are expected to complete a plan of study that identifies a concentration such as technology management, Systems Engineering, software project management for purposes of pursuing the Master of Engineering in Engineering Management.

Core Courses and Specializations

Engineering Management is at the intersection of science, engineering, management and behavioural science. It is a critical element in corporate and national competitive strategies. Managing technology is a powerful tool companies use to compete in an increasingly challenging global economy. It requires an understanding of how science becomes a technology, how technologies are developed into products and how products meet market demands. It also requires understanding how companies control their internal functions to exploit new technologies and markets. This program addresses the role new technology manager's play in technology based businesses.

Core Courses for MS-EM

The following are the core courses for MS-EM program:

Code	Course Title	Credit Hours
EMG 500	Principles of Engineering Management	03
EMG 501	Finance for Engineers	03
EMG 601	Engineering Project Management	03
EMG 604	Quality Engineering	03

Following is the university core:

Code	Course Title	Credit Hours
ESC 701	Research Methodology	03

Electives for Specializations

MS-EM program offers several soft streams of specialization. All courses in this program are designed to meet the scope and current trends of industry and market requirement. Students can also take courses from multiple streams which will help them to broaden their area of knowledge. It is

pertinent to highlight that these are soft specializations streams that would enable students to develop competencies in a specific area and will not be declared on the final transcript and degree certificate. The specializations would equip the students so that they may be able to better select technical opportunities and understand organizational challenges that prevent these techniques from being successful.

These specializations would also equip the students to become effective information system managers and help develop Pakistan's 'knowledge economy'. Primary objective of this specialization is to provide students with a deep understanding of what is involved in the Management of engineering institutions and organizations. This would be accomplished by reviewing a set of conceptual frameworks of engineering management, and by developing a critical view of two levels of management -- strategic and tactical. The strategic content will feature a broad review of significant management challenges before proceeding into assessing value of enabling applications through case studies and empirical research articles. The tactical content will focus on a triad which gives a basic foundation in engineering organizations including technology, general organizational challenges (e.g., governance, sourcing), and specific skills in managing engineering projects. The courses in this category are given below in such a way that the broad category of soft specialization is discussed as headline and the courses in that category are presented as a common table below:

Course Code	Course Title	Proposed Credit Hrs
1. Operations Management		
EMG 602	Business Process Analysis and Development	03
OPM 611	Operations and Production Management	03
SCM 510	Supply Chain Management	03
EMG 605	Forecasting and Decision Making	03
EMG 629	Advanced Operations Research	03
EMG 630	Industrial Psychology	03
2. Energy Management and Urban Planning		
EMG 607	Management in Global Energy Industry	03
EMG 608	Business Policy and Regulations in Global Energy Industry	03
EMG 609	Traffic Engineering	03
EMG 610	Urban and Regional Planning	03
EMG 632	Energy Economics	03
EEP 514	Renewable Energy	03

3. Organizational Management

EMG 627	Entrepreneurship for Engineers	03
HRM 648	Organizational Development	03
EMG 612	Marketing Management for Engineering Concerns	03
EMG 613	Advanced Statistical Methods for Engineering Research	03
MGT 662	Strategic Management	03
FIN 681	Financial Risk Management	03
SCM 512	Engineering Laws and Contract Management	03
EMG 615	Human Resource Management and Corporate Social Responsibility	03
EMG 616	Systems Thinking	03

4. Information, Knowledge and Software Management

SEN 762	Advanced Big Data Analytics	03
EMG 617	Information Systems Management	03
EMG 618	Enterprise Systems and Audit	03
EMG 619	Information Systems Strategy and Innovation	03
EMG 620	Information Systems Security and Ethics	03
SEN 756	Advanced Usability Engineering	03
EMG 621	Socio-Technical Systems	03
CSC 518	Decision Support Systems	03
SEN 658	Systems Requirement Engineering	03
SEN 621	Advanced Software and System Architecture	03
SEN 523	Automated Software Engineering	03
CSC 746	Advanced Data Mining and Warehousing	03
SEN 647	Advanced Software Project Management	03

5. Technology Management

EMG 614	Innovation and Technology Management	03
EMG 630	Technology and Entrepreneurship	03
EMG 701	Competitive Strategies in Technology Management	03
EMG 702	Transfer of Technology	03

Roadmap for MS-EM

The MS-EM program is divided into four semesters. The first semester mainly comprises of core courses, in addition to a university requirement course for the program. In semester two and three, a student is supposed to acquire competency by choosing appropriate elective courses in the area of interest. In the final semester, a student may opt to undertake research work (i.e. thesis) or study elective appropriate courses for his/her area of specialization.

Semester 1

Course Code	Course Title	Credits
	Core – I: Engineering Management	3
	Core – II: Finance for Engineers	3
	Core – III: Research Methodology	3
	Total	**9**

Semester 2

Course Code	Course Title	Credits
	Core – IV: Engineering Project Management	3
	Core – V: Quality Engineering	3
	Elective – I	3
	Total	**9**

Semester 3

Course Code	Course Title	Credits
	Elective – II	3
	Elective – III	3
ESC 500	Thesis I/ Course Work (Elective Course)	3
	Total	**9**

Semester 4

Course Code	Course Title	Credits
	Elective – IV	3
ESC 500	Thesis II/ Course Work (Elective Course)	3
	Total	**6**
	Total Program Credit Hours	**33**

Course Outline of New Courses

Course Title: Principles of Engineering Management
Course Code: EMG 500
Credit Hours Theory: Three (3)

Course Outline:

Principles of engineering management focusing on the managing technology and research and development. Topics include, but are not limited to, processes of project management, technological innovation, strategic and intermediate term planning, organizing, leadership, motivation, finance and budgeting, operations management, legal issues, working within groups, written and oral communication, and professionalism. Case studies and current literature will be utilized.

Recommended Books:

1. C. M. Chang (2016), "Engineering Management: Meeting the Global Challenges", 2nd Edition, CRC Press.

Course Title: Transfer of Technology
Course Code: EMG 702
Credit Hours Theory: Three (3)

Course Outline:

The Technology transfer course is designed to prepare students for effective technology transfer activities, to make complex decisions for innovation development and solve technology commercialization issues, using knowledge transfer models and technology transfer networks for business companies or research institutions. Upon successful completion of course, students should have understanding about technology transfer process and be prepared to use it in practice.
Salient topics include: Concept of technology transfer, Technology transfer process, Organizational models for technology transfer activities, Knowledge types and transfer models, understanding of complex technology markets and needs, Technology assessment, Open innovation and global technology transfer networks. Building strategic R&D alliances and negotiation of contracts, Introduction to Intellectual Property Law, Copyright Protection, Trademark Protection, Invention Protection, Commercial Secrets.

Recommended Books:

1. Phyllis L. Speser (2012) "The Art and Science of Technology Transfer". John Wiley & Sons.
2. Audretsch, D.B., Lehmann, E.E., Link, A.N., Starnecker, A. "Technology Transfer in a Global Economy". Springer, 2013.

Course Title: Technology and Entrepreneurship
Course Code: EMG 631
Credit Hours Theory: Three (3)

Course Outline:

This course focuses on technology entrepreneurs and their new ventures. It helps the student who is majoring in science, engineering, or other non- business disciplines to understand key aspects of entrepreneurship and the formation of new technology companies so that you can decide if a technology business path is right for you. Major class topics include learning to identify and evaluate innovation opportunities, assessing an industry, conducting market research, intellectual property strategies, the founding team, business models, and funding a new venture.

PART I FUNDAMENTALS OF BUSINESS AND ECONOMICS
Session 01: Chapter 01: Fundamentals of Business
Session 02: Chapter 02: Fundamentals of Economics
Session 03: Chapter 03: Technology Entrepreneurship in the Global Economy
PART II LEGAL STRUCTURE AND CAPITAL
Session 04: Chapter 04: Legal Structure and Equity Distribution
Session 05: Chapter 05: Capital and Deal Structuring
Session 06: Chapter 06: Exit Strategies & Return on Investment
PART III INTELLECTUAL PROPERTY AND CONTRACTS
Session 07: Chapter 07: Intellectual Property Management & Protection
Session 08: Chapter 08: Contracts
Session 09: Chapter 09: Negotiating Contracts
PART IV TECHNOLOGY VENTURE STRATEGY AND OPERATIONS
Session 10: Chapter 10: Launching Technology Ventures
Session 11: Chapter 11: Going to Market and Distribution Strategies
Session 12: Chapter 12: Financial Management & Control
Session 13: Chapter 13: Venture Management & Leadership
PART V MANAGING RISK AND CAREER DEVELOPMENT
Session 14: Chapter 14: Venture Risk Management
Session 15: Chapter 15: Managing Your Entrepreneurial Career
Session 16: Final Projects and their Review

Recommended Books:

1. Lechter, Duening (2010), "Technology Entrepreneurship: Creating, Capturing, and Protecting Value", 1st Edition, Academic Press, ISBN: 9780123745026
2. Claudio Petti (2009), "Cases in Technological Entrepreneurship: Converting Ideas into Value", 2009, Edward Elgar, ISBN 9781848441866
3. Abhishek Jain (2001), "The Technology Entrepreneur's Guidebook", 2001, Washington Technology Partners.

Course Title: Competitive Strategies in Technology Management
Course Code: EMG 701
Credit Hours Theory: Three (3)

Course Outline:

Innovation is taking place at breath-taking speed, with the birth of new and different industries, such as computers, integrated circuits, and pharmaceuticals that are primarily technology driven. This course will examine a variety of important strategic issues on how to manage innovation within these types of technology-oriented firms and industries. Indeed, an understanding of innovation is critical to the study of any

modern day management and economic activity, particularly as more and more advanced technology is absorbed into various, more traditional industries.

Course outline and breakdown:

1. Session 01: Part IA: Technological Innovation
2. Session 02: Part IB: Technological Innovation and Strategy
3. Session 03: Part IIA: Technological Evolution
4. Session 04: Part IIB: Industry Context
5. Session 05: Part IIC: Organizational Context
6. Session 06: Part IID: Strategic Action
7. Session 07: Part IIIA: Technology Sourcing
8. Session 08: Individual Paper Presentations: Each student: 15min + 10min Q&A)
9. Session 09: Part IIIB: Finding New Markets for New Technologies
10. Session 10: Part IIIC: Internal Corporate Venturing
11. Session 11: Part IVA: New Product Development
12. Session 12: Part IVB: Building Competencies/Capabilities
13. Session 13: Part VA: Innovation Challenges in Established Firms
14. Session 14: Chapter 13: Crafting a Deployment Strategy
15. Session 15: Group Project Presentations (Topics will be decided after Mid-term)
16. Session 16: Revision, Q&A and Exam review

Recommended Books:

1. Narayanan (2011), "Managing Technology and Innovation for Competitive Advantage", 1st edition. Pearson Education. ISBN: 0130305065

Course Title: Industrial Psychology
Course Code: EMG 629
Credit Hours Theory: Three (3)

Course Outline:

This course will provide an Introduction to Industrial and Organizational Psychology, a scientific discipline that studies human behaviour in the workplace. Organizational psychologists help institutions hire, manage, develop, support employees and align employee efforts with business needs. Their work contributes to outcomes such as better talent to achieve the strategic goals of the organization, reduced turnover, increased productivity, and improved employee engagement. Salient topics include: Principles, Practices and Problems of Industrial Psychology, Techniques, Tools and Tactics, Employee Selection 1: Principles and Techniques, Employee Selection 2: Psychological Testing

Performance Appraisal, Training and Development in Organizations, Leadership in Organization, Leadership in Organization, Motivation, Job Satisfaction and Job Involvement, Motivation, Job Satisfaction and Job Involvement, Motivation, Job Satisfaction and Job Involvement, Classical vs Modern Organizational Style}, Introduction of Change in Organization, Condition of Work, Engineering psychology, Stress at Work.

Recommended Books:

1. Frank J. Landy, Jeffrey M. Conte (2012), "Work in the 21st Century: An Introduction to Industrial and Organizational Psychology", 4th Eds, Wiley.
2. Michael G. Aamodt (2015), "Industrial/Organizational Psychology: An Applied Approach", 8th Eds, Cengage Learning.
3. Emmanuel B. DE Leon, "Industrial Psychology".

Course Title: Advanced Operations Research

Course Code: EMG 6xx
Credit Hours Theory: Three (3)

Course Outline:

Introduction to mathematical modelling. 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.

Recommended Books:

- Hamdi A. Taha (2010), "Operations Research: An Introduction", (9/e).
- F.S. Hillier, and G. J. Leibermann (2010), "Introduction to Operations Research", (10/e).

Course Title: Energy Economics
Course Code: EMG 632
Credit Hours Theory: Three (3)

The course relates to the method, application, and limitations of traditional economic approaches to the study of energy problems. Topics include microeconomic foundations of energy demand and supply; regression analysis, elasticity of demand, curve fitting, future projections, pricing and allocation of energy resources; macro linkages of energy with economics etc. It will also include discussions on energy market structures with (a) vertically integrated utilities (b) emerging concept of unbundled utilities with open access and competition in the market; regulatory practices, determination of prices for utility services and retail prices etc.

Text & Reference Books

1. **Bhattacharyya**, Subhes C **(2011), "**Energy Economics**:** Concepts, Issues, Markets and Governance**",** Springer.

Course Title: Renewable Energy
Course Code: EEP 514
Credit Hours Theory: Three (3)

Definition of Renewable Energy, category of resources, status of technological development, economics of utilization, distributed and grid based systems, hybrid systems, issues in exploitation of resources, policies for harnessing resources and future outlook. Review of experiences of various countries. Transfer of technologies to developing countries. Efficiency and environmental considerations.

Text & Reference Books

1. Godfrey Boyle (2012) "Renewable Energy: Power for a Sustainable Future", 3rd Ed, Oxford University Press.

Course Outline of Existing Courses

Course Title: Engineering Project Management
Course Code: EMG 601

Credit Hours Theory: Three (3)

Course Outline:

The objectives (of this course) for prospective project managers are to understand the role of a project in their organizations and to master the project management tools, techniques, and interpersonal skills necessary to orchestrate projects from start to finish. When students finish this course they would have learnt program and project portfolio management, role of PM, systems view of PM, understanding organizations, stakeholder management, project phases and project life cycle, project management process groups, mapping the process groups to the knowledge areas, estimating project times and costs, project integrations management, strategic planning and project selection, developing project plans, project closure, project management plans, project execution, project scope management, project time management, project cost management, project quality management, project human resource management, project communication management, project risk management, project procurement management.

Recommended Books:

- PMI (2017), "Guide to the Project Management Body of Knowledge (PMBOK® Guide)", 6th Ed, PMI Institute.
- Kathy Schwalbe (2015), "Information Technology Project Management", 8th Edition, Cengage Learning.

Course Title: Finance for Engineers
Course Code: EMG 603
Credit Hours Theory: Three (3)

Course Outline:

This course presents data analysis and econometric modeling using applications in finance. Equivalently, this course covers computational finance and financial econometrics. As such, the course utilizes concepts from microeconomics, finance, mathematical optimization, data analysis, probability models, statistical analysis, and econometrics.
Topics in financial economics include asset return calculations, portfolio theory, index models, the capital asset pricing model and investment performance analysis. Mathematical topics covered include optimization methods involving equality and inequality constraints and basic matrix algebra. Statistical topics to be covered include probability and statistics (expectation, joint distributions, covariance, normal distribution, sampling distributions, estimation and hypothesis testing etc.) with the use of calculus, descriptive statistics and data analysis, linear regression, basic time series methods, the simulation of random data and re-sampling methods.

Recommended Books:

Frank J. Fabozzi, Edwin H. Neave, Guofu Zhou (2011), "Financial Economics" Wiley.

1. David Ruppert (2010), "Statistics and Data Analysis for Financial Engineering, Springer-Verlag. A Beginner's Guide to R by Alain Zuur, Elena Ieno and Erik Meesters, Springer-Verlag.
2. R Cookbook by Paul Teetor, O'Reilly.

Course Title: Business Process analysis and Development
Course Code: EMG 602
Credit Hours Theory: Three (3)

Course Outline:

This course is the foundation for all courses in the Business Process Management curriculum and is required for CEG BPM certification. It provides an overview and discussion of the principles, concepts and techniques required to transform your business from a traditional, functional organization to a process-centric

organization. The course introduces a systematic approach and methodology for planning, monitoring, measuring and managing your company business process performance and for redesigning and improving specific processes. BPM is a must for everyone interested in business process improvement. Designed for business managers, business analysts, and practitioners involved in process-based change and the automation of process solutions. This course is the foundation for all other courses in the CEG BPM curriculum. It establishes a methodology, a common language, and a baseline for all other courses in the curriculum.

Recommended Books:

- Marlon Dumas, Marcello La Rosa, Jan Mendling, Hajo A. Reijers (2013), "Fundamentals of Business Process Management", Springer.
- Peter Franz, Mathias Kirchmer (2013), "Value-Driven Business Process Management: The Value-Switch for Lasting Competitive Advantage", McGraw-Hill Education.
- Tristan Boutros, Tim Purdie (2013), "The Process Improvement Handbook: A Blueprint for Managing Change and Increasing Organizational Performance", McGraw-Hill Education.

Course Title: Quality Engineering
Course Code: EMG 604
Credit Hours Theory: Three (3)

Course Outline:

This course outlines the Quality Engineer Body of Knowledge, which outlines specific areas of expertise. These include training in quality management systems (QMS) and the students will learn essential information about quality systems, auditing, product and process control and design, quality methods and tools, technologies, applied statistics, System Engineering, SPC, and Design of Experiments. Further, the quality engineer must understand the quality system, quality standards and regulations. On successful completion of this course students will be able to:

- Understand the relationship of the quality engineer to the quality system.
- Analyze the relationship of statistics to a process.
- Understand basic quality management principles.
- Understand process capability and use statistical process control to monitor a process.
- Generate acceptance sampling plans and identify and use technical quality tools.
- Incorporate quality technology in design, customer-supplier relationships, Reliability, Availability, and Maintainability (RAM), materials control, measurement, auditing, quality costs and document control within a quality system w.r.t ISO.
- Apply problem-solving tools and Software Engineering methodologies, process control and process capability plans, acceptance sampling, product quality and attribute controls.

Recommended Books:

2. Amitava Mitra (2016), "Fundamentals of Quality Control and Improvement" 4th Ed, Wiley.
3. K. S. Krishnamoorthi & V. Ram Krishnamoorthi (2011), "A First Course in Quality Engineering: Integrating Statistical and Management Methods of Quality", 2nd Ed, CRC Press.
4. Kenneth Rose (2014), "Project Quality Management: Why, What and How", 2nd Edition, J. Ross Publishing.
5. Thomas Pyzdek, Paul A. Keller (2013), "The Handbook for Quality Management: A Complete Guide to Operational Excellence", 2nd Ed, McGraw-Hill Education.
6. Genichi Taguchi, Subir Chowdhury, Yuin Wu (2004) "Taguchi's Quality Engineering Handbook", Wiley-Interscience.
7. Thomas Pyzdek, Paul A. Keller (2003), "Quality Engineering Handbook (Quality and Reliability)", 2nd Ed, CRC Press.

Course Title: Strategic Management
Course Code: MGT 662
Credit Hours Theory: Three (3)

Course Outline:

This course is designed to help the students integrate and apply their earlier functional courses and on-the-job experiences. The course takes the general management point of view, emphasizing the creation, implementation and evaluation of strategy in organizations. In addition to focusing on for-profit businesses, this section includes a module on strategy in non-profits as well. You will put yourselves in the shoes of top management and make the really important "Big Picture" decisions. You will develop expertise in the analysis of complex business situations and in clearly presenting your findings both orally and in writing. You will also further develop your ability to work effectively in teams.

Recommended Books:

1. Gregory G Dess, Gerry McNamara, Alan Eisner (2015), "Strategic Management: creating competitive advantages", 8th Ed, McGraw-Hill Irwin.

Course Title: Operations and Production Management
Course Code: OPM 611
Credit Hours Theory: Three (3)

Course Outline:

This Course include concepts, problems and techniques applicable to the operations of a variety of business organizations. The emphasis is on decision making (to include business ethics) in operational areas such as: facility requirements and utilization, control and coordination of resource inputs and outputs, types of transformation / conversion processes, and performance measurements.

Recommended Books:

- William J Stevenson (2017), "Operations Management" 13th Ed, McGraw-Hill Education; 13th Ed.
- Jay Heizer, Barry Render, Chuck Munson (2016), "Operations Management: Sustainability and Supply Chain Management", 12th Ed, Pearson Education.
- Roberta S. Russell & Bernard W. Taylor III (1998), "Operations Management, Focusing on Quality and Competitiveness", 2nd Ed, Prentice Hall, 1998.

Course Title: Supply Chain Management
Course Code: SCM 510
Credit Hours Theory: Three (3)

Course Outline:

This course is designed to study various aspects of supply chain, its objectives, decision phases, strategies and designs, planning, forecasting, operation processes, cycle view, push/pull view, macro processes, performance achievement, strategy into action (SIA), must win battles, coordination internally & externally, uninterrupted supplies, warehousing and transportations, profit improvement plans and finally a cost effective business

Recommended Books:

- Robert M. Monczka and Robert B. Handfield (2015), "Purchasing and Supply chain management", 6th edition, Prentice Hall

Course Title: Forecasting and Decision Making
Course Code: EMG 605
Credit Hours Theory: Three (3)

Course Outline:

This Course include how Forecasts and budgets are essential tools for successful business management. Understanding and using these management tools will facilitate effective decision making and strategic planning and ultimately support growth and development. Participants will be required to complete a pre-course assignment prior to attending the course. This assignment is designed to directly relate the course to participants' personal experience and provide practical application of the course outcomes.

Recommended Books:

1. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams, Jeffrey D. Camm, James J. Cochran (2015), "An Introduction to Management Science: Quantitative Approaches to Decision Making" 14th Ed, Cengage Learning.
2. Raghu Nandan Sengupta, Aparna Gupta, Joydeep Dutta (2016), "Decision Sciences: Theory and Practice", 1st Ed, CRC Press.

Course Title: Management in Global Energy Industry
Course Code: EMG 607
Credit Hours Theory: Three (3)

Course Outline:

This Course will enable Students to understand the role regulation plays in determining how the energy industry addresses the key energy challenges. Students would take a broad perspective across the energy industry, reviewing the activities and challenges faced by the various sectors. Work in a group on a business simulation that illustrates how risks and uncertainties have to be incorporated into the way managers guide a company. This will both bring to life a key part of the industry and illustrate the importance of effective teamwork in managerial decision-making. Students would learn to understand the concepts underlying the production/operations function. You will learn to appreciate the different nature of the tasks and issues involved in managing the production function in a manufacturing company and the operations function in a service organization.

Recommended Books:

1. Andrew Inkpen, Michael H. Moffett (2011), "The Global Oil & Gas Industry: Management, Strategy and Finance", PennWell Corp.

Course Title: Business Policy and Regulations in Global Energy Industry
Course Code: EMG 608
Credit Hours Theory: Three (3)

Course Outline:

This Course include the understanding diverse and integrated markets for primary energy, and the essential considerations driving business leaders and policy makers in development of global energy resources. This course provides an understanding to the business of primary energy production. We will examine the nature of demand and supply in global energy markets, and business considerations for participants in those markets. Students taking this course will be able to identify the distinctive challenges facing enterprises engaged in development of primary energy resources. The course is intended to provide a broad perspective of the challenges for businesses and policy authorities engaged in diverse but integrated global energy markets.

Recommended Books:

- Mike Bradshaw (2013), "Global Energy Dilemmas" 1st Ed, Polity
- Thomas L. Wheelen, J. David Hunger, Alan N. Hoffman, Charles E. Bamford (2017), "Strategic Management and Business Policy: Globalization, Innovation and Sustainability", 15th Ed, Pearson.

Course title: Traffic Engineering
Code: EMG 609
Credit Hours Theory: Three (3)

Course Outline:

This Course brief students about Traffic operations of roads, streets, and highways; traffic engineering studies; use of signs, signals, and pavement markings as traffic control devices; highway and intersection capacity, design and operations of traffic signals; current microcomputer models and applications. Understand the general characteristics related to main components of the highway system such as road users, vehicles, traffic and control systems, and various interactions among those components. Perform capacity analysis of rural highways, freeways, signalized intersections, and unsignalized intersections using the procedures described in the current version of the Highway Capacity Manual. Perform the capacity analysis of highway facilities by using the Highway Capacity Software. Understand highway safety related issues, calculate and interpret highway crash frequencies and rates, perform the methods to identify critical highway locations, and suggest applicable countermeasures.

Recommended Books:

- Roess, Prassas, & McShane, "Traffic Engineering", 3rd Ed, Pearson/Prentice Hall,
- Institute of Transportation Engineers ITE and Wolshon, Brian (2016), "Traffic Engineering Handbook", 7th Ed, Wiley.

Course title: Urban and Regional Planning
Code: EMG 610
Credit Hours Theory: Three (3)

Course Outline:

This Course include Understanding urban processes and contributing to sustainable urban development, Urban transport, infrastructure and social services, quality of urban life, urban modeling, planning and evaluation approaches as well as disaster risk management, urban environmental planning, and participatory GIS are typical themes in the urban planning and management course domain. Be able to identify key concepts in urban and regional planning. Understand the general planning process. Have a basic understanding of the major planning issues and debates. Be able to understand and apply planning principles to problems in land use planning, environmental planning, and economic development. Be able to acquire and analyze the essential data used in urban and regional planning. Identify a planning problem in a city YOU are familiar with and use planning concepts to solve the problem.

Recommended Books:

- Eugenie L. Birch (Eds) (2009), "The Urban and Regional Planning Reader", London & New York: Routledge.
- P. Calthorpe and W. Fulton. (2001), "The Regional City: Planning for the End of Sprawl", Island Press.
- T. L. Daniels, J.W. Keller, and M. B. Lapping (1995), "The Small Town Planning Handbook", 2nd Ed. Chicago, IL.

Course Title: Entrepreneurship and Engineering Concerns
Course Code: EMG 611
Credit Hours Theory: Three (3)

Course Outline:

This course is for students who want to build creative businesses in new or existing firms; foster effective, innovative work in the people they lead; and preserve their own creativity in the face of career pressures and organizational constraints. This course is designed to help you develop your own creativity, apply creative

ideas in entrepreneurial ventures, and support the creativity of the people you lead. You will learn to recognize, analyze, and support creative behavior in organizations in a wide variety of industries.

Recommended Books:

- Entrepreneurship: Strategies and Resources by Marc J. Dillinger, Third Edition (Pearson Education
- Essentials of Entrepreneurship and Small Business Management, Thomas W. Zimmerer, Norman M. Scarborough, Pearson Education
- Bradford, D.L. &Burke, W. W. (2005). Reinventing organization development: New approaches to change in organizations. Californina: Pfeiffer

Course name: Organizational Development
Course Code: HRM 648
Credit Hours Theory: Three (3)

Course Outline:

This Course enables students to learn that Organization Development (OD) is an area of practice and research in Human Resource Development (HRD). According to Cummings & Worley, OD is a "process that applies a broad range of behavioural science knowledge and practices to help organizations build their capacity to change and to achieve greater effectiveness, including increased financial performance, customer satisfaction, and organization member engagement". OD attempts to bring about change in the different levels of the organization (the individual, group and organization) using a wide variety of interventions.
This course will introduce students to the concepts of entrepreneurship so that they have the necessary skill set to explore entrepreneurial opportunities in order to create value, generate wealth and serve society. This course is for students who want to build creative businesses in new or existing firms; foster effective, innovative work in the people they lead; and preserve their own creativity in the face of career pressures and organizational constraints. This course is designed to help you develop your own creativity, apply creative ideas in entrepreneurial ventures, and support the creativity of the people you lead. You will learn to recognize, analyze, and support creative behavior in organizations in a wide variety of industries. In this course, theoretical models and the process of OD will be discussed. Students will also learn how to improve individual, group/team and organizational performance through the use of OD techniques or interventions like group dynamics, training, culture change, and work-life balance.

Recommended Books:

- Cummings, T. G. & Worley, C. G. (2009).Organization development and change (9th edition).Canada: South-Western Cengage Learning.
- De Guia, F. (2000). Culture change: key to organization development: A success story. Makati City: Florence de Guia& Associates
- Brown, D. R. (2011). An experiential approach to organizational development. (8th ed). New Jersey: Pearson Education, Inc.

Course Title: Marketing Management in Engineering Concerns
Course Code: EMG 612
Credit Hours Theory: Three (3)

Course Outline:

These Course brief students about Combines intermediate and advanced statistical methods with practical research applications and computer software. Develops commonly used statistical models such as Two and Three-Way Analysis of Variance as well as Multiple Linear Regression for the solution of common business

and industrial research problems. The statistical models are implemented and interpreted in the context of actual data sets using available statistical software (MVPSTats, SPSS, and special purpose software).
At the conclusion of this course, the student should possess the ability to perform required statistical analyses for virtually any uni-variate application in a business / industrial setting. Able to describe and implement management information systems, ERP and manufacturing execution systems.

Recommended Books:

Course Title: Advanced Statistical Methods for Engineering Research
Course Code: EMG 613
Credit Hours Theory: Three (3)

Course Outline:

This course combines intermediate and advanced statistical methods (specifically ANOVA) with practical research applications and computer software. It also explains and gives practical experience in the use commonly used statistical experimental design models including Two and Three-Way Analysis of Variance as well as Linear Regression (time permitting) for the solution of common business and industrial research problems. The statistical models are implemented and interpreted in the context of actual data sets using statistical software programs. Mandatory Prerequisites are: EMEN 5005 and EMEN 5900; OR APPM 4570/5570 and APPM 4580/5580, or the equivalent as assessed and approved solely by the instructor. The Design & Analysis of Factorial Experiments for 2 Factors - Model I, Model II, and Model III Applications; Fully Crossed and Nested Analyses - Common Transformations. The Design and Analysis of Factorial Experiments with 3 or More Factors - Model I, Model II, and Model III Applications; Fully Crossed and Nested Analyses - AET Determination - Quasi- and Pseudo-F Ratios Review of Simple regression and correlation. Additional Measures of Relationship - Special-Purpose Indices and Methods for Correlation and Association. Non-Linear Regression Analysis, Introduction to Multiple Regression Analysis.

Recommended Books:

- Statistical Principles of Experimental Design, 2nd Edition, by B. J. (Ben) Winer, McGraw-Hill, 1971.
- Design of Experiments in Quality Engineering, by Jeffrey Luftig & Victoria Jordan, McGraw-Hill Publishing Company, 1998.

Course Title: Innovation and Technology Management
Course Code: EMG 614
Credit Hours Theory: Three (3)

Course Outline:

The framework of this course is an evolutionary process perspective on technology management and innovation. The focus is on processes to help firms better manage technology and innovation. The fundamental ideas underlying this evolutionary perspective are 1) a firm's technology strategy emerges from its technological competencies and capabilities; 2) technology strategies shaped by external (environmental) and internal (organizational) forces; and 3) the enactment of technology strategy, through the experience it generates, serves to further develop the firm's technological competences and capabilities. We will deal with typical issues that managers in technology based firms deal with. The course takes an innovative and creative view of information technology that extends beyond the province of business applications built and used by a single organization. You will learn how organizations can commercialize their technological innovations and how the associated risks and benefits might be managed. Through the open innovation paradigm you will see

how internal and external ideas can be brought together and innovations can be transferred inward and outward through licensing, joint ventures and spin-offs.

Recommended Books:

1. Schilling (2012). Strategic Management of Technological Innovation (4e). McGraw-Hill, New York, NY, USA.
2. Chesbrough (2003) Open Innovation (1e). Harvard Business School Press, Boston, MA, USA.
3. Osterwalder & Pigneur (2010) Business Model Generation (1e). Wiley Hoboken, NJ, USA.

Course Title: Financial Risk Management
Course Code: FIN 681
Credit Hours Theory: Three (3)

Course Outline:

This course will focus on variety of risks faced by financial managers and the tools available for managing these risks. Particularly, we shall focus on credit risk, interest rate and liquidity risks, market risk, foreign exchange risk, and country risk. We shall learn about the tools and techniques available for managing these risks such as future contracts, option contracts, swaps, value-at-risk (VaR) and other standard risk-hedging techniques, and methods of measuring volatility. Students attending this course are expected to have studied basic courses of investment and portfolio management and have good understanding of asset pricing models.

Recommended Books:

- Hull, John C., 2007, Risk Management and Financial Institutions (RMFI), Prentice-Hall.
- Hull, John C., 2006, Options, Futures, and Other Derivatives [OFOD], Prentice-Hall (sixth edition).
- Ross, Stephen A., Wester field, Randolph W., Jaffe, Jeffery F., & Roberts, Gordon S., Corporate Finance, Any Edition, McGraw Hill Ryerson, 1999. [Referred to below as "RWJR"]
- Risk Management and Derivative by Rene Stulz, second edition.

Course Outline: Engineering Laws and Contract Management
Course Code: SCM 512
Credit Hours Theory: Three (3)

Course Outline:

Many of us unwittingly enter into contracts every day of our lives – when we leave our car in a car park, when we take a train or bus journey or when we shop. Entering into a business contract is altogether more complex and the implications of getting it wrong can have far reaching effects on the profitability of your business. Understand the origin and legal reasoning behind many of the contract clauses and terminology you use and understand why terms are couched in the way they are. Be better prepared to write and negotiate contract arrangements that provide sufficient protection to your company. Understand some of the core doctrines within English contract law such as the sanctity of contract, the privet of contract, the concept of reasonableness and how these have adapted over recent years. Identify the critical elements required to create a legally binding contract enforceable by law.

Recommended Books:

Course Title: Human Resource Management and Corporate Social Responsibility
Course Code: EMG 615
Credit Hours Theory: Three (3)

Course Outline:

This Course is designed to explore human resource management (HRM) in an international setting, on a course designed in response to the increasing internationalization and workforce diversity of organizations.
The course focuses on managing human resources in organizations that operate across national borders and the cross cultural issues of people management. It is for those wishing to develop careers in HRM at a strategic and international level within organizations operating in the international environment.
The course enables you to develop a critical understanding of the philosophies and general practices of international HRM appreciate and critically evaluate the latest theoretical concepts, principles, standards and frameworks of HRM practice develop skills in solving complex scenarios related to improving the activities and functions of modern HRM develop a holistic approach to examining issues and solving complex International HR problems. You develop your professional expertise and improve your employability and career prospects by gaining broader international business, management and leadership knowledge. We begin by introducing you to organization theory, which covers organizational design, organizational theory and methodologies for understanding complex organizations. You also develop your critical thinking on issues such as organizational change and innovation.

Recommended Books:

- All the electronic resources i.e. slides, handouts and books are made available on the group site
- The assignments have to be submitted in hard copy on or before the date announced

Course Title: Systems Thinking
Course Code: EMG 616
Credit Hours Theory: Three (3)

Course Outline:

This Course is about to Understand that issues facing the world are complex and multi-dimensional, straddle many different factors and involve diverse multi-stakeholder systems. Understand the context in which the problems arise (culture, political systems, and values) and how disciplines or areas of interest fit into the whole. Understand how different disciplines are interconnected and interdependent. Obtain skills to address the underlying root causes rather than the symptoms of a problem. Identify positive and negative feedback across components of a system. Obtain skills to address problems that appear to be intractable. Understand how the changing nature of the world impacts upon the way in which people and organizations make decisions.

Recommended Books:

Course Title: Advanced Big Data Analytics
Course Code: SEN 762
Credit Hours Theory: Three (3)

Course Outline:

This course shall provide the fundamental knowledge to equip students being able to handle those challenges. This discipline inherently involves many fields. Because of its importance and broad impact, new software and hardware tools and algorithms are quickly emerging. A data scientist needs to keep up with these ever changing trends to be able to create a state-of-the-art solution for real-world challenges.

This Big Data Analytics course shall first introduce the overview applications, market trend, and the things to learn. Then, students shall be introduced fundamental platforms, such as Hadoop, Spark, and other tools, such

as IBM System G for Linked Big Data. Afterwards, the course will introduce several data storage methods and how to upload, distribute, and process them. This shall include HDFS, HBase, KV stores, document database, and graph database. The course will go on to introduce different ways of handling analytics algorithms on different platforms. Then, students shall introduce visualization issues and mobile issues on Big Data Analytics. Students will then have fundamental knowledge on Big Data Analytics to handle various real-world challenges.

Afterwards, the course will zoom in to discuss large-scale machine learning methods that are foundations for artificial intelligence and cognitive networks. The course will discuss several methods to optimize the analytics based on different hardware platforms, such as Intel & Power chips, GPU, FPGA, etc. The lectures will conclude with overview of the future challenges of Big Data, especially on the ongoing Linked Big Data issues which involves graphs, graphical models, spatio-temporal analysis, cognitive analytics, etc.

Given large amount of data, one fundamental scientific challenge is how to develop efficient and effective computational tools to analyze the data, revealing insight and make predictions. Data analytics is the science of achieving these goals. It is an inter disciplines of machine learning, data mining, statistics, and so on. This class aims to provide an overview of advanced machine learning, data mining and statistical techniques that arise in data analytic applications. In this class, you will learn and practice advanced data analytic techniques, including: parallel algorithms, online algorithm, locality sensitive hashing, topic modelling, structure learning, and time-series analysis.

Recommended Books:

- C. Bishop, Pattern Recognition and Machine Learning, Springer 2007.
- All of statistics: a concise course in statistical inference. Larry Wasserman. Springer, 2004
- Trevor Hastie, Robert Tibshirani, Jerome. H. Friedman. The elements of statistical learning: data mining, inference and prediction. Springer, 2009

Course Title: Information Systems Management
Course Code: EMG 617
Credit Hours Theory: Three (3)

Course Outline:

This course introduces the student to the area of computer-based information system. In this course you will study system types its components, SDLC and different models of SDLC. You will also study design methods, security, virus and threats to information system. In addition to these topics you will also learn risk management and E-commerce.

Recommended Books:

- Kenneth C. Laudon and Jane P. Laudon (0), "Management Information Systems", 8th Ed, Prentice Hall.

Course Title: Enterprise System and Audit
Course Code: EMG 618
Credit Hours Theory: Three (3)

Course Outline:

This course focuses on the theory and practice of implementing and utilizing enterprise-wide application systems in organizations and their audit. Few organizations attempt to build information systems on their own and many rely upon the marketplace to fulfil their information systems needs nowadays. Furthermore, the adoption of enterprise systems is usually done in the context of a larger organizational improvement and change initiative.

Enterprise systems are usually based on packaged software products, they drive for cross-functional integration and require organization-wide resources for their implementation. The lifecycle of enterprise systems including the development, the implementation, its use evaluation and audit involves company external entities (e.g. software vendors or consulting companies) as well as company internal entities (e.g. IT departments or end-users).

Recommended Books:

- Sawyer, S. (2001). A market-based perspective on information systems development. Communications of the ACM, 44(11), 97-102.
- Scott, J.E., Kaindl, L. (2000). Enhancing functionality in an enterprise software package. Information & Management, 37, 111-122.
- Design of Enterprise Systems: Theory, Architecture, and Methods, By Ronald E. Giachetti

Course Title: Information system strategy and Innovation
Course Code: EMG 619
Credit Hours Theory: Three (3)

Course Outline:

This Course is designed to examine the way information technology is being used to influence the competitive strategy of corporations and to assess the impact of strategic deployment of information systems. Students learn to effectively manage a firm's information and technology assets in order to meet the information needs of the organization. Topics include information systems strategies; the development of information system assets; organizational information infrastructure; databases and data management including decision making support; enterprise resource planning systems; e-business; social media use by organizations; information security and risk management; innovating with information technology; and leadership and management of information systems

Students learn to effectively manage a firm's information and technology assets in order to meet the information needs of the organization. Topics include information systems strategies; the development of information system assets; organizational information infrastructure; databases and data management including decision making support; enterprise resource planning systems; e-business; social media use by organizations; information security and risk management; innovating with information technology; and leadership and management of information system.

Recommended Books:

1. Rainer, Cegielski, Splettstoesser-Hogeterp, Sanchez-Rodriguez. Introduction to Information Systems. 2nd Canadian Edition, Wiley, 2011

Course Title: Information System Security and Ethics
Course Code: EMG 620
Credit Hours Theory: Three (3)

Course Outline:

This course provides a one-semester overview of information security. The technical content of the course gives a broad overview of essential concepts and methods for providing and evaluating security in information processing systems (operating systems and applications, networks, protocols, and so on).

In addition to its technical content, the course touches on the importance of management and administration, the place information security holds in overall business risk, social issues ethical perspective, such as individual privacy, and the role of public policy. This course will explore methods, tools, and techniques that intruders use to exploit vulnerabilities in systems. The course provides basic ethical elements of information

and computer security with its risk assessment. Additionally, awareness training, countermeasures and safeguards and continuity of operations are taught.

Recommended Books:

- M. Whitman and H. Mattord (2005), "Principles of Information Security", 2nd Ed, Course Technology.
- Motiwalla, L. F., and J. Thompson (2009), "Enterprise Systems for Management", Pearson Prentice Hall.
- Peter Gregor (2010), "CISSP Guide to Security Essentials", 1st Ed.

Course Title: Advanced Usability Engineering
Course Code: SEN 756
Credit Hours Theory: Three (3)

Course Outline:

This course will explore primary issues relating to usability, why they are necessary, their application, and their influence on design. Students will investigate various methods of conducting usability studies for original designs through testing scenarios and heuristic analysis. This course will give students a firm understanding of the user-centered methods and principles for the development of various kinds of interactive system, and to provide students with experience of analyzing, designing and evaluating graphical user interfaces.

Recommended Books:

- Jenny Preece, Helen Sharp, Yvonne Rogers (2015), "Interaction Design: Beyond Human-Computer Interaction" 4th Ed, Wiley.
- Leventhal and Bames (2007), "Usability Engineering: Process, Products, and Examples", Pearson and Prentice Hall.
- Jakob Nielsen (1993), "Usability Engineering", Academic Press.

Course Title: Socio-Technical Systems
Course Code: EMG 621
Credit Hours Theory: Three (3)

Course Outline:

We live and work in complex adaptive and evolving socio-technical systems. These systems may be complex for a variety of reasons. For example, they may be complex because there is a need to coordinate many groups, because humans are interacting with technology, because there are non routine or very knowledge intensive tasks, and so on. At the heart of this complexity is a set of adaptive agents who are connected or linked to other agents forming a network and who are constrained or enabled by the world they inhabit. Computational modelling can be used to help analyze, reason about, predict the behaviour of, and possibly control such complex systems of "networked" agents.

This course is based on the simulation of complex socio-technical systems. This course teaches the student how to design, analyze, and evaluate such computational models. It will introduce several styles of simulation including agent based and system dynamics. Examples of applications of these tools to various problems such as epidemiology, organizational adaptation, information diffusion, impact of new technology on groups, and so on, will be discussed. The course should be appropriate for graduate students in all areas. This course does not teach programming. Issues covered include: common computational approaches such as multi-agent systems, general simulation and system dynamics, heuristic based optimization procedures including simulated annealing and genetic algorithms, representation schemes for complex systems (particularly, groups, organizations, tasks, networks and technology), analysis techniques such as virtual experiments and response surface mapping, docking (model-to-model analysis), validation and verification, and social Turing tests. Illustrative models will be drawn from recent publications in a wide variety of areas including

distributed artificial intelligence, knowledge management, dynamic network analysis, computational organization theory, computational sociology, computational epidemiology, and computational economics.

Recommended Books:

- Law &Kelton, "Simulation Modeling & Analysis", McGraw Hill.
- Carley, K. & M. Prietula (Eds) "Computational Organization Theory" Lawrence Erlbaum Associates.
- Epstein, J. & R. Axtell (1997), "Growing Artificial Societies", Boston, MA: MIT Press.
- Sterman, J. (2000), "Business Dynamics: Systems thinking and modeling for a complex world". Irwin/McGraw-Hill.

Course: Decision Support Systems
Code: CSC 518
Credit Hours Theory: Three (3)

Course Outline:

This Course is about to review of the literature in the area of decision support systems (DSS) and DSS frameworks. Understanding the process of decision-making and issues involved in the design, implementation and evaluation of DSS. Additional topics include data mining, user interfaces, knowledge-based DSS, and research directions in DSS. Knowledge gained will be applied through the design and implementation of a DSS prototype.

Recommended Books:

- F. Burstein (2008), "Hand Book On Decision Support Systems", Springer, 2008.
- Ephraim Turban and Jay Aronson (2001), "Decision Support Systems and Intelligent Systems", Prentice-Hall.
- Robert Clemen (1996), "Making Hard Decisions", 2nd Ed, Duxbury.

Course Title: Advanced Requirement Engineering
Course Code: SEN 658
Credit Hours Theory: Three (3)

Course Outline:

This Course focused on Systems engineering which is an interdisciplinary field of engineering focusing on how complex engineering projects should be designed and managed over their life cycles. Course is about importance of System engineering. Systems engineering is a well-developed body of knowledge, techniques, and methodologies in general use throughout technically complex industries. Its goal is the efficient production of high-quality products that meet the requirements of customers. All aspects of the process--from initial definition of mission requirements to test, verification, and fabrication of the product--must be carefully planned and executed.

Recommended Books:

Course Title: Advanced Software and System Architecture
Course Code: SEN 621
Credit Hours Theory: Three (3)

Course Outline:

This Course is designed to give emphasizes on Systems engineering is an interdisciplinary field of engineering focusing on how complex engineering projects should be designed and managed over their life cycles. Course is about importance of System engineering. Systems engineering is a well-developed body of knowledge, techniques, and methodologies in general use throughout technically complex industries. Its goal is the efficient production of high-quality products that meet the requirements of customers. All aspects of the process--from initial definition of mission requirements to test, verification, and fabrication of the product--must be carefully planned and executed.

Recommended Books:

- Alexander Kossiakoff (2011), "Systems Engineering Principles and Practice".

Course name: Advanced Software Project Management
Course Code: SEN 647
Credit Hours Theory: Three (3)

Course Outline:

This course deals with managing information technology and software development projects. It is not restricted to project managers, but encompasses the art and science of using teamwork to meet project goals. The team includes the project manager, lead developers, software engineers, supporting functions, business experts and other stakeholders. Therefore, this course is directed to students across a wide range of backgrounds and interests. The student will learn how to conceptualize, initiate, plan and execute a successful project. Students will be able to recognize the principles of general management theory which transfer to software project management, apply techniques for successfully managing a project throughout its life-cycle, interpret the processes and knowledge areas in the Project Management Institute's Project Management Body of Knowledge, formulate the determination of success as a measurable organizational value and consider the human side of projects including participation in a team project.

Recommended Books:

- Jack Marchewka (2012), "Information Technology Project Management" 4th edition, John Wiley & Sons.
- Frederick Brooks, Jr. (2010), "The Design of Design: Essays from a Computer Scientist", Pearson Education (2010).

Appendage 1704

Bahria University Karachi Campus

Course Assessment Report

of

ABC (SEN-111)

Fall 2018

Course Instructor: XYZ

Table of Contents

General Guidelines

Aims and Objectives:

1. The objective of this report is to assess the **Course Learning Outcomes (CLO)** and **Program Learning Outcomes (PLO)** covered by the course. Other additional types of assessment can be used if useful (such as online student survey).
2. Assessment is mandatory for all courses in each semester. Each faculty member teaching a course must produce a Course Assessment Report (CAR) as part of the course portfolio.
3. If a course has several sections and each section is taught by a different instructor, assessment must be done for each section separately. However, a joint report should be produced for a single course.
4. The report must contain both direct assessment (marks obtained by students in quizzes, assignments, exams, projects, etc.) and indirect assessment (opinion of students through surveys).
5. Each faculty member must keep his/her data at the most detailed level. Having the data at the detailed level will serve as evidence. It may also assist in generating any analysis that can be needed later.
6. Assessment is based on two different levels, i.e. CLOs and PLOs.

CLOs Assessment:

7. Level of satisfaction in CLOs is defined through the Key Performance Indicators (KPIs) set as follows:

- **Unsatisfactory:** given to a student whose score in a specific outcome is < 50%.
- **Developing**: given to a student whose score in a specific outcome is ≥ 50% and < 70%.
- **Satisfactory:** given to a student whose score in a specific outcome is ≥ 70% and < 90%.
- **Exemplary:** given to a student whose score in a specific outcome is ≥ 90%.

PLOs Assessment:

8. Levels of assessment in PLOs is defined through KPIs set as follows:

a. For direct assessment:

- **Unsatisfactory:** given to a student whose score in a specific outcome is < 60%.
- **Developing:** given to a student whose score in a specific outcome is ≥ 60% and < 70%.
- **Satisfactory:** given to a student whose score in a specific outcome is ≥ 70% and < 90%.
- **Exemplary:** given to a student whose score in a specific outcome is ≥ 90%.

b. For indirect assessment:

- **Unsatisfactory**: corresponds to **Disagree** + **Strongly Disagree** in a specific outcome.
- **Developing**: corresponds to **Neutral** in a specific outcome.
- **Satisfactory**: corresponds to **Agree** in a specific outcome.
- **Exemplary**: corresponds to "**Strongly Agree**" in a specific outcome.

9. The final judgment of the attainment of PLOs is based on the followings:

Table 1: Criteria for attainment of PLOs.

Exceeds	Meets	Progressing	Does Not Meet

Expectations (EE)	Expectations (ME)	Towards Expectation (PE)	Expectations (DNME)
The average grade ≥ 90%	The average grade is ≥ 70% and < 90%	The average grade is ≥ 60% and < 70%	The average grade is < 60%

Continuous Quality Improvement:

10. The analysis of the assessment results must be oriented towards:

- Identifying the issues and root causes behind the non-attainment of a specific outcome.
- The attainment of CLOs must be mapped to the **Bloom's Taxonomy** level/domains and analyzed w.r.t. lagging of students in certain level(s).
- When analyzing the results of PLOs assessment of a course, we must necessarily pay attention to the cases with DNME and PE.
- Pay attention to cases with an important discrepancy (such as > 15%) between direct and indirect assessment for a specific PLO; especially if the direct assessment (opinion of teacher) is much higher than the indirect assessment (opinion of students).
- Pay attention to Online Student Survey, where if we have questions with Unsatisfactory or Developing, we should also comment them.
- Determining corrective actions to be taken in the following semester(s) to resolve those issues and root causes.

11. At the end of each semester / beginning of following semester, an assessment meeting will be held at the department level in order to evaluate the **teaching achievements and issues** of the past semester based on course assessment reports done for each course taught. An **improvement plan** will result based on that assessment meeting. All faculty members should be involved and work to implement the improvement plan during the following semester(s).

1. **Course Summary**

Course Title	ABC
Course Code	SEN-111
Credit Hours	3+0
Prerequisite	EFG
Instructor	HIJ
Semester	5th Semester (Fall 2018)
Class & Section	BSE-5A
Number of Enrolled Students	32
Average GPA	x.yy

Course Learning Outcomes (CLOs)

CLO #	CLO Statement	Bloom's Taxonomy
CLO 1:	Describe the fundamental concepts of ...	**C1**
CLO 2:	Describe the main services ...	**C1**
CLO 3:	Explain ...	**C2**
CLO 4:	Work in coordination within ...	**A2**

Blooms Taxonomy Domains/Levels

Cognitive	Knowledge (C1)
	Comprehension (C2)
	Application (C3)
	Analysis (C4)
	Synthesis (C5)
	Evaluation (C6)
Affective	Receiving Phenomena (A1)
	Responding to Phenomena (A2)
	Valuing (A3)
	Organization (A4)
	Internalizing (A5)
Psychomotor	Perception (P1)
	Set (P2)
	Guided Response (P3)
	Mechanism (P4)
	Complete Overt Response (P5)
	Adaption (P6)

	Organization (P7)

Students Grading Profile

Grading System

Letter Grade	Grade Point	Percentage	
A	4.0	≥ 85	-
A-	3.67	≥ 80	< 85
B+	3.33	≥ 75	< 80
B	3.00	≥ 71	< 75
B-	2.67	≥ 68	< 71
C+	2.33	≥ 64	< 68
C	2.00	≥ 60	< 64
C-	1.67	≥ 57	< 60
D+	1.33	≥ 54	< 57
D	1.00	≥ 50	< 53
F	0.00	-	< 50
W	Withdrawn	-	-

Grades Distribution

Letter Grade	Grade Point	# Students	%
A	4.0	2	5%
A-	3.67		
B+	3.33		
B	3.00		
B-	2.67		
C+	2.33		
C	2.00		
C-	1.67		
D+	1.33		
D	1.00		
F	0.00		
W	Withdrawn		
Average GPA =x.yy			

2. CLOs Assessment

Direct assessment of CLOs attainment considers quizzes, presentation, assignments, midterm and final exam done by students during the whole semester and proceeds as follows:

- Assign each question in exam, quiz and assignments to a specific CLO.
- Count the marks allocated to each CLO.
- Count the average score achieved by students in each CLO.

MAPPING OF CLOS TO COURSE EVALUATION INSTRUMENTS

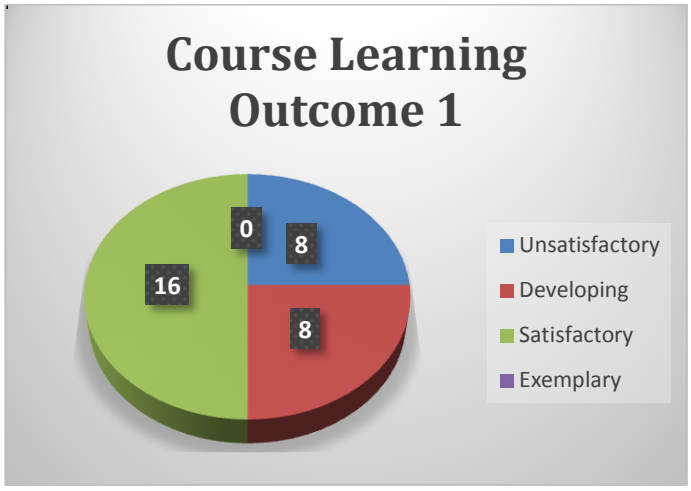
EI	CLO's			
	CLO 1	CLO 2	CLO 3	CLO 4
QUIZ#01	✓			
QUIZ#02		✓		
QUIZ#03			✓	
ASSIGNMENTS#01	✓			
ASSIGNMENTS#02			✓	
ASSIGNMENTS#03				✓
MIDTERM EXAM	✓	✓		
FINAL EXAM	✓	✓	✓	

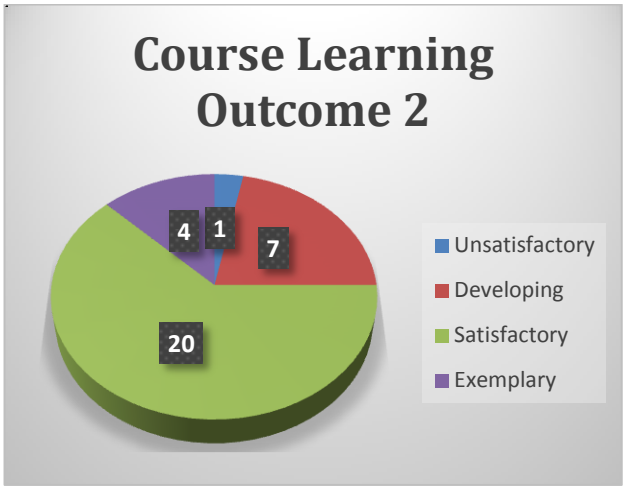
Table 2: Marks distribution over direct assessment instruments and CLOs.

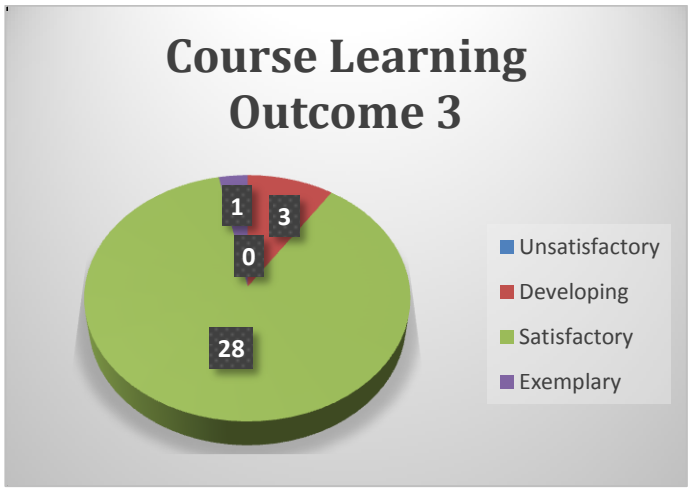
CLO #	Quizzes	Assignments	MidTerm	Final Exam	Total per CLO
CLO 1	Quiz1 (5.0)	Assign1 (5.0)	Q1(3), Q2(3), Q3(3), Q4(3)	Q2(6)	28.0
CLO 2	Quiz2 (2.5)	None	Q5(3), Q6(5)	Q4(6), Q5(6)	22.5
CLO 3	Quiz3 (2.5)	Assign2 (5.0)	none	Q1(10), Q3(6), Q6(6), Q7(10)	39.5
CLO 4	None	Assign3 (10.0)	none	none	10.0
Total per Assessment Instrument	10.0	20.0	20.0	50.0	100.0

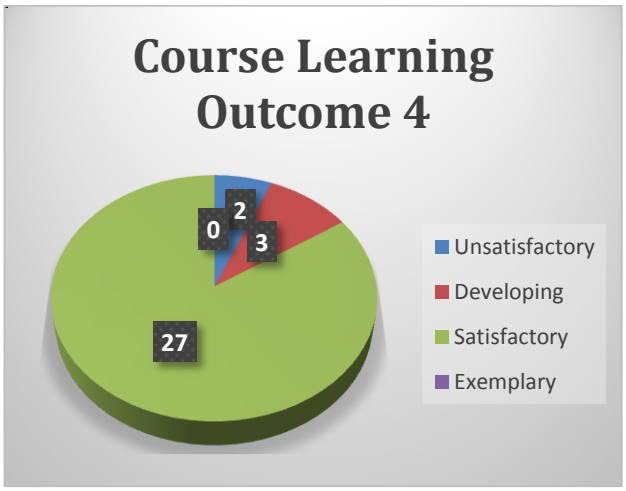
The results obtained by number of students in each course learning outcomes summarized as follows:

	CLO 1	CLO 2	CLO 3	CLO 4
Unsatisfactory	8	1	0	2
Developing	8	7	3	3
Satisfactory	16	20	28	27
Exemplary	0	4	1	0
Total	**32**			


Course Learning Outcome 1
0
8
16
8
Unsatisfactory
Developing
Satisfactory
Exemplary


Course Learning Outcome 2
4
1
7
20
Unsatisfactory
Developing
Satisfactory
Exemplary


Course Learning Outcome 3
1
3
0
28
Unsatisfactory
Developing
Satisfactory
Exemplary


Course Learning Outcome 4
0
2
3
27
Unsatisfactory
Developing
Satisfactory
Exemplary

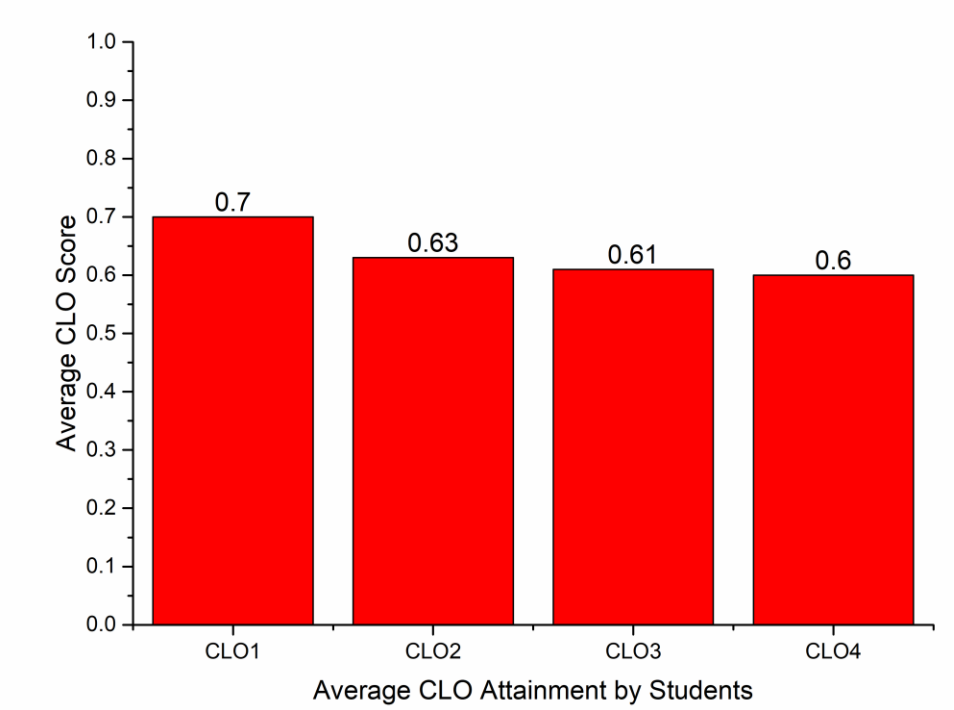


Figure 1: Average attainment of CLOs by all students.

CLO clearance is achieved by obtaining 50% of the score. Based on this criterion:

- Approximately 95% of the students have achieved CLO 1
- Approximately 79% of the students have achieved CLO 2
- Approximately 62% of the students have achieved CLO 3
- Approximately 88% of the students have achieved CLO 4

Mapping of CLOs attainment to Bloom's Taxonomy

Performing a general analysis, students generally lack in CLO3 which is mapped to Comprehension (C2) Bloom's Taxonomy. As a result, students lack in:

- The ability to comprehend the meaning of materials.
- Answering in own words while still using terminology appropriate to the concepts.

3. PLOs Assessment

Attainment of PLOs through direct Assessment

Direct assessment of attainment of program learning outcomes considers quizzes, presentation, assignments, midterm and final exam done by students during the whole semester and proceeds as follows:

- Assign each question in exam, quiz and assignments to a specific PLO.
- Count the marks allocated to each PLO.
- Count the average score achieved by students in each PLO.

Mapping of CLOs to PLOs

PLO's	CLO's			
	CLO 1	CLO 2	CLO 3	CLO 4
PLO:1 (Engineering Knowledge)	✓			
PLO:2 (Engineering Problem Analysis)		✓		
PLO:3 (Designing and Development)			✓	
PLO:4 (Investigation)				
PLO:5 (Modern tool usage)				
PLO:6 (Engineer and Society)				
PLO:7 (Environment and Sustainability)				
PLO:8 (Professionalism and Ethics)				
PLO:9 (Individual and Team Work)				
PLO:10 (Communication)				✓
PLO:11 (Project Management)				
PLO:12 (Lifelong Learning)				

PLO #	Quizzes	Assignments	MidTerm	Final Exam	Total per PLO
PLO 1	Quiz1 (5.0)	Assign1 (5.0)	Q1(3), Q2(3), Q3(3), Q4(3)	Q2(6)	28.0
PLO 2	Quiz2 (2.5)	None	Q5(3), Q6(5)	Q4(6), Q5(6)	22.5
PLO 3	Quiz3 (2.5)	Assign2 (5.0)	none	Q1(10), Q3(6), Q6(6), Q7(10)	39.5
PLO 10	None	Assign3 (10.0)	none	none	10.0
Total per Assessment Instrument	10.0	20.0	20.0	50.0	100.0

The results obtained by students in exams are summarized as follows:

	PLO (1)	PLO (2)	PLO (3)	PLO (10)
Maximum	28.0	22.5	39.5	10.0
AVG Score	19.6	14.18	24.10	6.0

AVG Score %	70.00%	63.02%	61.01%	60.00%
Remarks	Satisfactory	Developing	Developing	Developing

Attainment of PLOs through indirect Assessment

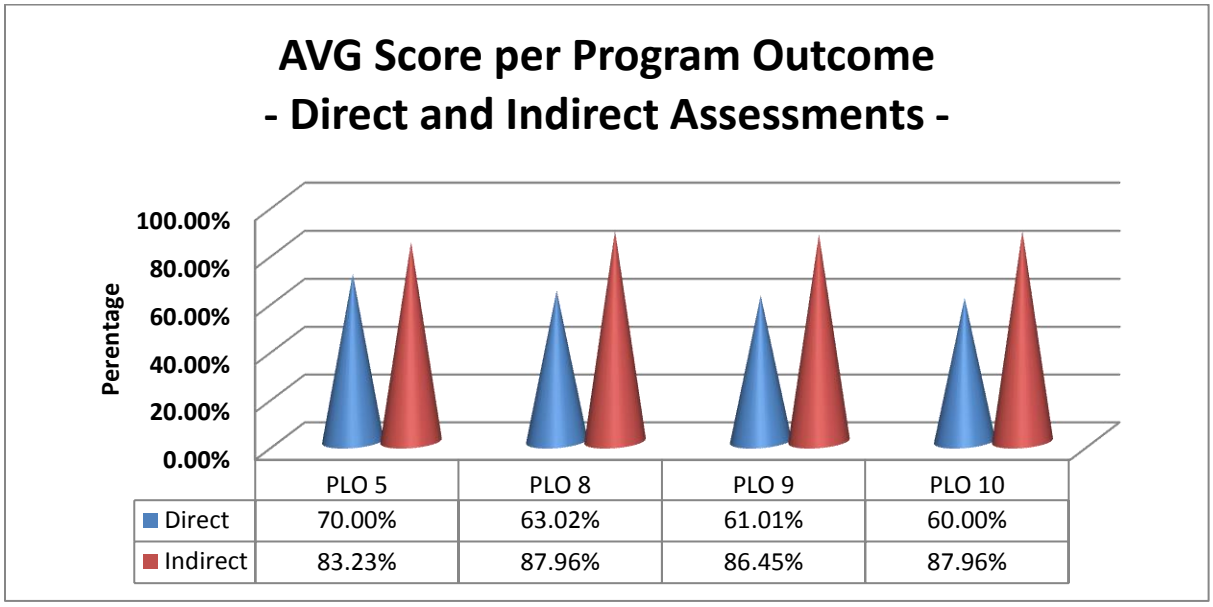
The summary of the course learning outcomes survey conducted with students at the end of the course is given below.

		Strg Agr (1)	Agree (2)	Neutral (3)	Disagree (4)	Str Disagr (5)	Total	AVG Score
CLO 1	Nbr	14	16	1	0	0	31	
	%	45.2%	51.6%	3.2%	0.0%	0.0%	100%	88.39%
CLO 2	Nbr	17	11	3	0	0	31	
	%	54.8%	35.5%	9.7%	0.0%	0.0%	100%	89.03%
CLO 3	Nbr	12	17	2	0	0	31	
	%	38.7%	54.8%	6.5%	0.0%	0.0%	100%	86.45%
CLO 4	Nbr	11	14	6	0	0	31	
	%	35.5%	45.2%	19.4%	0.0%	0.0%	100%	83.23%

The aggregated results from course learning outcomes to program learning outcomes, when using the average score for each student outcome, are as follows:

PLO	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Total	AVG Score
PLO (1)	35.48%	45.16%	19.35%	0.00%	0.00%	100.0%	83.23%
PLO (2)	46.24%	47.31%	6.45%	0.00%	0.00%	100.0%	87.96%
PLO (3)	38.71%	54.84%	6.45%	0.00%	0.00%	100.0%	86.45%
PLO (10)	46.24%	47.31%	6.45%	0.00%	0.00%	100.0%	87.96%

Summary of results for both direct and indirect assessment



The degree of attainment of program learning outcomes according to direct and indirect assessment, by using both the average score, is summarized in the following table.

Program Outcomes Covered by Course	Direct Assessment	Indirect Assessment
	When using the AVG score	When using the AVG score
PLO (1)	**(ME)**	**(ME)**
PLO (2)	**(PE)**	**(ME)**
PLO (3)	**(PE)**	**(ME)**
PLO (10)	**(PE)**	**(ME)**

Bahria University Islamabad Campus

Course Assessment Report

of

ABC (CEN-XXX)

Fall 2018

Course Instructor: XYZ

Table of Contents

General Guidelines

Aims and Objectives:

12. The objective of this report is to assess the course covered in the previous semester covering aspects related to student performance, curriculum and attainment of Course Learning Outcomes (CLOs). It highlights the deficiency in student performance, course contents, CLOs and recommends future modifications which may be incorporated to improve the course quality.

13. Assessment is mandatory for all courses in each semester. Each faculty member teaching a course must produce a Course Assessment Report (CAR) as part of the course portfolio.

14. If a course has several sections and each section is taught by a different instructor, assessment must be done for each section separately. However, a joint report should be produced for a single course.

15. The integral of this report must contain direct assessment based on student performance in quizzes, assignments, exams, projects, etc. both in terms of marks/grade obtained and CLO attainment on individual and cohort levels.

CLOs Assessment:

Level of satisfaction in CLOs is defined through the Key Performance Indicators (KPIs) set as follows:

- **Unsatisfactory:** given to a student whose score in a specific outcome is < 50%.
- **Developing**: given to a student whose score in a specific outcome is ≥ 50% and < 70%.
- **Satisfactory:** given to a student whose score in a specific outcome is ≥ 70% and < 84%.
- **Exemplary:** given to a student whose score in a specific outcome is ≥ 85%.

Continuous Quality Improvement:

The analysis of the assessment results must be oriented towards:

- Identifying the issues and root causes behind the non-attainment of a specific course learning outcome.
- The attainment of CLOs must be mapped to the **Bloom's Taxonomy** level/domains and analyzed w.r.t. lagging of students in certain level(s).
- Determining corrective actions to be taken in the following semester(s) to resolve those issues and root causes.

At the end of each semester / beginning of following semester, an assessment meeting will be held at the department level in order to evaluate the **teaching achievements and issues** of the past semester based on course assessment reports done for each course taught. An **improvement plan** will result based on that assessment meeting. All faculty members should be involved and work to implement the improvement plan during the following semester(s).

Blooms Taxonomy Domains/Levels

Cognitive	Knowledge (C1)
	Comprehension (C2)
	Application (C3)
	Analysis (C4)
	Synthesis (C5)
	Evaluation (C6)
Affective	Receiving Phenomena (A1)
	Responding to Phenomena (A2)
	Valuing (A3)
	Organization (A4)
	Internalizing (A5)
Psychomotor	Perception (P1)
	Set (P2)
	Guided Response (P3)
	Mechanism (P4)
	Complete Overt Response (P5)
	Adaption (P6)

Grading System

Letter Grade	Grade Point	Percentage	
A	4.0	≥ 85	-
A-	3.67	≥ 80	< 85
B+	3.33	≥ 75	< 80
B	3.00	≥ 71	< 75
B-	2.67	≥ 68	< 71
C+	2.33	≥ 64	< 68
C	2.00	≥ 60	< 64
C-	1.67	≥ 57	< 60
D+	1.33	≥ 54	< 57
D	1.00	≥ 50	< 53
F	0.00	-	< 50
W	Withdrawn	-	-

	Organization (P7)	

Course Summary

Course Title	ABC
Course Code	CEN-111
Credit Hours	3+0
Prerequisite	EFG
Instructor	HIJ
Semester	5th Semester (Fall 2018)
Class & Section	BCE-XX
Number of Enrolled Students	XX
Average GPA	x.yy

Course Learning Outcomes (CLOs)

CLO #	CLO Statement	Bloom's Taxonomy
CLO 1:	Describe the fundamental concepts of ...	**C1**
CLO 2:	Describe the main services ...	**C1**
CLO 3:	Explain ...	**C2**
CLO 4:	Work in coordination within ...	**A2**

Students Grading Profile

Grades Distribution in the Course

Letter Grade	Grade Point	# Students	%
A	4.0	2	5%
A-	3.67		
B+	3.33		
B	3.00		
B-	2.67		
C+	2.33		
C	2.00		
C-	1.67		
D+	1.33		
D	1.00		
F	0.00		
W	Withdrawn		
Average GPA =x.yy			

CLOs Assessment

Direct assessment of CLOs attainment considers quizzes, presentation, assignments, midterm and final exam done by students during the whole semester and proceeds as follows:

- Count the marks allocated to each CLO.
- Count the average score achieved by students in each CLO.
- Following table presents the mapping of the CLOs with various assessment tools/activities.

MAPPING OF CLOS TO COURSE EVALUATION INSTRUMENTS

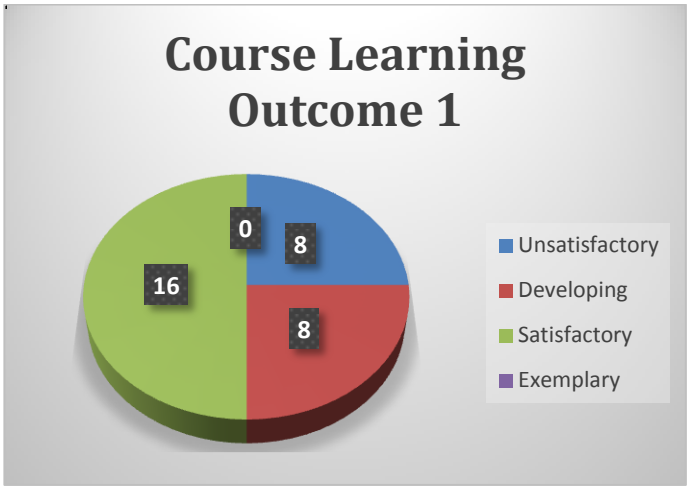
EI	CLO's			
	CLO 1	CLO 2	CLO 3	CLO 4
QUIZ#01	✓			
QUIZ#02		✓		
QUIZ#03			✓	
ASSIGNMENTS#01	✓			
ASSIGNMENTS#02			✓	
ASSIGNMENTS#03				✓
MIDTERM EXAM	✓	✓		
FINAL EXAM	✓	✓	✓	

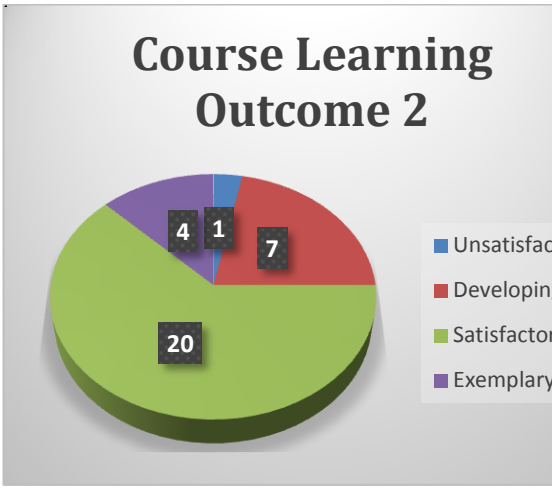
Table 3: Marks distribution over direct assessment instruments and CLOs.

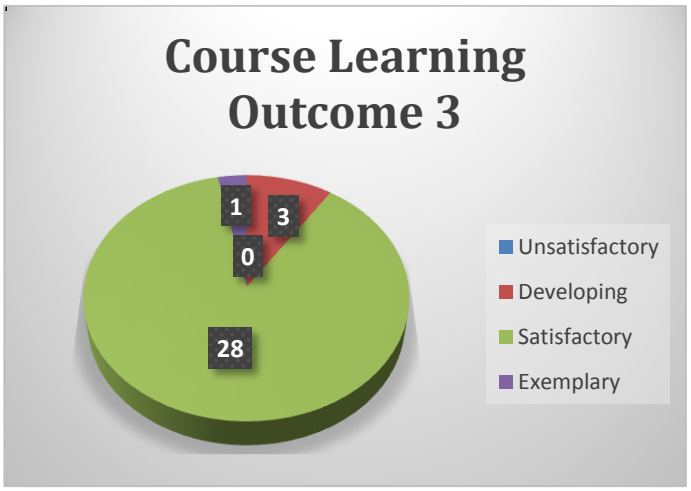
CLO #	Quizzes	Assignments	MidTerm	Final Exam	Total per CLO
CLO 1	Quiz1 (5.0)	Assign1 (5.0)	Q1(3), Q2(3), Q3(3), Q4(3)	Q2(6)	28.0
CLO 2	Quiz2 (2.5)	None	Q5(3), Q6(5)	Q4(6), Q5(6)	22.5
CLO 3	Quiz3 (2.5)	Assign2 (5.0)	none	Q1(10), Q3(6), Q6(6), Q7(10)	39.5
CLO 4	none	Assign3 (10.0)	none	none	10.0
Total per Assessment Instrument	10.0	20.0	20.0	50.0	100.0

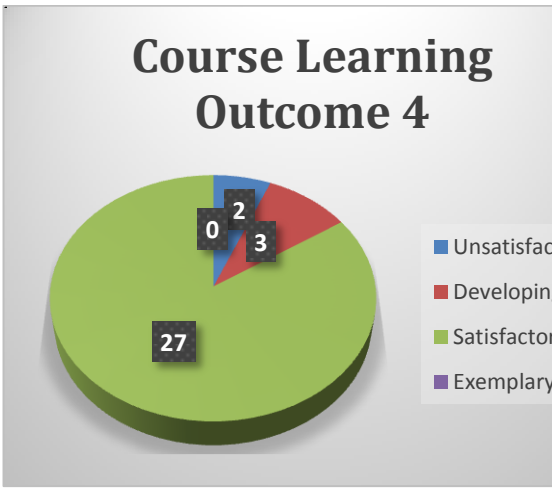
The results obtained by number of students in each course learning outcomes summarized as follows:

	CLO 1	CLO 2	CLO 3	CLO 4
Unsatisfactory	8	1	0	2
Developing	8	7	3	3
Satisfactory	16	20	28	27
Exemplary	0	4	1	0
Total	**32**			


Course Learning Outcome 1
0
8
16
8
Unsatisfactory
Developing
Satisfactory
Exemplary


Course Learning Outcome 2
4
1
7
20
Unsatisfac
Developin
Satisfacto
Exemplary


Course Learning Outcome 3
1
3
0
28
Unsatisfactory
Developing
Satisfactory
Exemplary


Course Learning Outcome 4
0
2
3
27
Unsatisfac
Developin
Satisfacto
Exemplary

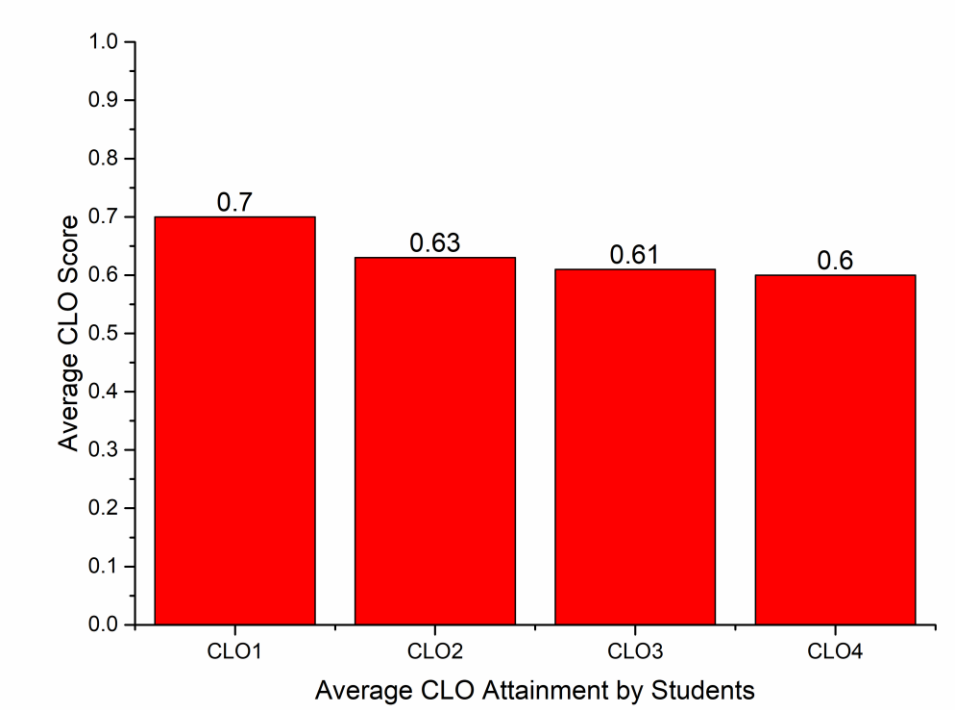


Figure 2: Average attainment of CLOs by all students.

CLO clearance is achieved by obtaining 50% of the score. Based on this criterion:

- Approximately 95% of the students have achieved CLO 1
- Approximately 79% of the students have achieved CLO 2
- Approximately 62% of the students have achieved CLO 3
- Approximately 88% of the students have achieved CLO 4

Mapping of CLOs attainment to Bloom's Taxonomy

Performing a general analysis, students generally lack in CLO3 which is mapped to Comprehension (C2) Bloom's Taxonomy. As a result, students lack in:

- The ability to comprehend the meaning of materials.
- Answering in own words while still using terminology appropriate to the concepts.

Recommendations for Improvement in Course Contents

Recommendations for Improvement in CLOs

Recommendations for Improvement in Mapping of CLOs to PLOs

Name of Faculty Members: _____
Data & Signature: _____

Appendage 1705

POLICY FOR REGISTERING/COMPLETING DEFICIENCY COURSE IN MS DEGREE PROGRAMS – ENGINEERING SCIENCES

1. Pre-requisite/deficiency courses are to be assigned by the Admission Committee (as per the approved roadmap of the concerned program) and notified by the department to student, Dean ES, Dir PGP, Dir Campus, Dir Admission and Dir Exam.
2. The student must register deficiency courses with the undergraduate degree programs of Bahria University.
3. The student shall be offered provisional admission in relevant MS program subject to successful completion of deficiency courses within a maximum duration of 1 year.
4. The provisional admission of the student will be cancelled, if he/she is unable to complete deficiency courses after one year.
5. Student has to pay deficiency courses fee as per undergraduate program credit hour rates.
6. The deficiency courses shall be recorded on transcript as PASS / FAIL. The passing marks for the deficiency courses shall be as per BU undergrad rules {50%}.
7. If a course has a Lab component then based on Admission Committee recommendation registering in Lab shall also be compulsory. For those courses, passing both theory and lab work of the course shall be mandatory.

8. The deficiency courses shall not be included in CGPA calculations of the degree program.
9. The Students can register and complete their deficiency courses by adopting either of the following methods:

Method – 1 (Completion of deficiency courses prior to starting MS degree)

10. A student cannot register in MS degree program until (s)he successfully completes his deficiency courses.
11. Temporary enrollment shall be assigned to student for the completion of deficiency course(s).
12. The duration during which the student completes the deficiency course(s) shall not be considered as part of student's MS degree duration.
13. The student completing their deficiency course(s) prior to starting MS degree shall be eligible for honors and awards.
14. The UG semester rules shall be applicable to the student including registration, attendance, examinations etc.

Method – 2 (Completion of deficiency courses along with MS degree)

15. Based on Admission Committee recommendation, students can register in those MS courses for which they have already studied pre-requisites in their previous degree.
16. To complete deficiency course(s) within one year of registering in the MS program, the student shall be allowed to register four courses per semester.
17. Students registering in deficiency courses along with MS degree will deviate from their regular degree roadmap and shall not be eligible for awards and honors after degree completion.

Appendage 1706

Curriculum of
Masters in Computer Science
(Revision 2018)

Bahria University

Table of Contents

MSCS PROGRAM

PROGRAM MISSION

The mission of the MSCS program is to produce Computer Science graduates who are able to apply their theoretical knowledge and analytical skills to create effective and novel solutions to practical and research oriented computing problems.

PROGRAM OBJECTIVES

The key objectives of the MSCS program include the following.

1. To provide an in-depth understanding of the theory and concepts of the core Computer Science areas.
2. To prepare students for graduate level training in specialized areas of Computer Science.
3. To enable learning of the latest computing tools and technologies.
4. To enable students apply their knowledge and analytical skills to create effective and novel solutions to a wide range of computing problems.
5. To develop effective oral and written communication skills.
6. To prepare students to work effectively independently as well as in groups.

PROGRAM LEARNING OUTCOMES

Students graduating from the MSCS program are expected to gain:

1. Ability to apply Mathematical foundations, computational theory and algorithmic principles to solve practical as well as research oriented computing problems.
2. Ability to turn complex programming specifications into well-designed and well-tested computer programs.
3. Acquaintance with the latest computing tools and technologies.
4. Ability to communicate effectively in written and oral form.
5. Ability to pursue continuous professional development.
6. Ability to work on practical and research based problems collaboratively as well as independently.

Course Codes	Course Names	

ELIGIBILITY CRITERIA

HEC recognized 4 years Bachelor degree in CS/SE/CE/EE/IT or equivalent or MCS/MIT with CGPA 2.5/4.0 (Semester System) or 50% marks (Annual System). NTS-GAT (General)/ GRE/University entry test passed with 50% marks. The candidates must have taken the following pre-requisite courses for MSCS program.

a. Computer Programming
b. Analysis of Algorithms
c. Computer Architecture
d. Operating Systems
e. Theory of Automata

DISTRIBUTION OF CREDIT HOURS

Category	Credit Hours
Core Courses	12
University Requirement	3
Elective Courses	9
Thesis	6
Total credit hours	**30**

LIST OF COURSES

CORE COURSES

UNIVERSITY REQUIREMENT

ELECTIVE COURSES

CSC-504	Ubiquitous Computing	
CSC-505	Intelligent User Interface Design and Evaluation	
CSC-515	Virtual Reality	
CSC-516	Game Theory	
CSC-701	Computer Supported Cooperative Work	
SEN-720	Advanced Human Computer Interaction	
SEN-756	Advanced Usability Engineering	

CSC-518	Decision Support Systems	
CSC-715	Intelligent Agents	
CSC-719	Machine Learning	
DSC-704	Deep Learning	
CSC-741	Advanced Natural Language Processing	
CEN-745	Advanced Digital Image Processing	
CSC-749	Advanced Neural Networks and Fuzzy Logic	
CSC-751	Pattern Recognition	
CSC-764	Computer Vision	
CSC-750	Intelligent Tutoring Systems	

EET-519	Distributed Networking	
EET-520	Network Administration and Management	
EET-556	Mobile Communications and Networking	
EET-702	Advanced Network Security	
EET-	Advanced Network Design	

713		
EET-716	Advanced Topics in Wireless Networking and Communications	
EET-718	Network Performance Evaluation	
EET-761	Network Protocols and Standards	
CSC-781	Cloud Computing	
CSC-553	Advanced Information Theory	
CSC-746	Advanced Data Mining	
CSC-747	Text Mining	
CSC-752	Advanced DBMS	
CSC-753	Distributed Databases	
CSC-754	Object Oriented Databases	
CSC-755	Web based DBMS	
CSC-756	Multimedia Databases	
CSC-760	Advanced Data Warehousing	
CSC-514	Information Retrieval Techniques	
SEN-764	Ontology Engineering	
SEN-761	Semantic Web	

ROAD MAP – MS CS

Course Code	Course Title	Credits
Semester 1		
CSC-503	Advanced Theory of Computation	3
CSC-521	Advanced Design and Analysis of Algorithms	3
ESC-701	Research Methodology (University Requirement)	3
	Total	**9**
Semester 2		
CSC-720	Advanced Operating Systems	3
CEN-720	Advanced Computer Architecture	3
	Elective I	3
	Total	**9**
Semester 3		
	Elective II	3
	Elective III	3
	Thesis I / Elective IV	3
	Total	**9**
Semester 4		
	Thesis II / Elective V	3
	Total	**3**
Total Program Credits		**30**

COURSE OUTLINES

Advanced Theory of Computation

Course Code: CSE-503

Credit Hours: 3

Prerequisites: Theory of Automata
It is assumed that students have had decent exposure to computability topics in an undergraduate-level course.

Objectives: The theory of computation is concerned with the theoretical limits of computability. Several mathematical models of computation have been formulated independently and under any such computational model, the existence of well-defined but unsolvable problems can be formally shown. These topics form part of the core of the mathematical foundations of computer science that will provide students and researchers with a sound theoretical view of the most fundamental concepts of computation.

At the end of the course, the student should be able to:

- Formalize mathematical models of computations;
- Use these formalisms to explore the inherent limitations of computations; and
- Describe some major current approaches for investigating feasible computation.

Course outline:

Finite Automata and Regular Languages: determinism and non-determinism, checking vs. computing, properties of finite automata, regular expressions, the pumping lemma, closure properties

Universal models of computations: issues of computability, the Turing machine, translation between models, model independence

Computability theory: primitive and partial recursive functions, encoding a Turing machine, recursive and R.E. sets, Rice's theorem and the Recursion theorem, Unsolvability

Complexity theory: reducibility among problems, reduction and complexity classes, hierarchy theorems, model-independent complexity classes, NP-completeness, space completeness, provably intractable problems

Proving problems hard: NP-complete problems, P-completeness proofs, Turing reductions and search problems, the polynomial hierarchy and enumeration problems

Complexity theory in practice: restriction of hard problems, strong NP-completeness, the complexity of approximation, the power of randomization, complexity and constructive mathematics

Resources:

1. Michael Sipser. *Introduction to the Theory of Computation, Third Edition*, Published by Cengage Learning, 2012.
2. John E. Hopcroft, Rajeev Motwani, and Jeffrey D. Ullman, *Introduction to Automata Theory, Languages, and Computation*, Addison-Wesley, 2006.
3. Mikhail J. Atallah and Mariana Blanton (Eds.), *Algorithms and Theory of Computation Handbook: General Concepts and Techniques*, CRC Press, New York,

2009 (2nd Edition).
4. Thomas Cormen, Charles Leiserson, Ronald Rivest, and Cliff Stein, *Introduction to Algorithms*, McGraw Hill Publishing Company and MIT Press, 2009 (3rd Edition).
5. Peter Linz, *An Introduction to Formal Languages and Automata*, Jones and Bartlett Publishers, 2006.
6. Dexter Kozen, Theory of Computation, Springer, 2006.

Advanced Design and Analysis of Algorithms

Course Code: CSC-521

Credit Hours: 3

Prerequisites: Design and Analysis of Algorithms/Data Structures and Algorithms

Students should have a solid background in fundamental algorithms, data structures and discrete mathematics. This background should include a working knowledge of sorting techniques, stacks, queues, lists, hash tables, heaps, binary search trees, recursion, set theory, graph theory, counting and probability theory, basic calculus, and proofs by mathematical induction.

Objectives: Algorithm design and analysis is a fundamental and important part of computer science. This course introduces students to advanced techniques for the design and analysis of algorithms and explores a variety of application areas. Upon completion of the course, students should be able to explain the mathematical concepts used in describing the complexity of an algorithm, and design and apply algorithms appropriate to a particular situation.

Course outline: **Advanced algorithm analysis**: Asymptotic analysis, Average case analysis, Probabilistic analysis, Amortized analysis

Fundamental algorithmic strategies: Brute-force, Greedy, Divide-and-Conquer, Backtracking, Branch-and-Bound

Advanced algorithm design: NP-Completeness, Heuristic and Approximation Algorithms, Randomized Algorithms, Geometric Algorithms

Parallel Algorithms: The PRAM model, Design techniques for parallel algorithms, Optimality and efficiency issues of PRAM algorithms.

Distributed Algorithms: The Computational model, Distributed algorithms for Broadcasting, Leader Election, Message Routing, Event Ordering and Resource Allocation problems, Complexity issues.

Genetic Algorithms: Major elements of genetic algorithms, Genetic solutions of computationally hard problems, Parallel Genetic algorithms.

Resources:

1. Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms (3rd ed.), MIT Press, 2009.
2. M. Mitzenmacher and E. Upfal, Probability and Computing, Cambridge University Press, 2005.
3. Vazirani, Approximation Algorithms, Springer-Verlag, 2004.
4. Borodin and El-Yaniv, Online Computation and Competitive Analysis, Cambridge University Press, 1998.
5. Direct Methods for Limit and Shakedown Analysis of Structures: Advanced Computational Algorithms and Material Modelling (Solid Mechanics and Its Applications) by Paolo Fuschi, Aurora Angela Pisano, Dieter Weichert
6. Robert Sedgewick, Analysis of Algorithms, Addison Wesley, 1996.
7. Motwani and Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
8. Gregory R. Andrews, Foundations of Multithreaded, Parallel and

Distributed Programming, Addison Wesley, 2000.
9. Albert Y. H. Zomaya, Parallel and Distributed Computing Handbook, McGraw Hill, 1995.

Advanced Operating Systems

Course Code: CSC-720

Credit Hours: 3+0

Prerequisites: Operating Systems, Data Structures, Computer Architecture

Objectives: The operating systems course is of prime importance in the curriculum of any graduate or undergraduate program in computer science. This course deals with advance concepts with relevance to the graduate level study. It has been designed using references of similar courses being offered at accredited universities. The intension is to deliver the state of art operating system concepts ranging from embedded micro kernels to popular platforms like LINUX, SOLARIS, Windows 2000 and XP. The internals, architecture, device driver writing and the distributed processing support on multi processor systems are the focus of course.

An effort is made to conduct the course in such a way that the students get a research orientation. For this purpose state of art research articles will be reviewed and areas of further research will be identified. In some cases we may be able to come up with a research papers.

Course outline: The course builds on the features of state of art Operating Systems like multi threading, scheduling and Inter process communication models, Concurrent programming and deadlock issues in multi core processor support.

The Virtual Memory Management vs Distributed Shared Memory, Dynamic File systems and information security mechanisms along with distributed coordination principles and mechanisms of distributed file systems supported by case studies of NFS, ANDREW, Google file systems etc are covered in detail with exposure to areas of research.

Device Drivers development fundamentals under Linux and Windows NT / XP operating systems and device management with specific reference to multimedia and real time operating systems are discussed

Case studies include:
LINUX Kernel and services architecture, Windows XP operating system a study of Kernel features, multi processing, memory management and services architecture and Solaris operating system features

Evaluation of operating system performance, Queuing theory, Markov processes, Bench marking, Simulation and testing methods are discussed.

Advanced Computer Architecture

Course Code: CEN-720

Credit Hours: 3+0

Prerequisites: Computer Architecture

Objectives: This course covers the advanced concepts in computer architecture including computer organization instruction set design principles and MIPS architecture, principles of scalable performance, pipelining, instruction level parallelism, compilers, code optimization, caches, main and virtual memory. Students will also be introduced to parallel computers and storage devices.

Course outline: Computer Organization review, Instruction Set Design principles and MIPS architecture, Principles of Scalable Performance, Speedup Performance laws, Scalability analysis and approaches, Pipelining: Basic pipelining, Data and control Hazards, Exceptions, Branch Prediction, Speculation, Performance Evaluation, Instruction level Parallelism, Score Board Architecture, Dynamic Scheduling ,Multiple instruction issue using superscalar approach,VLIW – software based ILP ,Compilers and code optimization, Caches, Cache basics, Techniques to reduce miss rate, Techniques to reduce miss penalty, Programming for memory performance, Main memory organization, Virtual Memory and paging, Storage devices, Parallel Computers, Multiprocessors, Parallel Architectures and applications, Synchronization Mechanisms.

Resources:

1. John L. Hennessy and David A. Patterson, "Computer Architecture: A quantitative approach", 4th edition 2006
2. D. Sima, T. Fountain, P. Kacsuk, "Advanced Computer Architecture", Addison-Wesley, 1997
3. H.S. Stone, "High-performance Computer Architecture", 3rd edition, Addison-Wesley, 1993
4. Patterson, D. A. and Hennessy, J. L., "Computer Organization and Design: The Hardware/ Software Interface", Morgan Kaufmann, 1998
5. Kai Hwang, "Advanced Computer Architecture", McGraw Hill, 2008
6. William Stallings, "Computer Organization and Architecture", 5th Edition, Prentice Hall International Inc., 2000
7. Computer Architecture, Fifth Edition: A Quantitative Approach (The Morgan Kaufmann Series in Computer Architecture and Design) 5th Edition, by David A. Patterson, 2011.

Research Methodology

Course Code: ESC-701

Credit Hours: 3+0

Prerequisites: None

Objectives: This course is aimed at providing the students with an ability to undertake postgraduate level research and an appreciation of relevant ethical and professional issues. After completing this course, students will be able to: Formulate research questions and carry out research investigations, Identify various sources of information and critically analyze the collected information, Identify and apply appropriate research methods in order to plan, conduct and evaluate their research, Effectively report/publish the results of research activities and Develop and deliver presentations to disseminate research findings.

Course outline: Introduction to research, Qualitative and Quantitative research, The scientific method of research, Choosing a research problem, Choosing a research advisor, Literature Review – Conducting and writing, Formulating the research question, Identifying variables and generating hypothesis, Research Design/Methodology, Information gathering and data collection, Data representation, analysis and interpretation, Writing a research proposal, Ethics of research – Plagiarism and Intellectual property rights, Organizing and managing conferences and workshops, Writing research papers/Reviewing research papers, Planning and delivering scientific presentations, Writing thesis/dissertations

Resources:

1. *Research Methodologies – A step by step guide for beginners*, Ranjit Kumar, 2005.
2. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, John W. Creswell, 2008.
3. *How to Research*, L. Blaxter, C. Hughes, M. Tight, 4th Edition, 2010.

Ubiquitous Computing

Course Code: CSC-504

Credit Hours: 3+0

Prerequisites: Human Computer Interaction

Objectives: Ubiquitous computing integrates computation into the environment, rather than having computers as distinct objects. Embedding computation into the environment will enable people to move around and interact with computers more naturally than they currently do. Therefore, the objective of this course is to help students gain a general understanding of ubiquitous computing, ubiquitous computing field of study and interfaces for ubiquitous computing.

Course outline: Introduction to ubiquitous computing, ubiquitous computing systems, privacy in ubiquitous computing, ubiquitous computing field studies, Ethnography in ubiquitous computing, interfaces for ubiquitous computing, location if ubiquitous computing, context-aware computing and processing sequential sensor data.

Resources:

1. Ubiquitous Computing Fundamentals by John Krumm
2. Ubiquitous Computingby Eduard Babkin ISBN 978-953-307-409-2, Publisher: InTech, Published: February 10, 2011

Intelligent User Interfaces Design and Evaluation

Course Code: CSC-505

Credit Hours: 3+0

Prerequisites: Human Computer Interaction

Objectives: The third wave of HCI has brought computing systems in everyday life of humans. Earlier HCI field mainly focused on cognitive aspects but now human centered computing has extended the traditional software process by extending conventional requirements engineering and evaluation processes. The objective of this course is to facilitate students to get acquainted with advanced user interface design and evaluation methodologies.

Course outline: Scenarios and Personas, Mental Models and Affordances, Tangible User Interfaces, Design as Applied Perception, Information Processing and Skilled Behavior, Cognitive Dimensions of Notational Frameworks, User Mental Modeling, Activity Theory, Distributed Cognition, Interaction Design, Evaluation Studies (Controlled v/s Natural settings), Inspections, Analytics and Models, Field Evaluation Methods

Resources:

1. Dourish P. (2001) Where the Action Is: The Foundations of Embodied Interaction. MIT Press
2. Readings in Intelligent User Interfaces, Mark T. Maybury, Wolfgang Wahlster, Morgan Kaufman Publishers, 1998
3. Markus, M.L. & Keil, M. (1994) If we build it, they will come: Designing information systems people want to use. Sloan Management Review
4. Dunne, A.; Raby, F. (2001): Design Noir: The Secret Life of Electronic Objects, Birkhäuser
5. Ehn, P. (1988): Work-Oriented Design of Computer Artifacts. Stockholm, Arbetslivscentrum.
6. Gaver, B., Beaver, J.; Benford, S. (2003) Ambiguity as a resource for design. Proc. of CHI03. ACM Press, S. 233-240.
7. Multimedia Interaction and Intelligent User Interfaces: Principles, Methods and Applications, by Ling Shao, Caifeng Shan, Jiebo Luo – 2010.

Virtual Reality

Course Code: CSC-515

Credit Hours: 3+0

Prerequisites:

- Computer Graphics
- C/C++ Programming

Objectives:

The objective of this course is to introduce students to Virtual Reality (VR).In this course, we will discuss the basics and detail of rapidly growing field of VR. At the end of the course, students should be able to and to use virtual reality in its own domain of application and should have a clear understanding of the various possibilities of this far-reaching technology.

Course outline:

Understanding the basic principles of virtual reality, historical development of virtual reality, virtual reality hardware and software, applications for current virtual reality hardware and software, designing and constructing a simple virtual environment, social, philosophical, and psychological factors and implications of virtual reality.

Resources:

1. Introduction to Virtual Reality by John Vince, Springer 2004
2. Virtual Reality Technology by Burdea, Grigore and Coiffet, Philippe, second edition. New York: John Wiley & Sons, 2003
3. Virtual Reality Technology, John Wiley & Sons, Burdea G. and P. Coiffet, 1994.
4. Virtual Reality Photography: Creating Panoramic and Object Images, by Scott Highton,2010.

Game Theory

Course Code:	CSC-516
Credit Hours:	3+0
Prerequisites:	Linear Algebra
Objectives:	The objective of this course is to provide a foundation of game theory to help students apply game theory to problem solving in a rigorous way. At the end of this course, the students can expect to be able to model real-world situations using game theory, analyze the situations using game theoretic concepts, and design correct and robust solutions (mechanisms, algorithms, protocols) that would work for rational and intelligent agents.
Course outline:	Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium, Mixed Strategy Nash Equilibrium, Von Neumann - Morgenstern Utility Theory, Rationalizable Strategies, Sperner's Lemma, Fixed Point Theorems, and Existence of Nash Equilibrium,Computation of Nash Equilibrium, Complexity of Computing Nash Equilibrium, Introduction to Mechanism Design, Social Choice Functions and Mechanisms, Incentive Compatibility and Revelation Theorem, Properties of Social Choice Functions, GibbardSatterthwaite Theorem and Arrow Impossibility Theorem, Quasilinear Mechanisms, Vickrey-Clarke-Groves Mechanisms, Bayesian Incentive Compatible Mechanisms, Revenue Equivalence Theorem, Optimal Auctions and Myerson Auction
Resources:	1. Game Theory: Analysis of Conflict by Roger B. Myerson. Harvard University Press, September 1997. 2. A Course in Game Theory by Martin J. Osborne, Ariel Rubinstein. The MIT Press, August 1994. 3. Game Theory and Strategy by Philip D. Straffin, Jr. The Mathematical Association of America, January 1993. 4. Fun and Games: A Text On Game Theory byKen Binmore. D. C. Heath & Company, 1992. 5. Behavioral Game Theory: Experiments in Strategic Interaction, by Colin F. Camerer - 2011.

Computer Supported Cooperative Work

Course Code: CSC-701

Credit Hours: 3+0

Prerequisites: Human Computer Interaction

Objectives: The objective of the course is to impart knowledge about synchronous and asynchronous group work, workflow management systems, organizational and technology design. After completing the course students will be able to understand cooperative work processes within socio-technical systems and supported software technology. Furthermore students will understand the evaluation mechanisms for evaluating application systems for distributed and collaborative work.

Course outline: Social and Scientific Foundations (ethnography, Small group research, organization theory), applications to support synchronous and asynchronous cooperation, Workflow Management Systems, Media Spaces and Cooperative Virtual Environments (CVE), Functionality to promote group awareness (awareness), Coordination, ordering Systems, Customizable groupware Systems, development of methods of cooperative systems, Integrated organization and technology design.

Resources:

1. Schmidt, K. Cooperative Work and Coordinative Practices, 2012
2. Koch, M. Computer Supported Cooperative Work, 2007
3. Bødker, S. (2006) When second wave HCI meets third wave challenges, Proc. of NordiCHI, ACM Press, S. 1-8.
4. Crabtree, A. (2003): Designing Collaborative Systems: A Practical Guide to Ethnography, Springer.

Advanced Human Computer Interaction

Course Code: SEN-720

Credit Hours: 3+0 Minutes of the 17th FBOS – ES

Prerequisites: Human Computer Interaction

Objectives: The objective of this course is to highlight the importance if user interfaces design. Students will be able to learn different design theories and organizational aspects revolving around human computer interaction. After the completion of the course students will be able to employ best practices for better user interface design.

Course outline: Fundamentals of interaction design from perception, working and cognitive Psychology, theories of design: Distributed Cognition, Activity Theory, structuration theory, Text, Image, video, audio and animation Job Analysis, Basics of tasks and basic technologies: web-based systems, peer-to-peer systems, Fundamentals of Software and Media Ergonomics, methods of user-centered interaction design, Organizational aspects of the design of complex interactions.

Resources:

1. Carroll, John M.: HCI Models, Theories and Frameworks, Morgan Kaufman, 2003
2. Blum, Bruce I.: Beyond Programming: To a New Era of Design, Oxford University Press 1996
3. Nielsen, Jakob: User Experience Design, Academic Press, 1994
4. Preece, J., Rogers, Y., Sharp, H.: Interaction Design, Wiley and Sons, 2002
5. Interaction Design: Beyond Human - Computer Interaction by Yvonne Rogers, Helen Sharp, Jenny Preece, 2002
6. Human-Computer Interaction Advanced Interaction, Modalities, and Techniques: 16th International Conference, HCI International 2014, Heraklion, Crete, ... Part II (Lecture Notes in Computer Science) by Masaaki Kurosu, 2014.

Advanced Usability Engineering

Course Code: SEN-756

Credit Hours: 3+0

Prerequisites: Human Computer Interaction

Objectives: In this course students will learn the skills of usability engineering, ethnographic research methods for data collection as well as evaluation strategies such as heuristics evaluation and user studies. Furthermore different design paradigms, different Schools of thought and the interplay of technology, people and the environment will be discussed.

Course outline: Ethnographic methods to study the context of use, Usability Engineering Lifecycle, Narrative approaches to the understanding of future uses, methods of heuristic evaluation of the usability interactive system, Empirical methods for evaluating the usability of interactive systems under controlled conditions, Usability Testing, Skills of test moderator, Setting up testing environment, Variations in standard testing procedures, Designing user experience.

Resources:

1. Dana Chisnell, Jeffrey Rubin, Jared Spool: Handbook of Usability Testing - How to Plan, Design, and Conduct Effective Tests 2008
2. Jakob Nielsen: User Experience Design. Academic Press Inc, 1993.
3. Mary Beth Rosson, John M. Carroll: User Experience Design:
4. Scenario-Based Development of Human-Computer Interaction. Morgan Kaufmann, 2001.
5. Hugh Beyer, Karen Holtzblatt: Contextual Design - Defining Customer- Centered Systems. Morgan Kaufmann, 1998.
6. Randall, Dave, Harper, Richard, Rouncefield, Mark: Fieldwork for Design - Theory and Practice. Springer, 2007.
7. Advances in Usability Evaluation, Francesco Rebelo, Marcelo M. Soares – 2012.

Decision Support Systems

Course Code: CSC-518

Credit Hours: 3+0

Prerequisites: None

Objectives: This course should enable a student to understand managerial decisions, to participate in the decision making process, and to be able to develop models and systems to support the decision making. This course focuses on the use and application of information systems to support the decision-making process. Different types of systems are discussed as a basis for designing and developing highly effective decision support systems. Data models, interactive processes, knowledge-based approaches and integration with database systems are also described. Theoretical concepts would be applied to real-world applications.

Course outline: Decision support systems overview, Decision Making, Systems, Modeling, and Support, business intelligence, Data Management, Modeling and Analysis, Decision Support System Development, Fundamentals of Expert Systems and Intelligent Systems, Collaborative Computing Technologies, Knowledge Management

Resources:

1. Efraim Turban and Jay E. Aronson, Decision Support Systems and Intelligent Systems, Seventh Edition, Prentice Hall Pub. M 2004.
2. Decision Support Systems and Business Intelligence Systems. 9e. by E. Turban & J. Aronson, 2010

Intelligent Agents

Course Code:	CSC-715
Credit Hours:	3+0
Prerequisites:	None
Objectives:	The primary objective of this course is to provide an introduction to the basic principles and applications of intelligent agents. The emphasis of the course is on teaching the fundamentals, and not on providing a mastery of specific commercially available software tools or programming environments. Students will be presented with a wide range of theories of relevance to their research and development to model agent's knowledge representation and learning. Emphasis will be placed on understanding concepts of thinking, planning and learning aspects of intelligent agents and using them to model and build relevant agent-based systems.
Course outline:	Agent, Environment, Interaction, Solving Problem by Search Algorithms, Informed Search, Constraint Satisfaction Problem, Logical Agents , Theorem Proving Algorithms (propositional logic, predicate logic), Partial Order Planning, Graph Plan, BDI Agents, Decision trees , Neural Networks, Reinforcement learning, Q-learning, Temporal Difference Learning, Monte Carlo Methods.
Resources:	1. Stuart Russel and Peter Norvig, Artificial Intelligence, A modern Approach, 3rd Edition 2. Michael J. Wooldridge, Reasoning about Rational Agents. 3. Jack Minker, Logic Based Artificial Intelligence. 4. Steven Michael LaValle, Planning Algorithms. 5. Ethem Alpaydin, Introduction to Machine Learning.

Machine Learning

Course Code: CSC-719

Credit Hours: 3+0

Prerequisites: Computer Programming
Statistics

Objectives: This course is an overview of concepts and techniques in machine learning, beginning with topics such as classification and linear regression and ending up with more recent topics such as boosting, support vector machines, hidden Markov models, and Bayesian networks. The course will give the student the basic ideas behind modern machine learning methods.

Course outline: Introduction to Machine Learning, Concept learning, Decision tree learning, Linear models for regression, Linear models for classification, Artificial neural networks, Kernel methods, Sparse kernel machines, Mixture models and the EM algorithm, Evaluation, Combining multiple learners, Support vector machines, Bayesian networks

Resources:

1. C. M. Bishop, Pattern recognition and machine learning, Springer, 2006.
2. Tom M. Mitchell, Machine Learning. McGraw-Hill, 1997.
3. Python Machine Learning, Sebastian Raschka, 2015.

Deep Learning

Course Code: DSC-704

Credit Hours: 3+0

Prerequisites: Machine Learning

Objectives: The objective of this course is to acquaint the students with the state-of-the-art deep learning techniques to solve different learning problems. Students will learn to design as well as implement deep neural network architectures (through hands-on tasks) to solve various recognition problems.

Course outline: Introduction to neural networks, activation functions and back-propagation; Convolutional Neural Networks: History, Convolution, Pooling, CNNs for classification, Deep learning Software, CNN Architectures; Sequence Modeling: Recurrent and Recursive Nets: Long-Short Term Memory models and variants, Language modeling and image captioning, Unsupervised learning: Restricted Boltzmann Machines and Auto-encoders; Case Studies.

Resources:

- Deep Learning (Adaptive Computation and Machine Learning series), Ian Goodfellow, Yoshua Bengio, Aaron Courville, The MIT Press, 2016.
- Deep Learning: A Practitioner's Approach, Josh Patterson and Adam Gibson, O'Reilly Media, 2017.
- Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms, Nikhil Buduma and Nicholas Locascio, O'Reilly Media, 2017
- Deep Learning with Python, Francois Chollet, O'Reilly Media, 2017.

Advanced Natural Language Processing

Course Code: CSC-741

Credit Hours: 3+0

Prerequisites: -

Objectives: This course is intended to introduce the students to the fundamental concepts and ideas in natural language processing (NLP). Students will be acquainted with the algorithms available for the processing of linguistic information as well as the underlying computational properties of natural languages. By the end of this course the student should be able to carry out independent work with modern techniques for processing of texts.

Course outline: Introduction to NLP and its applications, Grammar checkers, dictation, document generation, NL interfaces, The different analysis levels used for NLP, Markup, Finite state automata, Recursive and augmented transition networks, Lexical level: Error-tolerant lexical processing (spelling error correction), Transducers for the design of morphologic analyzers, Part-of-speech tagging, Representations for linguistic resources, Syntactic level: Grammars (e.g. Formal/Chomsky hierarchy, DCGs, systemic, case, unification, stochastic), Parsing (top-down, bottom-up, chart (Earley algorithm), CYK algorithm), Semantic level: Logical forms, Ambiguity resolution, Semantic networks and parsers, Procedural semantics, Montague semantics, Vector Space approaches, Pragmatic level: Knowledge representation, Reasoning, Plan/goal recognition, Speech acts/intentions, Natural language generation.

Resources:

1. Handbook of Natural Language Processing, Nitin Indurkhya and Fred J. Damerau, Chapman & Hall/Crc, Second Edition, 2010.
2. Natural Language Processing and Text Mining, Anne Kao and Steve R. Poteet, Springer, 2010.
3. Speech and Language Processing, Daniel Jurafsky and James H. Martin, Pearson Prentice Hal, 2nd Edition, 2008.
4. Foundations of Statistical Natural Language Processing, Christopher D. Manning, Hinrich Schuetze, The MIT Press; 1st edition, 1999.
5. Natural Language Understanding, James Allen, Pub. Benjamin/Cummings, 2nd edition, 1995.

Advanced Digital Image Processing

Course Code: CSC-745

Credit Hours: 3+0

Prerequisites: None

Objectives: This course will provide mathematical foundations and practical techniques for digital manipulation of images, image acquisition, preprocessing, segmentation. The course will expose the students to the basic theory and algorithms widely used in digital image processing. After the completion of this course the students will be able to understand the basic concepts behind the processing of digital images as well as various techniques of filtering/processing images in spatial as well as in frequency domain. The course will serve as the basis for more advance topics in Computer Vision.

Course outline: Introduction to Digital Image Processing Computer Vision and Pattern Recognition, Fundamentals Element of visual Perception, Image Sensing and Acquisition Image Sampling and Quantization. Pixel operations, linear & Non linear operations, Image Enhancement in spatial Domain: Background, Grey level Transformations, Filtering in spatial domain. Image Enhancing in Frequency Domain: Frequency domain, Fourier Transform, Filtering in frequency domain, Color Image Processing, Fundamentals of Image Compression, Lossless and lossy compression, Image Compression standards, Image Segmentation: Detection of Discontinuities, Edge and Boundary detection, Thresholding, Region Based segmentation, Morphological image processing, Representation schemes: Boundary and region descriptors.

Resources:

1. *Digital Image Processing,* R. C. Gonzalez and R. E. Woods, Addison Wesley, 3rd Edn., 2007.
2. *Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab,* Chris Solomon and Toby Breckon, 2011.

Advanced Neural Networks and Fuzzy Logic

Course Code: CSC-749

Credit Hours: 3

Prerequisites: Artificial Intelligence

Objectives: This course presents an overview of the theory and applications of artificial neural network and fuzzy systems to computer science and software engineering applications. The objective of this course is on the understanding of various neural network and fuzzy systems models and the applications of these models to solve computing/software engineering problems.

Course outline: Introduction Contexts for and Motivation Neural Networks: Artificial Intelligence Artificial Neural Network overview.

Supervised Learning: Single-Layer Networks , Perceptrons , Adalines Supervised Learning: Multi-Layer Networks.

Multi-Layer Perceptrons (MLPs) , Backpropagation , Conjugate Gradient method , Levenberg-Marquardt (LM) method , Madalines , Radial-Basis Networks , Cascade-Correlation Networks , Polynomial Networks , Recurrent Networks (Time series , Backpropagation through time , Finite Impulse Response (FIR) MLP), Temporal Differences method (TD).

Unsupervised Learning

Simple Competitive Networks: Winner-take-all | Hamming network , Learning Vector Quantization (LVQ), Counterpropagation Networks (CPN) , Adaptive Resonance Theory (ART) , Kohonen Self-Organizing Maps (SOMs) , Principal Component Analysis networks (PCA)

Associative Models

Linear Associative Memory (LAM) , Hopfield Networks , Brain-State-in-a-Box , BSB) , Boltzmann Machines and Simulated Annealing , Bi-Directional Associative Memory (BAM)

Optimization Problems

Neural Network Approaches, Evolutionary Programming , Fuzzy logic and its connection to NNs

Resources:

1. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall, Upper Saddle River, NJ, SECOND EDITION, 1999
2. Artificial neural networks: an introduction, by Kevin L. Priddy, Paul E. Keller-Technology & Engineering-2005
3. Neural networks: methodology and applications, by G. Dreyfus-computers-, 2005
4. Evolving Fuzzy Systems - Methodologies, Advanced Concepts and Applications, By Edwin Lughofer, 2011.

Pattern Recognition

Course Code: CSC-751

Credit Hours: 3+0

Prerequisites:

1. Probability and Statistics
2. Linear Algebra

Objectives: The goal of this course is to provide an introduction to the fundamental concepts of machine learning and pattern recognition with examples from several application areas. The students will be acquainted with real world regression and classification problems and the models and classifiers to solve these problems. Students will also be introduced to dimensionality reduction and feature selection concepts. Additionally, students will be exposed to various clustering techniques. A key objective to this course is for the students to also acquire hands-on experience related to classification and clustering tasks.

Course outline: Introduction to Pattern recognition and Machine learning, Matrices and vectors: Toeplitz and Vendermonde matrices, classification and regression, Bayesian Decision theory, Normal Density and decision functions for normal distribution, Maximum likelihood estimation, Dimensionality reduction – Component analysis, feature selection, Hidden Markov Models and Artificial neural networks, Non-parametric methods, Unsupervised learning and clustering: Clustering techniques.

Resources:

1. Pattern Classification, Duda, Hart and Stork, Second Edition, Wiley, 2001.
2. Pattern recognition and Machine Learning, Christopher M. Bishop, Springer, 2007.
3. Introduction to Machine Learning, Ethem Alpaydin, MIT Press, 2004.
4. The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani and Jerome Friedman, Springer, 2009.
5. Pattern Recognition and Classification: An Introduction, by Geoff Dougherty - 2012 S. Theodoridis & K. Koutroumbas, Academic Press, 2008.

Computer Vision

Course Code: CSC-764

Credit Hours: 3+0

Prerequisites: Digital Image Processing

Objectives: B y the end of this course, the students would have developed an understanding of the problems in simulating human perception into machines. Students will have a thorough understanding of the state of the art computer vision methods, algorithms and results. The students will also be able to apply the tools and techniques learned to solve practical vision related problems.

Course outline: Introduction to Computer Vision and related areas along with applications, Image formation and representation: imaging geometry, digitization, cameras and projections, rigid and affine transformations, Filtering: convolution, smoothing,. Segmentation: region splitting and merging; quadtree structures for segmentation; Feature detection: edge detection, corner detection, line and curve detection, SIFT and HOG descriptors, shape context descriptors. Model fitting: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures. Camera calibration: camera models; intrinsic and extrinsic parameters; affine, and perspective camera models. Epipolar geometry: introduction to projective geometry; epipolar constraints; the essential and fundamental matrices; Motion analysis: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; Motion tracking: the Kalman filter; Object recognition and shape representation.

Resources:

1. Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011.
2. Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011.
3. Computer Vision: A Modern Approach, By David Forsyth, Jean Ponce, Prentice Hall, 2003.
4. Computer Vision, By Linda G. Shapiro, George C. Stockman, Prentice Hall, 2001.
5. Handbook of Mathematical Models in Computer Vision, By Nikos Paragios, Yunmei Chen, Olivier Faugeras, Birkhäuser, 2006

Intelligent Tutoring System

Course Code: CSC-750

Credit Hours: 3

Prerequisites:

Objectives: The goal of this course is to survey the scientific literature pertaining to intelligent tutoring systems and design a tutoring system for functional dependencies encompassing an exercise module, a learning action tracking module, a self-assessment module for the learner and an assessment module for the educator. Data mining techniques will be used on well-designed activity logs to extract patterns to provide feedback to learners for self-assessment and global patterns for group assessment.

Course outline: An Intelligent tutoring system (ITS) provides individualized computer-based instruction to students. These systems emerged from application of artificial intelligence techniques to the computer aided instruction CAI systems. The difference is that an ITS usually compares the student's work with expert solutions or strategies, models the student's probably knowledge of a domain and provides coaching or advice, taking into account what the student's knowledge of state, preferred learning style, etc.

Resources:

1. Advances in Intelligent Tutoring Systems by Nkambou, Riichiro Mizoguchi, Jacqueline Bourdeau – 2010
2. Intelligent tutoring systemsb by D. Sleeman, J. S. Brown – 1982
3. Intelligent Tutoring Systems in E-Learning Environments by Stankov, Slavomir – 2010

Distributed Networking

Course Code: EET-519

Credit Hours: 3+0

Prerequisites: Computer Networks

Objectives: The objective is to give students a clear overview of the problems and issues that must be dealt with in constructing robust and flexible distributed applications as well as the underlying network protocols needed to support them. The emphasis is on the conceptual basis for distributed and networked systems rather than a detailed study of particular systems and standards. Concepts will be illustrated with examples from practical systems.

Course outline: Network Overview: interfaces, protocols and services, connection-oriented and connectionless services, Overview of distributed system architecture: motivation, system structures, ODP Reference model and distribution transparencies, design issues.; Interaction primitives: message passing, remote procedure call, remote object invocation; Internet Network Measurement, Network Restoration, Routing; Multicast Routing, TCP/IP; Linux Networking and related kernel, Linux-based Content Switch Design; Intel IXP Network Processor and related IDE, MLPS, IS, RSVP, Differential Services; Overview of widea area network design Erlang, 2 node voice network design, 3 node data network design; Graph Theory, Traffic and Cost Generators, Access network design; Multispeed Access Design, Multicenter Local Access Design; Mesh Network Design

Resources:

1. Wide Area Network Design, by Robert S. Cahn, 1998
2. Communication Networks, Chapters 7-10, by Alberto Leon-Garcia and Indra Widjaja, 2003
3. Distributed Networks: Intelligence, Security, and Applications by Qurban A. Memon – 2016

Network Administration and Management

Course Code: EET-520

Credit Hours: 3+0

Prerequisites: Computer Communication and Networks, Operating System

Objectives: This course will give an overview of systems and network administration based on both Windows and Linux environments. The objective are common system administration tasks and practices and how to implement and maintain standard services like email, file sharing, DNS and similar. The course is primarily dealing with the Linux and Windows operating systems and especially with Linux-based servers and Window-based clients, but some information about the most fundamental differences between various Linux systems will be provided. In labs focus is on how to install, setup and maintain Linux server machine and toper form various system administration and security related tasks on those machines

Course outline: Brief introduction to the Networks, Homogenous and Heterogeneous networks ,Issues involved in the setup of Heterogeneous networks, File systems, Configuration issues, Fundamentals of Linux user interface, Installation and administration of heterogeneous networks using Windows and Linux platforms. System installation, booting and halting the system, file systems and directory permission structures, print and disk quotas, device configuration and management, user account administration, security, client administration, disk maintenance, remote access, remote administration, the use of schedulers, the use of advanced scripting to ease system administration tasks, configuration management, template implementation and cross directory implementation

Resources:

1. Practice of System and Network Administration, the 2nd Edition by Thomas A,Limoncelli, Hogan, 2005.
2. Windows Administration Latest Edition, Microsoft Press
3. Linux Administration Guide Latest Edition
4. Network Security, Administration and Management: Advancing Technology and Practice: Advancing Technology and Practice by Kar, Dulal Chandra- 2011

Mobile Communications and Networking

Course Code: EET-556

Credit Hours: 3+0

Prerequisites: Wireless Communication, Computer Networks, Data Communications

Objectives: This course focuses on network issues for Mobile communication networks. The course will cover basic theory, namely the analysis of queues and combinatorial algorithms, and it will also include an overview of the plethora of wireless mobile communications systems under development and deployment, ranging from indoor systems to satellite personal communication systems.

Course outline: History of mobile communications, fundamental definitions, characteristics of mobile communication systems, some current and proposed systems/standards. Characterization of the mobile communication channel: path loss, multipath fading, shadowing, Doppler shift, mathematical channel models, channel measurement. Techniques used for communication over fading multipath channels: forward error correction coding and interleaving, adaptive equalization, and diversity techniques. Cell layout, cell sectorization and cell splitting, Establishment of calls, handoff and power control, registration and location updating, security. Signaling between the mobile terminal and the network. Frequency reuse factor vs. inter-station distance for hexagonal grid, impact on system capacity, impact of sectorization on capacity. Erlang capacity.Specific topics include: Poisson processes and continuous-time, discrete state Markov models, Architecture of existing mobile communication systems and potential future systems Services, call flow scenarios in GSM including handoffs. Detail design and comparison of GSM and Mobile WiMax, mobile ad hoc networks including wireless sensor communication, mobile communication with satellites.

Resources:

1. Jochen H. Schiller, Mobile Communications, 2nd Edition, 2003
2. James E. Katz, Handbook of Mobile Communication Studies, 2008
3. Christopher Cox, An Introduction to LTE: LTE, LTE-Advanced, SAE and 4G Mobile Communications, 2012
4. Erik Dahlman, Stefan Parkvall and Johan Skold, 4G: LTE/LTE-Advanced for Mobile Broadband, 2011
5. Sassan Ahmadi, Mobile WiMAX: A Systems Approach to Understanding IEEE 802.16m Radio Access Technology, 2010
6. Uyless Black, Second Generation Mobile and Wireless Networks, 1st Edition, Prentice Hall, 1998

Advanced Network Security

Course Code: EET-702

Credit Hours: 3+0

Prerequisites: Computer networks

Objectives: To provide overview how to design, best possible secure and efficient network depending upon users profile, applications and other requirements.

Course outline: Overview of Network Security ,Threat Models, Trust , Authentication, Wireless Security, Single-Host Security, Authentication, File protection, integrity; privileges, C and Shell Programming pitfalls, Programmed threats; Worms, Viruses, Trojan Horses
Basics of cryptography, Cryptographic Protocols, General techniques, Email privacy, digital signatures, Kerberos, Digital cash, Cryptographic file systems, Secure network transactions
IP Protocols, Firewalls, Intrusion detection, IPsec , Physical connectivity, Network management tools (NIS, NFS, Active Directory), Client/Server application security
WWW considerations, X Windows, CMW, Firewalls
DOS Mitigation, VPNs, Special Topics: Viruses, SPAM

Resources:

1. Eric Cole, Network Security Bible, 2009
2. William Stallings, Network Security Essentials: Applications and Standards, 4th Edition, 2010
3. Kwok T. Fung, Network Security Technologies, Auerbach Publications/CRC Press, 2004
4. M Yusuf Bhaiji, Network Security Technologies and Solutions, Pearson Education, 2008
5. C. Kaufman, Network Security, Private Communication in a Public World, Prentice Hall, 2002

Advanced Network Design

Course Code: EET-713

Credit Hours: 3+0

Prerequisites: Computer Networks

Objectives: In this course students will learn to architect, build and manage the next generation networks capable of supporting multimedia technologies such as Voice over IP, desktop video conferencing, presence management and other specialized real-time applications. Students will study the advanced broadband network technologies and protocols i.e. SONET/SDH, ATM, VoIP, MPLS, GMPLS xDSL, WLL etc., the services that are provided by those technologies

Course outline: Principles of broadband Networks and communication, SONET, IP over SONET, Frame Relay, ATM concepts, services and applications. MPLS Traffic Engineering, QoS and Failure Recovery, Network Algorithmics, packet classification, switching, Cisco IOS operating system, QoS, packet scheduling, Reservation protocols, Endnode performance, MultiMedia systems, Compression, Multimedia system implementation, Unified systems, Presence Management, Network Traffic Analysis, Network Management of multimedia networks ATM Standards and technology for local and wide area networks. ATM adaption layer, Access switching, ATM WAN Switches. ATM Service classes, QoS, ISDN technology. VoIP, IP over ATM, xDSL,.

Resources:

1. Priscilla Oppenheimer, Top-Down Network Design, 3rd Edition, 2010
2. James D. McCabe, Network Analysis, Architecture, and Design, Third Edition, 2007
3. Ulysses Black, Advanced Internet Technologies,1st Edition, Prentice Hall, 1998
4. William Stallings,High Speed Networks: TCP/IP and ATM Design Principles, 1st Edition, Prentice Hall, 1998
5. Leon-Garagia and Indra Widjaja, Communication Networks, McGraw-Hill, 2003

Advanced Topics in Wireless Networking and communications

Course Code: EET-716

Credit Hours: 3+0

Prerequisites: Computer Networks, Data Communications

Objectives: This course is designed to give the *design concepts* of networking of different wireless communication systems.

Course outline: Following topics related to wireless networking and communication will be covered: Transmission Fundamental, Antennas and Propagation, Spread Spectrum, Coding and Error control, Satellite communications, Cellular wireless Networks (1G, 2G, 3G, 4G(LTE)GSM, HSCSD, GPRS, EDGE, UMTS), Mobile IP and Wireless Access Protocol, Wireless LAN Technology, Cordless Systems and Wireless Local Loop (WIMAX), Bluetooth and IEEE 802.15, Wireless Sensor Networks, RFID

Resources:

1. James T. Geier, Designing and Deploying 802.11n Wireless Networks, 2010
2. William Stallings, Wireless Communications and Networks, 2nd Edition, 2007

Network Performance Evaluation

Course Code: EET-718

Credit Hours: 3+0

Prerequisites: Simulation and Modeling, Computational Techniques

Objectives: The objective is to give students a clear understanding of analytical modeling techniques for predicting computer system performance.
Give some sort of Motivation and survey; the need for performance prediction in optimization and system design.

Course outline: Basic probability theory: renewal processes; Markov processes; birth and death processes; the single server queue; Little's law; embedded Markov chain; M/G/1 queue; queues with priorities; queuing networks - open, closed, multi-class; equilibrium state space probabilities, proof for single class; normalizing constants; computation of performance measures; convolution algorithm; mean value analysis; application to multi-access systems with thrashing.
Decomposition and aggregation: Norton's theorem; M/M/n queue; multiple independent parallel servers.
The course also offers an introduction to performance modeling using a stochastic process algebra, eg PEPA. To include: expansion law, apparent rate, steady-state analysis, transient state analysis through uniform inaction and reward
vectors

Resources:

1. Performance modeling of communication networks and computer architecture by Harrison, Peter G and Patel, Naresh M., 1998
2. Modeling of computer and communication systems, Mitrani, I, 1987
3. Probabilistic modeling by Mitrani, I., 1998
4. Network Performance Engineering: A Handbook on Convergent Multi-Service, by Demetres D. Kouvatsos 2011

Network Protocols and Standards

Course Code: EET-761

Credit Hours: 3+0

Prerequisites: Computer Networks

Objectives: This course covers the Network Protocols and Standards used by various entities in an end-to-end Internet connection. Specifically, Bridging and Routing Protocols are taught.

Course outline: Introduction, IEEE 802 LANs and LAN addressing, Protocol type multiplexing, Basic bridging concepts, Transparent Bridging, Transparent Bridges, Learning process, Spanning tree algorithm, BPDUs, Forwarding and blocked states, Root and designated bridges, Learning after STA, Aging, Bridge topology changes, Failures and additions, Bridge settable parameters, Avoiding temporary loops in spanning tree recalculation, Source routing bridges, SR-TB, SRT bridges, Traffic class expediting in 802.1D, Dynamic multicast filtering in IEEE 802.1D Basic and extended filtering services, GARP and GMRP, State machine for GARP's simple applicants, GARP information propagation (GIP), Virtual bridged LANs (VLANs) VLAN tags (VLAN IDs), VLAN registration and GARP VLAN registration (GVRP), Learning process, IPv4, Proxy ARP, ICMP, NAT BOOTP, BOOTP message format, DHCP, DHCP state machine, Interior gateway protocols, RIP Version2, OSPF, EGP, CIDR, Steiner trees MOSPF , PIM (SM and DM)

Resources:

1. Interconnections, 2nd/ed by Radia Perlman, 1999
2. Routing in the Internet, 2nd/ed by Christian Huitema, 1999
3. BGP4 Inter-Domain Routing in the Internet by John W. Stewart, 1998
4. Network Security Essentials Applications and Standards (5th Edition)Mar 16, 2013, by William Stallings

Cloud Computing

Course Code: CSC-781

Credit Hours: 3

Prerequisites:

Objectives:

- Understanding the systems, protocols and mechanisms to support cloud computing
- Develop applications for cloud computing
- Understanding the hardware necessary for cloud computing.
- Design and implement a novel cloud computing application.

Course outline: This course introduces students to the cloud and the computing on the cloud. Initially, the focus is on the technology context, i.e. multi-core architectures, virtualization, parallel computing models and big data storage. Next, famous cloud computing models including Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS) are studied with the help of Amazon AWS (IaaS), Microsoft Azure (PaaS) and Google App Engine (SaaS). In addition to Computing models, Data and computation models, e.g. MapReduce, are an important part of this module. The theoretical concepts are explained with hand-on experience of cloud platforms supported by case studies. The course concludes with an insight into the cloud risk areas including risks with service provider, technical risks, security issues, connectivity issues, etc. and research work in these areas is also discussed.

Resources:

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

Advanced Information Theory

Course Code: CSC-554

Credit Hours: 3+0

Prerequisites: Basic probability and linear algebra as well as a minimum of mathematical maturity are the only prerequisites. An introduction to what computer scientists mean by "information", including topics in data compression (such as zip files and mp3), error correcting codes, information entropy, cryptography, and randomness. This is an intermediate course in computer science, and as such requires some background in programming as well as math through at least pre-calculus.

Objectives: This course presents the fundamentals of Information Theory, that stays at the basis of modern digital communications, data compression, lossy source coding and multiuser networks.

Course outline: Asymptotic Equipartition Theorem, types, and typical sequences, Information measures and their properties: entropy, Kullback-Leibler divergence, mutual information, source coding theorem, channel coding theorem, rate distortion theory, quantization, maximum entropy principle Typical sequences and typical sets, error exponents in: hypothesis testing, source coding, and channel coding, information theory and estimation, rudiments of network information theory.

Resources:

1. T.M. Cover and J.A. Thomas, Elements of Information Theory, 2nd ed., Wiley, 2006;
2. I. Csisz`ar and J. K¨orner, Information theory: coding theorems for discrete memoryless systems, 2nd ed., Cambridge University Press, 2011.
3. Codes: an introduction to information communication and cryptography by Norman Biggs, 2008

Advanced Data Mining

Course Code: CSC-746

Credit Hours: 3+0

Prerequisites: Database Management System
Data Structures and Algorithms

Objectives: By the end of this course students will be familiar with concepts of Data Warehousing including: Strategic need of data warehousing, Building blocks of a data warehouse, Data warehouse project management, Business requirements of a data warehouse, Architectural components of a data warehouse, Data warehouse metadata management, Dimensionality Modeling, ETL & Data quality, Online Analytical Processing, as well as the following areas of data mining: Motivation for data mining, Data Preprocessing, Data mining primitives and query languages, Architectures of data mining systems, Major Data Mining Tasks, Cluster Analysis , Statistical measures in large databases, Classifications and Predictions, Anomaly Detection

Course outline: Introduction to Data Warehouse, Planning and Requirements, Data Warehouse Architecture, Data Warehouse Infrastructure, Dimensional Modeling, Metadata, Extraction, Transformation and Loading, Online Analytical Processing, Data Preparation Techniques: outlier and missing data analysis, Data Reduction Techniques, Introduction to Data Mining, Modeling and Principal Feature Extraction, Clustering, Hierarchical Clustering, Partitional Clustering, Classification , Decision Tree Classification, Bayesian Classification, Nearest Neighbor Classification.

Resources:

1. Data Warehousing Fundamentals for IT Professionals, Paulraj Pooniah, Wiley, 2nd Edition, 2010.
2. Data Mining Concepts & Techniques, Jaiwei Han, Micheline Kamber, 2nd Edition, 2005.
3. Tutorial on Data Mining, Eamonn Keogh

Text Mining

Course Code: CSC-747

Credit Hours: 3+0

Prerequisites: Data Mining, Databases

Objectives: Text Mining is aimed at extracting useful information (usually) from huge unstructured datasets by employing techniques from information retrieval, natural language processing and data mining. The objective of this module is to get a good understanding of the basic text mining techniques and study some of its applications as well.

Course outline: Introduction: background, dealing with information overload and information overlook, unstructured vs. (semi-)structured data, evolving information needs and knowledge management issues, the business case for text mining. The text mining pipeline: information retrieval, information extraction and data mining. Fundamentals of natural language processing: linguistic foundations, levels of linguistic analysis.
Approaches to text mining: rule-based vs. machine learning based vs. hybrid; generic vs. domain specific; domain adaptation. Dealing with real text: text types, document formats and conversion, character encodings, markup, low-level processes (sentence splitting, tokenization, part of speech tagging, chunking). Information extraction: term extraction, named entity recognition, relation extraction, fact and event extraction; partial analysis vs. full analysis. Data mining and visualisation of results from text mining. Evaluation of text mining systems: evaluation measures, role of evaluation challenges, usability evaluation, the U-Compare initiative. Text mining applications and services; case studies.

Resources:

1. Text mining handbook: advanced approaches in analyzing unstructured data, Feldman, Ronen and James Sanger, Cambridge University Press, Edition: 2nd ,2008
2. Text mining: classification, clustering and applications, Srivastava, Ashok and Mehran Sahami, Chapman & Hall, Edition: 1st , 2009
3. Mining Text Data by Charu C. Aggarwal, ChengXiang Zhai - 2012

Advanced DBMS

Course Code: CSC-752

Credit Hours: 3+0

Prerequisites: Introduction to Database Systems

Objectives: At the end of this course, the expectation is that the students will gain competence in following areas: Databases beyond relational, Query optimization, Data marts, Data warehousing, XML, OLAP

Course outline: Object-Oriented Databases, Object-Relational Databases, Mobile Databases, Temporal, Spatial and Geographic Databases, Distributed Database Design, Distributed Multimedia Database Systems, Data Warehouse and OLAP Systems, Business Intelligence, XML Data Models, XML Documents and DTD, XML Query Languages, Current Research and Development Trends of Database Analysis, Design, Modeling and Applications.

Resources:

1. An Advanced Course in Database Systems: Beyond Relational Databases, S. W. Dietrich and S. D. Urban, Prentice Hall, 2005.
2. Database Management Systems, Ramakrishnan R & Gehrke J, 3rd edn, McGraw Hill, New York, 2003.
3. ADVANCED DATABASE MANAGEMENT SYSTEM by Rini Chakrabarti, Shilbhadra Dasgupta - 2011

Distributed Databases

Course Code: CSC-753

Credit Hours: 3+0

Prerequisites: Database Management Systems

Objectives: Be familiar with the currently available models, technologies for and approaches to building distributed database systems; have developed practical skills in the use of these models and approaches, so that they will be able to select and apply the appropriate tools for a particular case; be aware of the current research directions in the field and their possible outcomes; be able to carry out research and be able to apply learned skills to solving practical distributed database related tasks.

Course outline: Distributed database architecture, Distributed database design, Distributed query processing , Query decomposition and optimization of distributed queries, Distributed transaction management and concurrency control, Distributed DBMS reliability, Distributed database operating systems, Distributed multidatabase systems, Client/Server database systems.

Resources:

1. Oszu, T. and Valduriez, P. *Principles of Distributed Database Systems*, 2nd ed., Prentice-Hall, 1999
2. Coronel, Morris & Rob, *Database Systems Design, Implementation, and Management* (9th Edition), Cengage Learning: Boston, MA, 2011
3. Latest research papers will be used.

Object Oriented Databases

Course Code: CSC-754

Credit Hours: 3+0

Prerequisites: Introduction to Database Systems

Objectives: This course covers advanced aspects of object technology. The course teaches a variety of approaches to advanced issues important in real world applications. Particular attention is given to topics that improve the precision and quality of developed systems. The course shows how to use Rational Software Architect to document and aid the advanced design concepts.

The course covers a variety of techniques encountered in complex mission critical applications today and guides students through the best practices of complex system development. Particular attention is given to topics that present the most productive solutions and identify approaches that may cause deficiencies during the lifetime of the system. In addition, the course covers areas of object storage and retrieval, distributed systems, business rules and objects and introduces architecture for supportable systems. Emphasizing productivity and quality, the course concludes with pragmatic guidelines on how to incorporate testing and quality assurance into the development process of object-oriented systems.

Course outline: Introduction to Object-Oriented Databases (General Issues, Concurrency Control, Transactions, Triggers and Notifiers, Distribution, Versions and Configurations), Data Model Issues (Object Identity, Data Models, Inheritance, Polymorphism, Genericity, Extensibility, Integrity Constraints, Composition, Relationship Support, Access to Meta-information, Data Sharing, Authorization), Language Issues (Persistence, Impedance Mismatch. Software Engineering Issues, Host Languages), Query Issues (Query Language, Indexing, Query Optimization), Database Evolution(Schema Changes, Effects of Changes, Database Conversion), Storage Management (Storage Schemes, Buffer Management, Clustering, Interoperability), Research Issues in Object Oriented Databases

Resources:

1. Introduction to Object-Oriented Databases, Won Kim, 2008
2. Index Data Structures in Object-Oriented Databases by Thomas A. Mueck, Martin L. Polaschek – 2012

Web based DBMS

Course Code: CSC-755

Credit Hours: 3+0

Prerequisites: Introduction to Database Systems

Objectives: Learn new ways to model data, Implement a DBMS, Become familiar with the expanding role of database technology.

Course outline: This course introduces concepts, techniques, technologies and APIs for web application development, The main focus of the course is on the Model-View-Controller design pattern employed by modern full-stack web frameworks. Concepts and techniques covered include client/server programming. database abstraction APIs, and asynchronous javascript. Examples of full-stack MVC frameworks include Ruby-on-Rails (written in Ruby), Django and TurboGears (written in Python)

Resources:

1. Database System Concepts, Korth and Silbershatz, 2010
2. Oracle 11g: SQL John Casteel Second Edition Cengage, 2009 ISBN: 978-1-439-04128-4

Multimedia Databases

Course Code: CSC-756

Credit Hours: 3+0

Prerequisites: Introduction to Database Systems

Objectives: 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.

Course outline: Introduction to Multimedia Databases, Multimedia Data, The Human Sensory System and Multimedia, An Introduction to SQL and Multimedia, Querying Multimedia Data, Modeling Multimedia Databases, Using Multimedia Metadata, Multimedia Database Architecture and Performance, Multimedia and the Internet, Dealing with Text Databases
Dealing with Image Databases, Dealing with Video Databases

Resources:

1. Principles of Multimedia Database Systems, by V.S. Subrahmanian, Morgan Kaufmann Publishing Company, San Fransisco, CA. 1998.
2. Principles of Database Query Processing for Advanced Applications (Morgan Kaufmann Series in Data Management Systems), by Clement T. Yu, Weiyi Meng, 1998.
3. Databases and Transaction Processing, An Application-Oriented Approach, Philip M. Lewis, Arthur Bernstein, and Micheal Kifer. Addison Wesley Publishers, 2002.
4. Intelligent Big Multimedia Databases by Andreas Wichert – 2015

Advance Data Warehousing

Course Code: CSC-760

Credit Hours: 3+0

Prerequisites: Database Management System
Data Structures and Algorithms

Objectives: By the end of this course students will be familiar with concepts of Data Warehousing including: Strategic need of data warehousing, Building blocks of a data warehouse, Data warehouse project management, Business requirements of a data warehouse, Architectural components of a data warehouse, Data warehouse metadata management, Dimensionality Modeling, ETL & Data quality, Online Analytical Processing, as well as the following areas of data mining: Motivation for data mining, Data Preprocessing, Data mining primitives and query languages, Architectures of data mining systems, Major Data Mining Tasks, Cluster Analysis , Statistical measures in large databases, Classifications and Predictions, Anomaly Detection

Course outline: Introduction to Data Warehouse, Planning and Requirements, Data Warehouse Architecture, Data Warehouse Infrastructure, Dimensional Modeling, Metadata, Extraction, Transformation and Loading, Online Analytical Processing, Data Preparation Techniques: outlier and missing data analysis, Data Reduction Techniques, Introduction to Data Mining, Modeling and Principal Feature Extraction, Clustering, Hierarchical Clustering, Partitional Clustering, Classification , Decision Tree Classification, Bayesian Classification, Nearest Neighbor Classification.

Resources:

1. Data Warehousing Fundamentals for IT Professionals, Paulraj Pooniah, Wiley, 2nd Edition, 2010.
2. Data Mining Concepts & Techniques, Jaiwei Han, Micheline Kamber, 2nd Edition, 2005.
3. Tutorial on Data Mining, Eamonn Keogh

Information Retrieval Techniques

Course Code: CSC-514

Credit Hours: 3+0

Prerequisites: Database Management Systems

Objectives: Information retrieval is aimed at obtaining information resources relevant to an information need. Search engines are a typical example of information retrieval systems. This course studies the theory, design, and implementation of (text-based) information retrieval systems.

Course outline: Introduction to Information Retrieval. Inverted indices and Boolean queries. Query optimization. The nature of unstructured and semi-structured text.

The term vocabulary and postings lists. Text encoding: tokenization, stemming, lemmatization, stop words, phrases. Optimizing indices with skip lists. Proximity and phrase queries. Positional indices.

Index construction. Postings size estimation, sort-based indexing, dynamic indexing, positional indexes, n-gram indexes, distributed indexing, real-world issues.

Index compression: lexicon compression and postings lists compression. Gap encoding, gamma codes, Zipf's Law, variable-byte encoding. Blocking. Extreme compression.

Dictionaries and tolerant retrieval. Dictionary data structures. Wild-card queries, permuterm indices, n-gram indices. Spelling correction and synonyms: edit distance, soundex, language detection.

Results summaries: static and dynamic. Evaluating search engines. User happiness, precision, recall, F-measure. Creating test collections: kappa measure, inter-judge agreement. Relevance, approximate vector retrieval.

Resources:

1. Introduction to information retrieval, Manning, Christopher D., Prabhakar Raghavan and Hinrich Schutze, Cambridge University Press , 2008
2. Modern information retrieval, R. Baeza-Yates and B. Ribeiro-Neto, ACM Press, 2009
3. Information Retrieval Techniques for Pattern Matching: Managing and Searching Textual and XML Information in 21st Century Applications, by Riccardo Martoglia, LAP Lambert Acad. Publ., 2010.

Ontology Engineering

Course Code: SEN-764

Credit Hours: 3+0

Prerequisites:

Objectives: This Course provides students with a theoretical and practical understanding of leading edge solutions for the Semantic Web. It introduces students to the W3C standard Web Ontology Language, OWL, its underlying Description Logics, establishing patterns to avoid the pitfalls in using OWL. The course provides an opportunity to become familiar with a widely used environment for developing and an API for applying OWL ontologies, and making use of reasoning services accessible via both. Ontology provide rich, repressive vocabularies of terms describing a domain (e.g. medicine, astronomy, music, etc.). They are key to information exchange, data integration and search.

Course outline: Introduction to Description Logics and Reasoning, concepts of semantic interoperability, integration and automation; concept of metadata and ontology; RDF and RDFS , Ontology Web Language (OWL) and Ontology Engineering Methodologies.

Resources:

1. Ontology Engineering in a Networked World, by Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, Enrico Motta – 2012
2. Ontological Engineering: with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web. First Edition - Asunción Gómez-Pérez, Mariano Fernandez-Lopez, Oscar Corcho, 2010.
3. D. Allemang and J. Hendler: Semantic Web for the Working Ontologist. Morgan Kaufmann (2008).

Semantic Web

Course Code: SEN-761

Credit Hours: 3+0

Prerequisites:

Objectives: Semantic Web is a group of methods and technologies to allow machines in understanding the meaning – or "semantics" – of information on the Web. The participants of this course will get the core concepts as well as application development using Semantic Web Technologies. This course includes XML with Document Type Definitions and Schemas: transformation/inference rules in XSLT, Rule ML, and the W3C rule language RIF: metadata with RDF (Resource Description Framework); metadata taxonomies with RDF Schema; description logic and the W3C ontology language OWL 2: as well as integrating these techniques for ontology/rule-based multi-agent systems.

Course outline: To sketch the overall architecture of the Semantic Web, identify the component technologies of the Semantic Web and explain their roles, illustrate the design principles of the Semantic Web by applying the technologies, understand certain limitations of the Semantic Web technologies, and be aware of the kinds of services it can and cannot deliver.

Resources:

1. Allemang, D., & Hendler, J. (2011). Semantic Web for the working ontologist. 2nd Edition, Morgan&Kaufmann Publisher. [ISBN:978-0-12-385965-5]
2. Heath, T., & Bizer, C. (2011). Linked Data: Evolving the Web into a Global Data Space. Morgan&Claypool Publisher.
3. Daconts, M.C., Orbst, L.J., & Smith, K.T.(2003). The Semantic Web: A Guide to the Future of XML, Web Services, and Knowledge Management. New York: Wiley. [ISBN: 0-471-43257-1]
4. Antoniou, G., & van Harmelen, F. (2004). A Semantic Web Primer. Cambridge, MA: MIT Press. [ISBN: 0-262-01210-3]

Appendage 1707

Curriculum of

Masters in Information Security (Revision 2018)

Bahria University

MSIS Program

Program Mission

The mission of the MSIS program is to produce knowledgeable, highly skilled and competitive Information Security graduates who are able to play an effective role in the efforts to make cyberspace reliable and secure for National and International communities.

Program Objectives

The key objectives of the MSIS program include the following.

1. To provide exposure to the knowledge and skills required to protect information assets.
2. To enable understanding of current threats and vulnerabilities and finding ways of developing effective countermeasures.
3. To contribute to the growing needs of information security professionals to protect and secure information assets.
4. To enable students design and implement effective security mechanisms for organizations using the latest tools and technologies.
5. To develop effective oral and written communication skills
6. To prepare students to work effectively independently as well as in groups.

Program Learning Outcomes

Students graduating from the MSIS program are expected to gain:

1. Understanding of the information security challenges in networks and software systems.
2. Ability to perform risk assessment of an organization's information assets.
3. Ability to apply the knowledge and skills acquired during the program to design and implement secure networked, software and distributed systems.
4. Acquaintance with the latest information security tools and technologies.
5. Ability to communicate effectively in written and oral form.
6. Ability to pursue continuous professional development.
7. Ability to work on practical and research based problems collaboratively as well as independently.

Eligibility Criteria

HEC recognized 4 years Bachelor degree in CS/SE/CE/EE/IT or equivalent or MCS/MIT with CGPA 2.5/4.0 (Semester System) or 50% marks (Annual System). NTS-GAT (General)/ GRE/University entry test passed with 50% marks.

Core Courses

S. No	Course Code	Course Title	Credit Hours
1	ISC-511	Number Theory	03
2	CSC-521	Advanced Design and Analysis of Algorithms	03
3	ISC-512	Computer and Network Security	03
4	ISC-746	Advanced Cryptography	03

Elective Courses

Sr. No	Course Code	Course Title
1	ESC-500	Thesis
2	EEN-510	Stochastic Process
3	EET-519	Distributed Networking
4	EET-520	Network Administration and Management
5	EET-553	Information theory and coding
6	EET-556	Mobile Communication and Networking
7	ISC-732	Advance Computer Security

8	ISC-733	Information Hiding
9	ISC-734	Wireless Network Security
10	ISC-735	Cloud Computing Security
11	ISC-736	Cyber Warfare
12	ISC-737	Computer and Network Forensics
13	ISC-738	Ethical Hacking
14	ISC-739	Cyber Crimes and Laws
15	ISC-740	Quantum Cryptography
16	ISC-747	Advanced Cryptanalysis
16	ISC-741	Algebraic Cryptanalysis
17	ISC-742	Intrusion Detection and Prevention
18	ISC-743	Penetration Testing and Vulnerability Analysis
19	EET-710	Advanced Computer Networks
20	CSC-720	Advanced Operating Systems
21	ISC-731	Information Security Management
22	ISC 748	Blockchain Essentials

Proposed Roadmap – MSIS

Semester-wise Breakdown: MS Information Security

Semester 1	
Course Code	**Course Title**
ISC-511	Number Theory
CSC-521	Advanced Design and Analysis of Algorithms
ISC-512	Computer and Network Security
	Total

Semester 2	
Course Code	**Course Title**
Elective Code	Elective-I
ISC-746	Advanced Cryptography
ESC-701	Research Methodology
	Total

Semester 3

Course Code	Course Title
Elective Code	Elective-II
ESC-500 / Elective Code	Thesis-I / Elective-III
Elective Code	Elective-IV
	Total

Semester 4

Course Code	Course Title
ESC-500 / Elective Code	Thesis-II / Elective-V
	Total
	TOTAL CREDIT HOURS

University Requirement

S	Cours	Course	Cred

r. No	e Code	Title	it Hours
1	ESC-701	Research Methodology	03

Description of courses

Course Title: **Number Theory**
Course Code: ISC-511
Pre-Requisite: None

Objectives:
The objective of this course is to introduce number theory that is an ongoing rich area of mathematical exploration and is noted for its theoretical depth, with connections and applications relating to physics and cryptography. The course will give in-depth knowledge of number primes, congruence's, and Diophantine equations and their usage in real-world problems. Also, the course will provide mathematical foundation for advance cryptographic techniques using elliptic curves.

Contents:
Time estimates for doing arithmetic, Divisibility and the Euclidean algorithm, Congruence, applications to factoring, Finite Fields and Quadratic Residues, Finite fields, Quadratic residues and reciprocity, cryptography: Some simple cryptosystems, Enciphering matrices, Public Key: The idea of public key cryptography, RSA, Discrete log, Knapsack, Zero-knowledge protocols and oblivious transfer. Primality and Factoring: Pseudo primes, The rho method, Fermat factorization and factor bases, The continued fraction method, The quadratic sieve method. Elliptic Curves: Basic facts, Elliptic curve cryptosystems, Elliptic curve primality test, Elliptic curve factorization.

Text Books:
Introduction to Number Theory by Anthony Vazzana, Martin Erickson, David Garth published by Chapman & Hall/CRC, 2007, ISBN 9781584889373.
Elementary Number Theory by David Burton, 2016, ISBN-13: 978-0073383149

Reference Books:
Number Theory: Structures, Examples, and Problems by TituAndreescu, AndricaDorin published by BIRKHAUSER BOSTON INC, 2009, ISBN: 9780817632458

Course Title: **Computer and Network Security**
Course Code: ISC-512
Pre-Requisite: None

Objectives:
The course will provide an optimal description of the concepts, methods, principles and applications of computer network security in particular, and cyberspace security in general. The understanding give awareness regarding security situations based on a constant security threat, the core and best practices their solutions currently in use. It is an essential security course for students, practitioners in networks, and professionals who develop and maintain secure computer network systems.

Contents:
Computer and network security essentials, Network Security: security attacks, TCP/IP & OSI model, security services, threats in networks, security in networks, data security, integrity measures, message authentication code, user authentication, basics of symmetric and public key cryptosystems, transport level security, SSL, TLS, HTTPS, network security measures: firewalls and IDS, ACLs

and capabilities, Access control models, Computer Security: Programming-Language Security, Buffer-overflow attacks, defenses and counterattacks, SQL injection, web security (XSS/CSRF attacks), Web attacks and defenses, Privacy/Anonymity: Database privacy.

Text Books:

Guide to Computer Network Security, by Joseph Migga Kizza published by Springer, 3rd edition, 2015.

Elementary Information Security, by Richard E. Smith, 2nd edition, 2013, ISBN: 978-1284055931

Reference Books:

Network Security: The Complete Reference, by Bragg published by McGraw Hill Professional, 2012.

Computer Network Security by Authors: Kizza, Joseph Migga published by Springer, ISBN 978-0-387-25228-5, 2005

Security in Computing, Charles P. Pfleeger and Shari P. Pfleeger, Fourth Edition, Pearson Education, 2011

Course Title: **Advanced Computer Networking**
Course Code: EET-710
Pre-Requisite: None

Objectives:

The objective of this course is to study advance concepts related to core networking technologies of wired and wireless networks. The core wired networking technologies include ATM, MPLS and NGNs where wireless networking technologies include WiFi, Vehicular networks, Sensor networks and ZigBee networks. Therefore, this core course is designed to address latest networking trends and advancements and trends in both wired and wireless networks.

Contents:

Advanced networking core technologies: Asynchronous Transfer Mode (ATM), Multiprotocol Label Switching (MPLS), and Next Generation Networks (NGN). Advance technologies: IPv6, mobility management (mobile IP and Proxy Mobile IP), Border Gateway Protocol (BGP). Wireless Ad hoc networks: Taxonomy of wireless networks, necessity for new protocols in wireless networks, IEEE 802.11, IEEE 802.15.4, Ad hoc routing protocols (AODV, DSR, DSDV, ZRP), Advancements in TCP for Ad hoc networks, Wireless Sensor Networks, Vehicular Networks, Multimedia Networks, Cross layer design issues and protocols.

Text Books:

Computer Networks: A Systematic Approach by Peterson and Davie, 4thedition.

Ad Hoc Wireless Networks: Architectures and Protocols, by C. Siva Ram Murthy and B. S. Manoj, published by PrenticeHall.

Reference Books:

Computer Networks and Internets" by Douglas E. Comer

Computer Networks" (4th Edition) by Andrew S. Tanenbaum

Course Title: **Advanced Operating Systems**
Course Code: CSC-720
Pre-Requisite: None

Objectives:
To address the advance concepts ranging from embedded micro kernels to popular platforms like LINUX, SOLARIS, Windows 2000 and XP. Distributed processing and synchronization, Real time and Multimedia support along with Fault tolerant computing are introduced. A major objective of this course is to introduce the vulnerabilities within operating system design that are used by different malwares.

Contents:
The course is designed to deliver the state of art operating system concepts ranging from embedded micro kernels to popular platforms like LINUX, SOLARIS, Windows 2000 and XP. The focus will be on the internals, architecture, device driver writing and the distributed processing support on multi-processor systems. Fault tolerant computing, presentation for multimedia and time critical applications. Apart from core OS concepts basic security aspects of OS will be covered like: Understanding the operations of Viruses and Worms, Vulnerability Analysis, Exploits: Buffer Overflows, Heap Overflow, Integer Overflow

Text Books:
Operating Systems Principles (8th Edition), by Silberschatz, Galvin.
LINUX Kernel Internals, by M.Beck, H. Boeme.
Reference Books:
Operating Systems, by Garry Nutt
Modern Operating Systems, by Andrew S. Tanenbaum
Advanced Windows NT, byJeffery Richter
Writing Device Divers for Windows NT, byAnthony Mason

Course Title: **Advanced Cryptography**
Course Code: ISC 746
Pre-Requisite: Number Theory

Objectives:
The course covers in detail all major areas of cryptography from classical to modern cryptosystems. The objectives of the course are to understand the following: Block Ciphers, Stream Ciphers, Hash Functions and MACs, Asymmetric Techniques and RSA, Discrete Logarithm Cryptosystems, Elliptic Curve Crypto-sytems, Identity - Based Encryption, Identification Schemes and Lattice Cryptosystems.

Contents:
Block cipher principles: Cryptology and its domains, cryptanalysis basics, Kirchhoff's principle, Confidentiality taxonomy, Classical Cipher Techniques and their cryptanalysis: Substitution (mono-alphabetic, homophonic, poly-alphabetic and Polygram ciphers), Permutation ciphers and Product ciphers, Modern Symmetric Ciphers and cryptanalysis: DES, AES, Two fish, block cipher operation, stream ciphers (RC4 and A5/1), Zero knowledge protocols and proofs of knowledge, public key

cryptography: RSA, Diffie-Hellman key exchange, digital signature standard, X.509 Certificates, Elliptic curve and Hyper-elliptic curve based cryptographic protocols, Pairing Based Cryptography, Lattice-based cryptography.

Text Books:
Introduction to Modern Cryptography, by Jonathan Katz, Yehuda Lindell, published by CRC Press, 2015.
Cryptography and Network Security, William Stallings, Fifth Edition, Pearson Education, 2011
Reference Books:
Cryptography Engineering: Design Principles and Practical Applications by Niels Ferguson, Bruce Schneier, and Tadayoshi Kohno, published by Wiley, 2011.
Understanding Cryptography: A Textbook for Students and Practitioners by ChristofPaar, Jan Pelzl, and Bart Preneel published by Springer, 1st ed. 2010.

Course Title: **Research Methodology**
Course Code: ESC-501
Pre-Requisite: None

Objectives:
The key objectives of this course include familiarization with research and its type, familiarization with the criteria for choosing research problem and research advisor, effective conduct of literature search, review and literature writing. Making students learn writing of research proposals, research thesis and research papers, acquaint students with plagiarism and its consequences, and equip students with different metrics to quantify research and researchers. Enable students make and deliver effective presentations.

Contents:
The course equips the students with the terminologies, skills, tools and practices involved in effective conduct of research. The major topics covered during the course include research and research types, choosing research problems and research advisors, How to carry out research, Formulation – Problem statement, Literature Review, Design – Methodology and Analysis - Data analysis and interpretation, Ethics of research and Presenting and publishing research.

Text Books:
Research Methodologies – A step by step guide for beginners, Ranjit Kumar
Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell
Reference Books:
How to Research, Loraine Blaxter, C. Hughes, M. Tight

Course Title: **Information Security Management**
Course Code: ISC-731
Pre-Requisite: None

Objectives:
Objective of this course is to introduce information security and assurance using both domestic and international standards with a management perspective. The course will familiarize students with foundational and technical components of information security, focusing on access control models, information security governance, and information security program assessment and metrics. The aim of the course is to provide strong foundation to students for identifying and addressing business risks through a disciplined security management process as specified by ISO 27001.

Contents:
Security Management - Systems, Models and Frameworks, IS 27001 - Information Security Management for Business Benefit, Governance and security policy, threat and vulnerability management, incident management, risk management, information leakage, sensitive data, contingency planning, business continuity, legal and compliance, security awareness and security implementation considerations, Internal Control, Audit and Security, CRAMM 5.0 (CCTA Risk Analysis and Management Method).

Text Books:
Information Security Management Handbook, 6th Edition by Harold F. Tipton
Management of Information Security by Michael E. Whitman

Reference Books:
Information Security Management: Concepts and Practice by Bel G. Raggad
IT Governance: An International Guide to Data Security and ISO27001/ISO27002 by Alan Calder

Course Title: **Advance Computer Security**
Course Code: ISC-732
Pre-Requisite: Advanced Operating Systems

Objectives:
The objective is to study advance computer system security concepts related to operating systems and programming languages. The course will unravel the complex topic of computer security by examining the variety of competing security systems and what makes them different from one another. The course aims to focus on Unix security, Windows security, database security, web security, and software security

Contents:
OS-level Memory Protection, Binary Code Reusing, Binary Code/Data Representation, Program Representation, Dynamic Binary, Principles of Program Analysis, Revealing Internals of Executable File Format Compiler, Linker, Loader. Library Interposition, Virtualization Technology and Applications, Virtual Machine Monitor (QEMU/ VirtualBox/Xen/KVM), Symbolic Execution and Whitebox Fuzzing, Vulnerability Analysis, Exploits: Buffer Overflows, Heap Overflow, Integer Overflow and Robust Exploits: ROP shellcode, Heap Spray, Fighting for Malware: Unpack, Disassemble, Decompile. Understanding the Threats such as Viruses and Worms, Logging, Auditing and Recovery. Honeypots and Honeyfarm.

Text Books:

Computer Security by Dieter Gollmann published by Wiley, 2011

Reference Books:

Computer Security Handbook, by Seymour Bosworth

Computer Architecture and Security: Fundamentals of Designing Secure Computer Systems 1st Editionby Shuangbao Paul Wang (Author), Robert S. Ledley

Course Title: **Information Hiding**
Course Code: ISC-733
Pre-Requisite: None

Objectives:
The aim of this course is to introduce techniques for hiding digital information by means of various obfuscatory and steganographic methods. The course aims to introduce cryptographic and non-cryptographic information hiding techniques including encryption, compression, data embedding and watermarking, data mimicry, and scrambling. Also, this course will emphasis on the applications of said techniques that facilitate message confidentiality and user identity authentication, and helps to ensure the integrity and security of computer passwords, ATM card information, digital signatures, information content, and electronic commerce.

Contents:
Framing information, reasons for secrecy, common techniques of information hiding, encryption and white noise, Secret sharing: splitting techniques, public key, stenographic file systems; compression techniques, Grammar and mimicry, turning and reverse, hiding information in images, anonymous remailers, ordering and re-ordering, spreading, watermarks, stenographicanalysis, obfuscation

Text Books:
Disappearing Cryptography, Third Edition: Information Hiding: Steganography & Watermarking by Peter Wayner
Information Hiding: Steganography and Watermarking - Attacks and Countermeasures by Neil Johnson, Zoran Duric, SushilJajodia
Reference Books:
Information Hiding by Stefan Katzenbeisser, Fabien Petitcolas

Course Title: **Wireless Network Security**
Course Code: ISC-734
Pre-Requisite: Advanced Computer Networking

Objectives:
The objectives of the course are to introduce the theory and practices used in wireless networks including IEEE 802.11, Bluetooth, ZigBee and cellular networks. The course will familiarize students with theory and practical knowledge of WiFi security featuring discovery and profiling, attacks, bypass techniques for popular authentication mechanisms, encryption keys cracking using special techniques.

Contents:
Wireless networking background: IEEE 802.11, Bluetooth, ZigBee and Cellular networks, Wireless Security background: WEP security model and issues, RC4, IEEE 802.11i, Robust security network in WPA-2, TSN/RSN encryption; discovering wireless networks, WiFi attacks: authentication flooding, CTS attacks, beacon flooding, disassociation attacks; Bypassing simple authentication, cracking WEP security, attacks on WPA/WPA2. Bluetooth and ZigBee security models, attacks and countermeasures, Security issues in cellular networks: network model, authentication, encryption and attacks. Security issues in smart environments

Text Books:
Hacking Wireless Networks - The ultimate hands-on guide by Mr Andreas Kolokithas
Hacking Exposed: Wireless Security Secrets & Solutions by Joshua Wright (Author), Johnny Cache

Reference Books:
Wireless Network Security A Beginner's Guide by Tyler Wrightson

Course Title: **Cloud Computing Security**
Course Code: ISC-735
Pre-Requisite: None

Objectives:
To understand the fundamentals of cloud architectures and their risk assessment. To understand how the cloud offers flexibility, adaptability, scalability, and the case of security-resilience. The course will present the strengths and weaknesses of securing your company's information with different cloud approaches. Also, the aim of this course will be to introduce the common attacks that can occur on your infrastructure, communications network, data, or services. Finally, to understand the secure cloud frameworks necessary to secure your business' assets while making the most of this new technology.

Contents:
Cloud computing basics, NIST cloud definition of cloud: SaaS, PaaS, IaaS, private cloud, public cloud, community and hybrid clouds, Virtualization. Cloud security fundamentals: Upside and downside security, risk management framework, trust, identity. Infrastructure security, data security and storage, Identity and access management, security mechanisms in cloud, privacy, audit and compliance, Security as a service.

Text Books:
Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice) by Tim Mather, Subra Kumaraswamy, Shahed Latif

Reference Books:
Securing the Cloud: Cloud Computer Security Techniques and Tactics by Vic (J.R.) Winkler
Cloud Computing: From Beginning to End by Mr. Ray J Rafaels

Course Title: **Cyber Warfare**
Course Code: ISC-736
Pre-Requisite: None

Objectives:
The objective of this course is to understand the principles, techniques, psychology, effects and legal aspects of cyber-attacks. The course focuses on the world of cyber-warfare through the use of recent case studies. It is aimed at teaching not only the issues related to cyber warfare from a computer science perspective but from military, sociological, and scientific perspectives as well. In this course students will learn how cyber-warfare has been performed in the past as well as why various actors rely on this new means of warfare and what steps can be taken to prevent it.

Contents:
The domain of cyber warfare: cyber espionage, cyber-crime, future threats, awareness and infrastructure. Legal status of cyber warfare: treaties and laws, the law of armed conflict, the Antarctic treaty and space law. Cyber-attacks: vulnerabilities, denial of service, defacement, attacker detection, important cyber-attacks in recent times. Cyber espionage and exploitation: purpose, strategies, cyber espionage doctrine, espionage against corporate world and military usage, social network exploitation. Cyber operations for infrastructure attacks; industry based attacks, methods,

reasons and benefits. Organized crimes in cyber space, role of cyber warfare in military doctrine, cyber early warning networks

Text Books:
Introduction to Cyber-Warfare: A Multidisciplinary Approach by Paulo Shakarian
Inside Cyber Warfare: Mapping the Cyber Underworld by Jeffrey Carr
Reference Books:
Cybercrime and Cyber Warfare by Igor Bernik

Course Title: **Computer and Network Forensics**
Course Code: ISC-737
Pre-Requisite: Computer and Network Security

Objectives:
The objectives of this course are to study computer and network security principles and practices for crime investigations and other legal actions. The students will learn how to use forensically-sound methodologies and software to acquire admissible electronic evidence with coverage areas of networks, computer, email forensics and cell phone forensics.

Contents:
Forensics Essentials and Criminalistics, Essentials of OS and Networking (Review), Forensic Modelling and Principles, Forensic Duplication, Forensics Analytics, File Carving, Cyber Forensics Tools and the Testing Thereof, Email forensics, Mobile Device Forensics, Network Surveillance and Accountability, Network Attack Trace back and Attribution, Multicast Fingerprinting, Multimedia Forensics, Intrusion and Online Frauds Detection, Steganography & Steganalysis, Anonymity/ Pseudonymity/ P3P, Cyber Law, Security and Privacy Policies and Guidelines, Ethical issues, Court Testimony and Report Writing Skills.

Text Books:
Guide to Computer Forensics and Investigations by Bill Nelson
Network Forensics: Tracking Hackers through Cyberspace by Sherri Davidoff
Reference Books:
Computer Forensics: Investigating Network Intrusions and Cyber Crime published by EC-Council Press
Computer Forensics: Principles and Practices by Linda Volonino

Course Title: **Ethical Hacking**
Course Code: ISC-738
Pre-Requisite: Computer and Network Security

Objectives:
The basic objective of this course is to introduce ethical hacking and to provide hands-on experience to students for replicating and launching common well known programming, web, database, network and operating systems based attacks. Remote access to system using malwares and use of on-shelf tools for hacking along with identifying weaknesses in administrative and security policies are the basic objectives of this course.

Contents:
Introduction to Penetration Testing, Legal and Ethical Considerations, Creating and Implementing a Test Plan, Social Engineering, Host Reconnaissance, Session Hijacking, Web Server Attacks, Database Attacks, Password Cracking, Network Devices & Attacks, Wireless Network Attacks, Trojans and Backdoor Applications, OS Specific Attacks, Denial of Service Attacks, System administration and secure policies.

Text Books:
Hands-On Ethical Hacking and Network Defence by Michael T. Simpson

Reference Books:
Gray Hat Hacking the Ethical Hacker's Handbook, Fourth Edition by Daniel Regalado
Basic Security, Penetration Testing and How to Hack by Isaac Sharpe

Course Title: **Cyber Crimes and Laws**
Course Code: ISC-739
Pre-Requisite: None

Objectives:
The objectives of this course are to impart in-depth knowledge of cyber threats and crimes, along with the national and international laws protecting against cyber-crimes. The course is also aimed to address the procedure of digital data collection, evidence handling and analysis. Another objective of this course is to create an awareness of individual's rights over digital information, public safety practises and ethical issues related to cyber laws.

Contents:
Cyber space, cyber terrorism, definition and types of cybercrimes: categorization, methods and tools, investigating cybercrimes (decision making, problem solving, conviction), advance investigations and forensics tools and techniques, seizing, imaging, and analysing digital evidence, case studies, national and internationals laws against cybercrimes, roles of agencies and national response centre's for cybercrimes, impact of social media on cybercrimes and awareness

Text Books:
Cyber Crime and Cyber Terrorism Investigator's Handbook by BabakAkhgar, Andrew Staniforth, Francesca Bosco

Reference Books:
Future Crimes: Everything Is Connected, Everyone Is Vulnerable and What We Can Do About It by Marc Goodman

Course Title: **Quantum Cryptography**
Course Code: ISC-740
Pre-Requisite: Advanced Cryptography

Objectives:
The objective of this course is to introduce the principles of quantum cryptography (or quantum key distribution) that is a state-of-the-art technique that exploits properties of quantum mechanics to guarantee the secure exchange of secret keys. The course will focus on the principles and techniques of quantum cryptography, setting it in the wider context of cryptography and security, with specific focus on secret-key distillation.

Contents:
Classical cryptography, information theory (classical and quantum), and applications of quantum cryptography, secret-key distillation, privacy amplification and reconciliation techniques, principles of quantum cryptography, algebraic attacks on quantum cryptography, post-quantum cryptography and future trends.

Text Books:
Quantum Cryptography and Secret-Key Distillation by Gilles van Assche

Reference Books:
Quantum Computation and Quantum Information: 10th Anniversary Edition by Michael A. Nielsen

Course Title: **Advanced Cryptanalysis**
Course Code: ISC - 747
Pre-Requisite: Advanced Cryptography

Objectives:
The objective of this course is to study cryptanalysis techniques that are applied on classical and modern cryptosystems. The course will cover a variety of ways to break, fix/repair and to measure/evaluate the security of cryptographic primitives. Study of major computational hard problems in cryptography (symmetric and public key). Step by step analysis of mathematical/algebraic/statistical attacks, methods and algorithms in cryptanalysis.

Contents:
Historical cryptanalysis, LFSR-based stream ciphers, Modern block ciphers (DES/AES/other), Differential cryptanalysis, linear cryptanalysis, algebraic cryptanalysis in block and stream ciphers. Self-similarity attacks. Groups, finite fields. Number theory. Attacks on public key cryptosystems. RSA, factoring, discrete logarithms, elliptic curves, lattice attacks. Protocol/mode/initialization attacks, Side channel attacks.

Text Books:
Modern Cryptanalysis: Techniques for Advanced Code Breaking, by Christopher Swenson published by John Wiley, 2012
Advanced Linear Cryptanalysis of Block and Stream Ciphers, by P Junod, A. Canteaut published by IOS press, 2011

Reference Books:
Cryptography and Network Security, William Stallings, Fifth Edition, Pearson Education, 2011
Introduction to Modern Cryptography, by Jonathan Katz, Yehuda Lindell, published by CRC Press, 2015.

Course Title: **Algebraic Cryptanalysis**
Course Code: ISC-741
Pre-Requisite: Advanced Cryptography

Objectives:
The objective of the course is to understand how to reduce the attacks on ciphers (cryptosystems) to systems of polynomial equations over finite fields and subsequent heuristics for efficiently solving these systems. The course of algebraic cryptanalysis will bridge the gap between ciphers and understanding how to break ciphers (code breaking). The course will allow students to turn ciphers into a system of equations and using techniques like finite field linear algebra, polynomial systems of equations, and graph colouring solve complex problems.

Contents:
Review of ciphering techniques, basics of linear algebra, complexity of GF-2 Matrix operations, exponent of certain matrix operations, quadratic sieve: Factoring integers via the quadratic sieve, with its applications to the cryptanalysis of RSA. Strategies for polynomial systems, algorithms for solving polynomial systems, block ciphers with small blocks, polynomial and graph colouring algorithms

Text Books:
Algebraic Cryptanalysis by Gregory Bard

Reference Books:
Cryptanalysis: Techniques for Advanced Code Breaking by Christopher Swenson
Quantum Attacks on Public-Key Cryptosystems by Song Y. Yan

Course Title: **Intrusion Detection and Prevention**
Course Code: ISC-742
Pre-Requisite: None

Objectives:
To introduce theory and practical knowledge related to network intrusion detection and prevention with concise information on different types of attacks, theoretical foundation of attack detection approaches, implementation, data collection, evaluation, and intrusion response. The objective also includes a review of commercially/publicly available intrusion detection and response systems.

Contents:
Network attacks review: Probes, DDoS, Worms attack, routing attacks. Intrusion detection approaches: Pattern matching, rule-based, state-based, data-mining based approaches, statistical models, biological and learning models. Data Collection: host and network based models. Foundations of detection: fuzzy logic, neural networks support vector machines, association rules and classification. Architecture and implementations, alert management and correlation, evaluation criteria and Intrusion response.

Text Books:
Network Intrusion Detection and Prevention: Concepts and Techniques by Ali A. Ghorbani, Wei Lu, Mahbod Tavallaee
Reference Books:
Intrusion Detection and Prevention by Carl Endorf, Gene Schultz, Jim Mellander
The Practice of Network Security Monitoring: Understanding Incident Detection and Response by Richard Bejtlich

Course Title: **Penetration Testing and Vulnerability Analysis**
Course Code: ISC-743
Pre-Requisite: Computer and Network Security

Objectives:
Penetration testers simulate cyber-attacks to find security weaknesses (vulnerabilities) in networks, operating systems, and applications. Therefore, the objective to teach how to properly utilize and interpret the results of modern day hacking tools, which are required to complete a penetration test. Tool coverage includes Backtrack and Kali Linux, Google reconnaissance, MetaGooFil, DNS interrogation, Nmap, Nessus, Metasploit, the Social Engineer Toolkit (SET), w3af, Netcat, post exploitation tactics, the Hacker Defender rootkit, and more.

Contents:
Definitions, concepts, and phases of vulnerability assessments, legal statutes and issues of vulnerability finding, Network Surveying, Port Scanning, System Identification / OS Fingerprinting, Vulnerability assessment and ethical hacking methodologies, technologies, and techniques and from a defensive and offensive perspective, Examining an organization for weaknesses and exploiting vulnerabilities remotely, Vulnerability Research and Verification, Service Identification, Internet Application Testing, Implementing appropriate countermeasures to thwart malicious hacking, Employing tools & exploits; Back Track, Core Impact, DDOS, Sniffers, Spoofing, Session Hijacking, Buffer Overflows, Hacking Web Servers and Applications, Google Hacking, Network

and host monitoring and traffic analysis, Reading, interpreting, and analysing network traffic and log files, Foot printing, scanning, enumeration and escalation.

Text Books:
The Basics of Hacking and Penetration Testingby Patrick Engebretson
Reference Books:
Mastering Kali Linux for Advanced Penetration Testing by Robert W. Beggs

Course Title: **Stochastic Process**
Course Code: EEN-510
Pre-Requisite: None

Objectives:
Objectives of the course are to introduce basic and advance probability theory, extend the knowledge related to random signal processes. Associating and linking the concepts of random signal processes with telecommunication networks, communications and signal processing through examples and assignments.

Contents:
Set theory, Introduction to probability, Joint and conditional probability, Independent events, Combined experiments, The Random Variables, Distribution Function, Density Function, Gaussian Random Variable, Other Random Variables, Conditional Distribution and Density Functions, Introduction to expectation and moments, Expectation, Moments, Inequalities, Transformation of a random variable, Computer generation of one random variable, Introduction to multiple random variables, Joint distribution, Joint density, Conditional distribution and density, Statistical independence, Distribution and density of sum of random variables, Introduction to operations on multiple random variables, Joint characteristic functions, Jointly Gaussian random variables, Transformation of multiple random variables, Linear transformation of Gaussian random variables, Limit theorems, Random processes, Stationary and independence, Ergodicity, Correlation function, Gaussian random process, Poisson random process.

Text Books:
P. Peebles, "Probability, Random Variables, and Random Principles, 4/e, McGraw Hill
Reference Books:
Probability, Random Variables and Stochastic Processes By: Athanasios Papoulis and S. Pillai , 4th edition
Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Prentice Hall, 2008

Course Title: **Advanced Design and Analysis of Algorithms**
Course Code: CSC-521
Pre-Requisite: None

Objectives:
The objective of this course is to study broad range of algorithms in depth and understand the design and analysis of various complex algorithms. The course will provide understanding of basic as well as advanced algorithms used in variety of applications and systems starting with probabilistic analysis, randomized algorithms, linear programming to more advance algorithm designs including

dynamic programming, greedy algorithms, new notion of edge-based flows and approximation algorithms.

Contents:
Computing Computational Complexity, Divide and Conquer, Dynamic Programming, Graphs, Network Flow, Ford-Fulkerson Algorithms, Stable Matching, Image Segmentation, Problem Session, Heuristics, Data Visualisation, Genetic Algorithms, Randomised Algorithms, Complexity Theory, NP Completeness, Reducibility, Approximation Algorithms

Text Books:
Introduction to Algorithms by Thomas H. Cormen
Algorithm Design by Jon Kleinberg
Reference Books:
An Introduction to Genetic Algorithms by Melanie Mitchell
Algorithms by Papa Dimitrios
Approximation Algorithms by Rajeev Motwani

Course Title: **Information theory and coding**
Course Code: EET-553
Pre-Requisite: None

Objectives:
Information theory is used in areas of contemporary science and engineering - communication, signal processing, data mining, machine learning, pattern recognition, computational neuroscience, bioinformatics, and cryptography. It is therefore the objective of this course to learn basic and advance concepts of Information theory alongside practical communication systems and examples.

Contents:
Introduction, Error detection code: independent errors, burst errors, redundancy and error detection. Repetition and Hamming codes, Data compression: Trees and codes, Kraft inequality, Huffman, types of codes. Probabilities and Inference, Sparse graph codes, Entropy and Shannon's coding theorem: binary entropy, bounds of entropy, trees, coding of information source. Mutual information and channel capacity: System entropy, mutual information, capacity of binary information system, Shannon's channel coding theorem.

Text Books:

Information Theory, Inference and Learning Algorithms by David J. C. MacKay
A Student's Guide to Coding and Information Theory by Stefan M. Moser, Po-Ning Chen
Reference Books:
Information Theory and Coding by Example by Mark Kelbert, Yuri Suhov

Course Title: **Mobile Communication and Networking**
Course Code: EET-556
Pre-Requisite: None

Objectives:
The objectives of this course are: to understand the basics of mobile communications and the use of wireless technologies in telecom industry, to understand basic wireless channel models and implement the functionality of wireless systems, to have a comprehensive knowledge of cellular mobile technologies in different applications and to learn the latest and future mobile and wireless technologies and their applications in everyday life.

Contents:
The course will start with an introduction of the fundamental architectures and principles of mobile and wireless networks and their relationships with the backbone Internet. This is followed by the detailed examinations of a number of most recently developed mobile wireless networking technologies and architectures. Several types of widely employed mobile wireless networks and research topics are investigated in-depth as the further applications of the newly developed wireless networking techniques. Topics like cellular networks and architectures (2G, 3G, 4G and beyond), roaming, handovers, mobile IP and PMIP, WLANs and Vehicular networks are covered in this course.

Text Books:
T. Rappaport: "Wireless Communications Principle & Practice" Prentice Hall.
Stallings, Wireless Communications and Networks, Prentice Hall
Reference Books:
Lee, William C. Y., Mobile Communication Engineering
Parsons, J.D., Mobil Radio Propagation Channel

Course Title: **Network Administration and Management**
Course Code: EET-520
Pre-Requisite: None

Objectives:
This course provides a comprehensive survey of essential aspects of system administration. A broad skillset required in this profession will be covered by providing students with an opportunity to develop hands-on skills on top of broad theoretical base. Objectives of the course include: describing a number of key system administration concepts and applying them to complex network environments, analysing various system administration problems and their solutions, and articulating solutions for large-scale client/server installations.

Contents:
This course expands on topics covered including operating system and file system concepts, software installation and package management, configuration management, TCP/IP networking, user management, host management, analytical system administration, user level services, network level services, SNMPv3 - USM: User-based Security Model, SNMPv3 -VACM: View Access Control Model, Multi-Protocol Label Switching (MPLS),Data Centres, Network Administration and Management in Cloud Systems, Network Administration and Management in IoTs.
Text Books:
Network Warrior, 2nd Ed,. 2011, by Gary A. Donabue
The Practice of System and Network Administration, 2nd Ed., 2007 by Limoncelli, Hogan and Chalup
Essential SNMP, 2nd Ed. 2005, by Douglas R. Mauro & Kevin J. Schmidt

Reference Books:

UNIX and Linux System Administration Handbook, 4th Ed., by Nemeth, Snyder, Hein and Whaley
Principles of Network and System Administration, 2nd Ed., by Mark Burgess
Network Management Concepts and Practice: A Hands-on Approach, Pearson Education 2004, by J Richard Burke

Course Title: **Distributed Networking**
Course Code: EET-519
Pre-Requisite: Advanced Computer Networking

Objectives:

This course is design to teach how distributed networks are designed and implemented in real systems and provides detail on basic topics like communication, replication, fault systems, tolerance, and security. Students will be given real life examples of Distributed Networks such as Ad hoc, sensor and delay tolerant networks

Contents:

Communication, Processes, Synchronization, Consistency and replication, Scalability, Caching and replication, Fault tolerance and security, Naming in Distributed environments, Distributed file systems and coordination-based systems, Middleware models, Distributed networks: Ad Hoc Networks, Sensor Networks, Delay-Tolerant Networks, Peer to Peer Networks

Text Books:

Andrew S. Tanenbaum, Maarten Van Steen, Distributed Systems: Principles and Paradigms, Pearson Education.
Kenneth P. Birman, Reliable Distributed Systems: Technologies, Web Services, and Applications.

Reference Books:

David Culler, Anoop Gupta, J.P. Singh, Parallel Computer Architecture: A Hardware/ Software Approach, Morgan Kaufmann.
George Coulouris, Jean Dollimore, Tim Kindberg, Distributed System Concepts and Design, Addison Wesley, 2001

Course Title: Blockchain Essentials
Course Code: ISC 748
Pre-Requisite: None

Objectives:

The objective of this course it to understand Concepts, features, and functionality of Bitcoin and the blockchain. Bitcoin is starting to come into its own as a digital currency, but the blockchain technology behind it could prove to be much more significant. Therefore, the course shall not be limited to bitcoins instead how blockchain can be used in other domains such as health, inventory, business etc shall be explored.

Contents: What is blockchain and why It's needed, how block chain works: planning the block chain, documenting ownership, hashing data, hashing & its issues, protecting user accounts, storing transactions, protecting data store, distributing data among peers. Bitcoin Protocol and Consensus: Bitcoin History: From the Cypherpunk Movement to JPMorgan Chase, Bitcoin Mechanics and Optimizations: A Technical Overview, Bitcoin IRL: Wallets, Mining, and More, Ethereum & Smart

Contracts: Enabling a Decentralized Future, Game Theory and Network Attacks: How to Destroy Bitcoin, Scaling Blockchain: Cryptocurrencies for the Masses, Enterprise Blockchains, Real-World Applications and future

Text Books:

Blockchain Basics by Deaniel Drescher Published by Apress, 1st edition, 2017.
Blockchain Technology Explained by Alan T. Norman, published by CreateSpace, 2017

Reference Books:

Bitcoin and Cryptocurrency Technologies by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, published by Princeton University press, 2016.

Appendage 1708

Elaboration of Mapping of University Vision, Program Mission and PEOs

The OBE frame work along with PEOs, PLOs and their alignment in terms of following table is accepted in 31st ACM.

Program Educational Objectives	Departmental Vision	Program Mission
6. Professional Employment	✓	✓
7. Technical Competence	✓	✓
8. Professional Growth	✓	✓
9. Social Engagement	✓	✓

- First of all there should be university Vision in place of Departmental vision. Moreover, in addition to above mentioned mapping table, there should be statements that can better explain these alignments.
- Bahria University has following Vision:
  "To become an internationally recognized university that contributes towards the development of nation through excellence in education and research"
  On the other hand the BEE Program Mission is as under:
  "The mission of Electrical Engineering program is to produce ethically sound and technically competent electrical engineers who can serve in the diverse fields of research, design & development, teaching, system installation, support and maintenance."
- The mission of BEE program is derived from the vision of Bahira University. For the fulfillment of the requirement of achieving international recognition there is need to produce high quality graduates and the mission of BEE program is focused on producing engineers who can contribute in diverse related and inter disciplinary domains nationally and internationally. However, achievement of this goal is not possible without achieving excellence in education and research. Hence, Electrical Engineering Departments of Bahira University at Islamabad and Karachi Campuses have aligned themselves to play their role for achievement of excellence in education and research.

- Following educational objectives of BEE program have been defined whose fulfillment will define the successful completion of mission of BEE program and consequently adherence to the vision of the university.

PEO 1: Professional Employment

Find employment related to Electrical engineering in the fields of design, development, research, operations and maintenance, technical sales and marketing as well as explore entrepreneurship and find jobs in diverse areas like business, law, NGOs, media etc.

PEO 2:Technical competence

Demonstrate technical competence in the field of electrical engineering through finding solutions to complex problems, design new products, and use their analytic, engineering and problem solving skills to provide value to their industry.

PEO 3:Professional growth

Pursue their professional growth by taking up higher studies for advanced degrees, learn new technologies as they emerge, develop skills in the usage of new tools, undertake professional development courses and keep themselves current in their chosen specialization.

PEO 4:Social Engagement

Work in multicultural teams, provide leadership in their area; be sensitive to ethical, moral, environmental, gender and societal issues and leave an impact of their work on the society and the community.

- The PEOs are categorize broadly in terms of professional employment, technical competence, professional growth and social engagement. Where first three fulfill the needs to produce technically competent engineers the last one targets ethical soundness of the graduate.

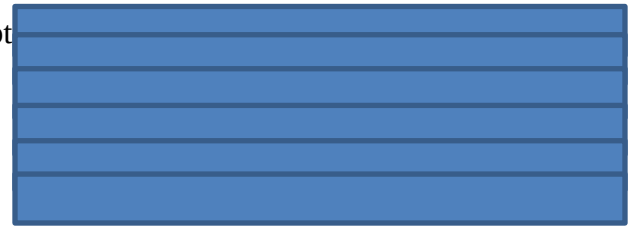
Program Educational Objectives	**Institutional Vision**	**Program Mission**
1. Professional Employment	Nation Development	Serve in Diverse Fields
2. Technical Competence	Excellence in education	Technically Competent
3. Professional Growth	Excellence in education and research	Design and Development
4. Social Engagement	Nation Development	Ethically sound

Appendage 1709

Department of Computer Engineering – BUXC

Form No.: CE-PEC-L3-01A

To be filled by Alumni
Name:
Name of Organization (opt
Designation (optional):
Year of Graduation:
Contact:
Email:



Hypertext Link to University Vision and Mission statements
Hypertext Link to Department Vision and Mission statements
Hypertext Link to Program Education Objectives (PEOs)

Dear Alumni,
We are glad that you have spent your 4 valuable years after completing Bachelor in Computer Engineering at Computer Engineering Department, Bahria University. You will be pleased to know that your alma mater has, in a short period of time, grown to be one of the leading and sought-after universities. We would like to place on record that your co-operation and support has contributed in no small measure towards this achievement.
To maintain and enhance higher teaching and research practices at Bahria University, the department of Computer Engineering has enlisted a few *Program Educational Objectives (PEOs)*.

1.	I am satisfied with the declared Program Educational Objectives (PEOs) of the Computer Engineering Department.	A	B	C	D	E	
2.	According to my experience the current BCE program is compliant with the above mentioned PEOs.	A	B	C	D	E	
3.	The department is moving in the right direction towards the attainment of the said PEOs.	A	B	C	D	E	We
4.	I am satisfied with the technical concepts gained during the degree program to cater the needs of the professional real-world scenarios. (PEO-I)	A	B	C	D	E	
5.	I am satisfied with the soft skills learnt during the degree program to cater for the challenges faced during my professional life. (PEO-II)	A	B	C	D	E	
6.	I am content with the level of ethical and social responsibility gained during the period of degree program. (PEO-III)	A	B	C	D	E	
7.	I am satisfied with the level of deployment of the learnt knowledge, concepts, skills and analytical abilities gained during the degree program. (PEO-IV)	A	B	C	D	E	

shall be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this quality enhancement process.

Rating:
A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

Do you want to suggest changes in PEOs statement? YES/NO:

Signature of Alumni and Date:
Signature of Placement Coordinator and Date:

Department of Computer Engineering – BUXC

Form No. CE-PEC-L3-01B

Sample Size:

The purpose of this survey is to summarize the alumni input on their satisfaction in terms of the appropriateness of the BCE-curriculum with respect to their professional needs.

Key Performance Indicators	Obtained score (Average)	Threshold
Percentage of Alumni satisfied with the declared Program Educational Objectives (PEOs) of the Computer Engineering Department?		50%
Percentage of Alumni agrees that the current BCE program is compliant to the PEOs?		50%
Percentage of Alumni agrees the department is moving in the right direction towards the attainment of the said PEOs?		50%
Percentage of Alumni satisfied with the technical concepts gained during the degree program to cater the needs of the professional real-world scenarios? (PEO-I)		50%

Percentage of Alumni satisfied with the soft skills learnt during the degree program to cater for the challenges faced during their professional life? (PEO-II)	50%
Percentage of Alumni who are content with the level of ethical and social responsibility gained during the period of degree program? (PEO-III)	50%
Percentage of Alumni satisfied with the level of deployment of leant knowledge, concepts, skills and analytical abilities gained during the degree program? (PEO-IV)	50%
Percentage of alumni currently employed	50%
Percentage of alumni started their own business/startup	5-10%
Percentage of alumni have completed or currently pursuing MS/PhD program	10%
Percentage of alumni working voluntarily for betterment of society	10%

Remarks (if any):

Placement Coordinator Sig and Date:

Department of Computer Engineering – BUXC

Form No. CE-PEC-L3-02A

To be filled by Employer
(Details of Employee)
Employee Name:
Designation:
Organization:
Joining Date:
Leaving Date:

Hypertext Link to University Vision and Mission statements
Hypertext Link to Department Vision and Mission statements
Hypertext Link to Program Educational Objectives (PEOs)

Dear Sir/Madam,
To maintain and enhance higher teaching and research practices at Bahria University, the department of Computer Engineering has enlisted a few *Program Educational Objectives (PEOs)*.
We shall be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this quality enhancement process.

Rating
A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	We are satisfied with the declared Program Educational Objectives (PEOs) of the Computer Engineering Department.	A	B	C	D	E
2.	According to our experience the current BCE program is compliant with the above mentioned PEOs.	A	B	C	D	E
3.	The department is moving in the right direction towards the attainment of the said PEOs.	A	B	C	D	E
4.	We are satisfied with the level of technical and problem-solving skills of your graduates. (PEO-I)	A	B	C	D	E
5.	We are satisfied with the level of teamwork and soft skills of your graduates to cater for the challenges faced in their professional lives. (PEO-II)	A	B	C	D	E
6.	We are satisfied with the level of ethical and social responsibility of your graduates with their positive contribution in our company. (PEO-III)	A	B	C	D	E
7.	We are satisfied with the level of success of your graduates in learning new areas, emerging engineering technologies needed for the professional development. (PEO-IV)	A	B	C	D	E

Any Suggestion and Remarks:
Employer Name:
Employer Signature and Date:

Department of Computer Engineering – BUXC

Form No. CE-PEC-L3-02B

Sample Size:

Key Performance Indicators	Obtained score (Average)	Threshold
Percentage of employers satisfied with the declared Program Educational Objectives (PEOs) of the Computer Engineering Department		50%
Percentage of employers' experience whether the current BCE program is compliant to the mentioned PEOs		50%
Percentage of employers who believe the department is moving in the right direction towards the attainment of the said PEOs		50%
Percentage of employers satisfied with the level of technical and problem-solving skills of our graduates (PEO-I)		50%
Percentage of employers satisfied with the level of teamwork and soft skills of our graduates to cater for the challenges faced in the professional lives (PEO-II)		50%
Percentage of employers satisfied with the level of ethical and social responsibility of our graduates with positive contribution in their companies (PEO-III)		70%
Percentage of employers satisfied with the level of success of our graduates in		50%

learning new areas, emerging
engineering technologies needed for the
professional development (PEO-IV)

Remarks (if any):
Placement Coordinator Sign and Date:

Department of Electrical Engineering – BUXC

Form No. EE-PEC-L3-01A

To be filled by Alumni
Name:
Name of Organization (optional):
Designation (optional):
Year of Graduation:
Contact:
Email:

Hypertext Link to University Vision and Mission statements
Hypertext Link to Department Vision and Mission statements
Hypertext Link to Program Educational Objectives (PEOs)

Dear Alumni,

We are glad that you have spent your 4 valuable years of Bachelor in Electrical Engineering at Electrical Engineering Department, Bahria University. You will be pleased to know that your alma mater has, in a short period of time, grown to be one of the leading and sought-after universities. We would like to place on record that your co-operation and support has contributed in no small measure towards this achievement.

To maintain and enhance higher teaching and research practices at Bahria University, the department of Electrical Engineering has enlisted a few *Program Educational Objectives (PEOs)* inline to the Washington Accord's consortium listed above.

We shall very much appreciate and be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this quality enhancement process.

1) Are you currently employed? No Yes If yes, than

Electrical engineering related field
Non-electrical engineering related field
Self-employed i.e. started your own business/startup

2) Have you presented your work at a technical forum such as conference, journal, symposium, technical competitions? No Yes If yes, Details

cured admission or currently pursuing or completed the MS or PhD Program?

No Yes If yes, Details

4) Have you attended any professional development course in the last one year?

No Yes If yes, Details

5) Are you a part of any voluntary organization working for the betterment of the society?

No Yes If yes, Details

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	I am satisfied with employment in Electrical Engineering and other diverse fields or with the exploration of entrepreneurship.	A B C D E
2.	I am satisfied with my technical competence in the field of electrical engineering to provide solutions to complex problems and to design new products providing value to the industry.	A B C D E
3.	The BEE Degree has enabled me to pursue professional growth by taking up higher studies and learning contemporary technologies which keeps me current in my chosen specialization.	A B C D E
4.	BEE Degree has been helpful in socially engaging by providing me the opportunity to work on different ethical, moral, environmental, gender and societal issues to leave an impact on society and community.	A B C D E
5.	The EE department is moving in the right direction towards the attainment of the said PEOs?	A B C D E

Any Other Remarks/Suggestions:

Signature of Alumni and Date:
Signature of Placement Coordinator and Date:

Department of Electrical Engineering – BUXC

Form No. EE-PEC-L3-01B

Sample Size:

The purpose of this survey is to summarize the alumni input on their satisfaction in terms of the appropriateness of the BEE-curriculum with respect to their professional needs

Key Performance Indicators	Obtained score (Average)	Threshold
Percentage of alumni currently employed		50%
Percentage of alumni working in Electrical Engineering (EE) field		50%
Percentage of alumni started their own business/startup or working in non-EE related field		10%
Percentage of alumni presented their work at a technical forums		5%
Percentage of alumni who have completed or currently pursuing MS/PhD program		15-20%
Percentage of alumni who attended professional development courses		20%
Percentage of alumni being part of voluntary organizations		15%
Satisfactory Percentage level of PEO 1		50%
Satisfactory Percentage level of PEO 2		50%
Satisfactory Percentage level of PEO 3		50%
Satisfactory Percentage level of PEO 4		50%
Satisfactory Percentage level of EE PEOs		50%

Remarks (if any):
Placement Coordinator Sig and Date:

Department of Electrical Engineering – BUXC

Form No. EE-PEC-L3-02A

To be filled by Employer
(Details of Employee)
Employee Name:
Designation:
Organization:
Joining Date:
Leaving Date:

Dear Sir/Madam,

To maintain and enhance higher teaching and research practices at Bahria University, the department of Electrical Engineering has enlisted a few *Program Educational Objectives (PEOs)*.

We shall be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this quality enhancement process.

Are the graduates employed in your organization working in the field closely related to electrical engineering? Yes No If NO, then give brief details

Are you satisfied with the technical competence of EE graduates working with your organization beyond 6 months? Yes No If NO, then can you please briefly describe the areas of improvement?

Have the graduates assumed leadership/managerial positions in your organization working beyond 4 years? Yes No If NO can you please briefly describe the reasons?

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	Graduates' employment in Electrical Engineering and other diverse fields or their exploration of entrepreneurship is satisfactory. (PEO 1)	A B C D E
2.	We are satisfied with the level of technical competence	A B C D E

demonstrated in the field of electrical engineering to provide solutions to complex problems and to design new products providing value to your industry. (PEO 2)

3. The BEE program has motivated the graduates to pursue professional growth by taking up higher studies and learning contemporary technologies. (PEO 3) A B C D E

4. The BEE program has given the graduates a sense of social engagement regarding different ethical, moral, environmental, gender and societal issues. (PEO 4) A B C D E

5. We are satisfied with the declared Program Educational Objectives (PEOs) of the Electrical Engineering Department.

Any Suggestion and Remarks:
Employer Name:
Employer Signature and Date:

Department of Electrical Engineering – BUXC

Form No. EE-PEC-L3-02B

Sample Size:

Key Performance Indicators	Obtained score (Average)	Threshold
Percentage of graduates working in Electrical Engineering (EE)		50%
Percentage of graduates working in fields unrelated to EE		10%
Percentage of employers satisfied with the technical competence of EE graduates		60%

Percentage of graduates assumed leadership/managerial positions in the organizations	15%
Satisfactory Percentage level of PEO 1	50%
Satisfactory Percentage level of PEO 2	50%
Satisfactory Percentage level of PEO 3	50%
Satisfactory Percentage level of PEO 4	50%
Satisfactory Percentage level of EE PEOs	50%

Remarks (if any):
Placement Coordinator Sign and Date:

Department of Software Engineering – BUXC

Form No. SE-PEC-L3-01A

To be filled by Alumni
Name:
Name of Organization (optional):
Designation (optional):
Year of Graduation:

Hypertext Link to University Vision and Mission statements
Hypertext Link to Department Vision and Mission statements
Hypertext Link to Program Educational Outcomes (PEOs)

Dear Alumni,

We are glad that you have spent your four valuable years of Bachelor in Software Engineering at Bahria University. You will be pleased to know that your *alma mater* has, in a short period of time, grown to be one of the leading and sought-after universities. We would like to place on record that your co-operation and support has contributed in no small measure for this achievement.

To maintain and enhance higher teaching and research practices at Bahria University, the department of Software Engineering has enlisted a few *Program Educational Objectives (PEOs)* in line with the Washington Accord's consortium.

We shall very much appreciate and be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this process.

The purpose of this survey is to obtain alumni input on their satisfaction in terms of the appropriateness of the BSE-curriculum with respect to their professional needs

We seek your help in completing this survey and improve the quality of the BSE program.

How long have you graduated from the BSE Program?

< 1 year 1-2 year(s) 3-5 year(s) 6-10 years >10 years

How many years of work experience do you have?

< 1 year 1-2 year(s) 3-5 year(s) 6-10 years >10 years

Of the total years of experience, how many years is related to the Software Engineering discipline?

< 1 year 1-2 year(s) 3-5 year(s) 6-10 years >10 years

How many professional development trainings/certifications/education (including MS/PhD) have you completed since your graduation?

< 1 year 1-2 year(s) 3-5 year(s) 6-10 years >10 years

Are you currently employed?

Yes No

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	I am satisfied with the 'Software-Engineering Knowledge' which I gained in the BSE program and deem it appropriate to start my professional career.	A B C D E
2.	I am satisfied with the 'Problem Analysis' skills and knowledge which I gained in the BSE program and deem it appropriate to start my professional career.	A B C D E
3.	I am satisfied with the Knowledge of Design and	A B C D E

Development of Solutions that I gained in the BSE program and deem it appropriate to start my professional career.

4. I am satisfied with the Investigation techniques I learned in the BSE program and deem it appropriate to start my professional career. A B C D E
5. I am satisfied with the 'Modern Tools for SE' that I learned in the BSE program and deem it appropriate to start my professional career. A B C D E
6. I have completed multiple trainings/certifications/education (including MS/PhD) since my graduation? A B C D E

Any Suggestion and Remarks:

Department of Software Engineering – BUXC

Form No. SE-PEC-L3-01B

Key Performance Indicators	Obtained score (Average)	Threshold
50% of the graduates are satisfied in terms of appropriateness of the curriculum with respect to their professional needs.		50%
15% of graduates have enhanced their skills through postgraduate studies or technical & professional education.		15%

Remarks (if any):

Head of Department Signature and Date:

Department of Software Engineering – BUXC

Form No. SE-PEC-L3-02A

To be filled by Employer
Employer Name:
Address:
Contact:

Hypertext Link to University Vision and Mission statements
Hypertext Link to Department Vision and Mission statements
Hypertext Link to Program Educational Outcomes (PEOs)

Dear Employer,

The purpose of this survey is to obtain employers' input on their satisfaction on the technical competence of Bachelors of Software Engineering (BSE) graduates, and on the ethical conduct, communication skills of the graduates working in their organization.

Therefore, we seek your help in completing this survey and improve the quality of our BSE program.

To maintain and enhance higher teaching and research practices at Bahria University, the department of Software Engineering has enlisted a few *Program Educational Objectives (PEOs)* in line with the Washington Accord's consortium.

We shall very much appreciate and be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this quality enhancement process.

Number of BSE graduates currently working in your organization?

0 to 1 2 to 5 6 to 20 21-50 >50

Total number of employees in your organization?

<10 11 to 50 50 to 200 201-1000 >1000

Are the graduates, how many years is related to the Software Engineering discipline?

< 1 year 1-2 year(s) 3-5 year(s) 6-10 years >10 years

Are you currently employed?

Yes No

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

		A	B	C	D	E
1.	We are satisfied with the 'Software-Engineering					

	Knowledge' which the graduates gained in the BSE program and deem it appropriate to start their professional career.	
2.	We are satisfied with the 'Problem Analysis' skills and knowledge which the graduates gained in the BSE program and deem it appropriate to start their professional career.	A B C D E
3.	We are satisfied with the Knowledge of Design and Development of Solutions that the graduates gained in the BSE program and deem it appropriate to start their professional career.	A B C D E
4.	We are satisfied with the Investigation techniques which the graduates learned in the BSE program and deem it appropriate to start their professional career.	A B C D E
5.	We are satisfied with the 'Modern Tools for SE' which the graduates learned in the BSE program and deem it appropriate to start their professional career.	A B C D E
6.	We are satisfied with the communication skills of the graduates of the BSE program.	A B C D E
7.	We are satisfied with the ethical conduct of the graduates of the BSE program while working individually as well as part of a team.	A B C D E
8.	We are satisfied with the managerial skills of the graduates of the BSE program.	A B C D E

Any Suggestion and Remarks:

Department of Software Engineering – BUXC

Form No. SE-PEC-L3-02A

Sample Size:

Key Performance Indicators	Obtained score (Average)	Threshold
Percentage of employers satisfied that the students have appropriate knowledge required to start professional career.		50%

Percentage of employers satisfied with the Problem Analysis skills acquired during BSE program.	50%
Percentage of employers satisfied with knowledge of Design and Development of solutions of the graduates of the BSE program.	50%
Percentage of employers satisfied with the investigation techniques known by the graduates of the BSE program.	50%
Percentage of employers satisfied with the knowledge and skill of the 'Modern Tools for SE' possessed by the graduates of the BSE program.	50%
Percentage of employers satisfied with the communication skills of the graduates of the BSE program.	50%
Percentage of employers satisfied with the ethical conduct of the graduates of the BSE program.	50%
Percentage of employers satisfied with the managerial skills of the graduates of the BSE program.	50%

Remarks (if any):
Placement Coordinator Sign and Date:

Complete list of all forms

XY can be replaced by EE/CE/SE
A shows it's a Form
B shows it's a Report

Level 1: CLO (Do the CLOs need to be mentioned on the forms?)

1. Form No.: XYZ-PEC-L1-01A = Student Course Evaluation Form.
2. Form No.: XYZ-PEC-L1-01B = Student Course Evaluation Report.
3. Form No.: XYZ-PEC-L1-02A = Taught Course Evaluation Form.
4. Form No.: XYZ-PEC-L1-02B = Taught Course Evaluation Report.

5. Form No.: XYZ-PEC-L1-03B = Subject Domain Specialist Report.

Level 2: PLO

1. Form No.: XYZ-PEC-L2-01A = Graduating Student Survey Forms
2. Form No.: XYZ-PEC-L2-01B = Graduating Student Survey Report

Level 3: PEO

1. Form No.: EE-PEC-L3-01A = Alumni Survey Form
2. Form No.: EE-PEC-L3-01B = Alumni Survey Report
3. Form No.: EE-PEC-L3-02A = Employer Survey Forms
4. Form No.: EE-PEC-L3-02B = Employer Survey Report

5. Form No.: CE-PEC-L3-01A = Alumni Survey Form
6. Form No.: CE-PEC-L3-01B = Alumni Survey Report
7. Form No.: CE-PEC-L3-02A = Employer Survey Forms
8. Form No.: CE-PEC-L3-02B = Employer Survey Report

9. Form No.: SE-PEC-L3-01A = Alumni Survey Form
10. Form No.: SE-PEC-L3-01B = Alumni Survey Report
11. Form No.: SE-PEC-L3-02A = Employer Survey Forms
12. Form No.: SE-PEC-L3-02B = Employer Survey Report

Remaining all meetings e.g. CAC/Research Group/Parents/CRs shall have minutes of the meeting and Internships Viva/CSP/FYP Presentation shall have coordinators Report annually.

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L1-01A

To be filled at the end of course by all enrolled students.

Course Name:
Course Code
Course Instructor:

CLOs to be displayed here directly from system.

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	CLOs were communicated at the start of the course.	A	B	C	D	E
2.	CLOs were covered in the course syllabus.	A	B	C	D	E
3.	The evaluation of the CLOs was communicated effectively.	A	B	C	D	E
4.	I was communicated throughout the semester about my score in each CLO.	A	B	C	D	E
5.	I was given multiple attempts to clear each CLO.	A	B	C	D	E

6. The subject matter presented in the course is modern, updated has increased my knowledge of the subject. A B C D E
7. The course integrates theoretical concepts with real-world applications. A B C D E

Any Suggestions and Remarks: [redacted]

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L1-01B

Auto Generated report for SDS Remarks
Course Name:
Course Code
Course Instructor:

[redacted]

No.	Query Statements	Weightage of each selection (A – E)
1.	CLOs were communicated at the start of the course.	
2.	CLOs were covered in the course syllabus.	
3.	The evaluation of the CLOs was communicated effectively.	
4.	I was communicated throughout the semester about my score in each CLO.	
5.	I was given multiple attempts to clear each CLO.	

6. The subject matter presented in the course is modern, updated has increased my knowledge of the subject.
7. The course integrates theoretical concepts with real-world applications.

Key:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L1-02A

To be completed by instructor of each section

Course Name:
Course Code:
Course Instructor:
Class and Section:
Semester:
Sample Size

CLOs to be displayed directly from system.

(CLOs)	Obtained score (Average)	Threshold
CLO-1 :		
CLO-2 :		
CLO-3 :		
CLO-4 :		

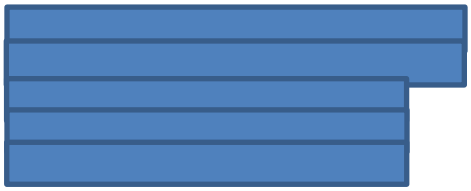
Remarks (if any):
Course Instructor Signature:

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L1-02B

To be completed by SDS if multiple section of same course

Course Name:
Course Code:
Batch:
Semester:
Sample Size



CLOs to be displayed here directly from system.

(CLOs)	Obtained score (Average) Section ()	Obtained score (Average) Section ()	Obtained score (Average) Section ()	Obtained score (Average) Section ()	Average	Threshold
CLO-1						
CLO-2						
CLO-3						
CLO-4						

Remarks (if any):
SDS Signature:

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L1-03B

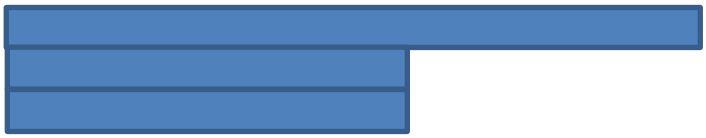
To be completed by respective SDS and discussed with respective Cluster head for further discussion at DBoS Level

Batch:
Semester:

Minutes of the 17th FBOS – ES

Courses Updated	Feedback on course	Changes based on feedback
Course 1 (and code):		
Course 2 (and code):		
……		

SDS Signature:
Suggestions and Recommendations
Cluster Head Signature:

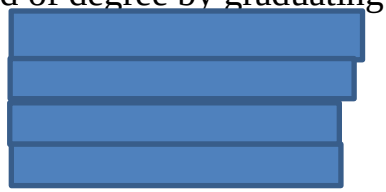


Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L2-01A

To be filled at the end of degree by graduating students

Student Name:
Enrollment No.:
Batch:
Year of Graduation:



Dear Graduating Student,

We are glad that you have spent over 3 valuable years of Bachelor in **XYZ** at **XYZ** department, Bahria University. You will be pleased to know that your alma mater has, in a short period of time, grown to be one of the leading and sought-after universities. We would like to place on record that your co-operation and support has contributed in no small measure for this achievement.

To maintain and enhance higher teaching and research practices at Bahria University, Pakistan Engineering Council (PEC) has enlisted a few Program Learning Outcomes (PLOs) inline with the Washington Accord's consortium. Program learning outcomes represent the culminating knowledge, behaviors, skills or abilities that students achieve with the progression of the program. The PLOs not only represent the skills or abilities

one would normally associate with a specific course or engineering, but they are also tied to our program and university mission, vision, and core values - making the learning experience distinct.

We shall very much appreciate and be thankful if you can spare some of your valuable time to fill up this feedback form and give us your valuable suggestions for further improvement of this process. Please rate yourself.

Rating:

A: Strongly Agree B: Agree C: Partially Agree D: Neutral E: Disagree

1.	Gained the ability to apply current scientific and engineering knowledge to solve complex engineering problems.	A B C D E
2.	Gained the ability to identify complex engineering problems and formulate solutions based on current scientific and engineering knowledge.	A B C D E
3.	Gained the ability to design and develop solutions for complex engineering problems while keeping in view health, safety and environmental considerations.	A B C D E
4.	Gained the ability to review and investigate complex engineering problems in a scientific way, starting from survey, inference and experimentation.	A B C D E
5.	Gained the ability to utilize modern tools for your problem solving, to provide solution for a complex engineering problem.	A B C D E
6.	Gained the ability to apply engineering knowledge to assess societal issues in a professional way, keeping in view the safety, legal and cultural constraints.	A B C D E
7.	Gained the ability to apply engineering knowledge to develop environmental friendly sustainable solutions	A B C D E
8.	Gained the ability to apply ethical principles and commit to professional ethics and norms of engineering practice.	A B C D E
9.	Gained the ability to work independently as well as in a team.	A B C D E
10.	Gained the ability to communicate effectively (both orally and writing) on complex engineering activities.	A B C D E
11.	Gained the ability to demonstrate management skills and lead a team of technical experts to manage multidisciplinary projects.	A B C D E
12.	Gained the ability to realize the importance of continuous professional development throughout your life.	A B C D E

Any Suggestion and Remarks:

Student Advisor Signature:

Department of XYZ Engineering – BUXC

Form No.: XY-PEC-L2-02B

Auto Generated Report need remarks from batch coordinator

Batch:

Year of Graduation:

	Obtained Percentages	Threshold
1. Ability to apply current scientific and engineering knowledge to solve complex engineering problems.		
2. Ability to identify complex engineering problems and formulate solutions based on current scientific and engineering knowledge.		
3. Ability to design and develop solutions for complex engineering problems while keeping in view health, safety and environmental considerations.		
4. Ability to review and investigate complex engineering problems in a scientific way, starting from survey, inference and experimentation.		
5. Ability to utilize modern tools for your problem solving, to provide solution for a complex engineering problem.		
6. Ability to apply engineering knowledge to assess societal issues in a professional way, keeping in view the safety, legal and cultural constraints.		
7. Ability to apply engineering knowledge to develop environmental friendly sustainable solutions		
8. Ability to apply ethical principles and commit to professional ethics and norms of engineering practice.		
9. Ability to work independently as well as in a team.		
10. Ability to communicate effectively (both orally and writing) on complex engineering activities.		
11. Ability to demonstrate management skills and lead a team of technical experts to manage multidisciplinary projects.		
12. Ability to realize the importance of continuous professional development throughout your life.		

Any Suggestion and Remarks:

Batch Coordinator Signature:

Minutes of the 17th FBOS – ES

Appendage 1711

Course Code	
Course Title/Name	**Internet of Things: Architecture and protocols**
Credit Hours/Contact hours	3/ 3 hours/week
Degree Program	**MS (EE)/PhD EE**
Prerequisites or Co-requisites	None
Assessment Methods and Weightage	Quizzes 10 Assignment/Research paper Presentations 20 Mid-Term Examination 30 Final Examination 40 **Total 100**
Textbook	Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, **"From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence",** 1st Edition, Academic Press, 2014.
Reference Material	• Vijay Madisetti and Arshdeep Bahga, **"Internet of Things (A Hands-on-Approach)",** 1stEdition, VPT, 2014. • Francis daCosta, **"Rethinking the Internet of Things: A Scalable Approach to Connecting Everything",** 1st Edition, Apress Publications, 2013
Instructor Name/Cluster Head/Subject Expert	**Instructor Name**: Dr. Saleem Aslam, Designation Associate professor Status ☑ Regular ☐ Visiting
Course Aims	This course aims at building the necessary background and foundation about IoTs. Basic IoT concepts covering architecture, PHY and MAC layer protocols along with enabling technologies (i.e., machine 2 machine communication) are the essential part of this course. Some advanced application of IoTs such as smart city, smart grid, and smart homes is also discussed.
Course Objectives	Main goal of this course is to teach different theories, concepts and building blocks involved in IoTs architectures for developing smart applications. The course will also prepare students to perform relevant R&D work.
Course Outcomes	At the end of this course, student will be: • Explain in a concise manner how the general Internet as well as Internet of Things works. • Understand constraints and opportunities of wireless and mobile networks

<table>
<tr><td></td><td colspan="2">for Internet of Things.
• Use basic measurement tools to determine the real-time performance of packet based networks.
• Analyze trade-offs in interconnected wireless embedded sensor networks.</td></tr>
<tr><td>Course Description/Catalogue</td><td colspan="2">Nil</td></tr>
<tr><td rowspan="12">Lecture Plan (16 Weeks)</td><td>Week #</td><td>Topic to be covered</td></tr>
<tr><td>1</td><td>Internet in general and Internet of Things: layers, protocols, packets, services, performance parameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, and multimedia.</td></tr>
<tr><td>2</td><td>Transport services: TCP, UDP, socket programming.</td></tr>
<tr><td>3</td><td>Network layer: forwarding & routing algorithms (Link, DV), IP-addresses, DNS, NAT, and routers.</td></tr>
<tr><td>4</td><td>Local Area Networks, MAC level, link protocols such as: point-to-point protocols, Ethernet, WiFi 802.11, cellular Internet access, and Machine-to-machine.</td></tr>
<tr><td>5</td><td>Mobile Networking: roaming and handoffs, mobile IP, and ad hoc and infrastructure less networks.</td></tr>
<tr><td>6</td><td>Real-time networking: soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements.</td></tr>
<tr><td>7</td><td>IoT definitions: overview, applications, potential & challenges, and architecture.</td></tr>
<tr><td>8</td><td>● IoT examples: Case studies, e.g. sensor body-area-network and control of a smart home.</td></tr>
<tr><td>9</td><td>M2M to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.</td></tr>
<tr><td>10</td><td>M2M to IoT – A Market Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.</td></tr>
<tr><td>11, 12</td><td>M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management</td></tr>
</table>

	13	**IoT Reference Architecture-** Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.
	14	**Real-World Design Constraints-** Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.
	15, 16	**Industrial Automation-** Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, **Commercial Building Automation-** Introduction, Case study: phase one-commercial building automation today, Case study: phase two-commercial building automation in the future.

Course Code	
Course Title/Name	**Internet of Things: Architecture and protocols**
Credit Hours/Contact hours	3/ 3 hours/week
Degree Program	**MS (EE)/PhD EE**
Prerequisites or Co-requisites	None
Assessment Methods and Weightage	Quizzes 10 Assignment/Research paper Presentations 20 Mid-Term Examination 30 Final Examination 40 **Total 100**
Textbook	Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, **"From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence",** 1st Edition, Academic Press, 2014.
Reference Material	• Vijay Madisetti and Arshdeep Bahga, **"Internet of Things (A Hands-on-Approach)",** 1stEdition, VPT, 2014. • Francis daCosta, **"Rethinking the Internet of Things: A Scalable Approach to Connecting Everything",** 1st Edition, Apress Publications, 2013
Instructor Name/Cluster Head/Subject Expert	**Instructor Name**: Dr. Saleem Aslam, Designation Associate professor Status ☑ Regular ☐ Visiting
Course Aims	This course aims at building the necessary background and foundation about IoTs. Basic IoT concepts covering architecture, PHY and MAC layer protocols along with enabling technologies (i.e., machine 2 machine communication) are the essential part of this course. Some advanced application of IoTs such as smart city, smart grid, and smart homes is also discussed.
Course Objectives	Main goal of this course is to teach different theories, concepts and building blocks involved in IoTs architectures for developing smart applications. The course will also prepare students to perform relevant R&D work.
Course Outcomes	At the end of this course, student will be: • Explain in a concise manner how the general Internet as well as Internet of Things works. • Understand constraints and opportunities of wireless and mobile networks for Internet of Things. • Use basic measurement tools to determine the real-time performance of packet based networks.

	• Analyze trade-offs in interconnected wireless embedded sensor networks.	
Course Description/Catalogue	Nil	
Lecture Plan (16 Weeks)	**Week #**	**Topic to be covered**
	1	Internet in general and Internet of Things: layers, protocols, packets, services, performance parameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, and multimedia.
	2	Transport services: TCP, UDP, socket programming.
	3	Network layer: forwarding & routing algorithms (Link, DV), IP-addresses, DNS, NAT, and routers.
	4	Local Area Networks, MAC level, link protocols such as: point-to-point protocols, Ethernet, WiFi 802.11, cellular Internet access, and Machine-to-machine.
	5	Mobile Networking: roaming and handoffs, mobile IP, and ad hoc and infrastructure less networks.
	6	Real-time networking: soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements.
	7	IoT definitions: overview, applications, potential & challenges, and architecture.
	8	● IoT examples: Case studies, e.g. sensor body-area-network and control of a smart home.
	9	**M2M to IoT**-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.
	10	**M2M to IoT – A Market Perspective**– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. **M2M to IoT-An Architectural Overview**– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.
	11, 12	**M2M and IoT Technology Fundamentals-** Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management
	13	**IoT Reference Architecture-** Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

	14	**Real-World Design Constraints-** Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.
	15, 16	**Industrial Automation-** Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, **Commercial Building Automation-** Introduction, Case study: phase one-commercial building automation today, Case study: phase two-commercial building automation in the future.

Course Code	
Course Title/Name	**Principles of 5G and IoT Communication**
Credit Hours/Contact hours	3/ 3 hours/week
Degree Program	**MS (EE)/PhD EE**
Prerequisites or Co-requisites	None
Assessment Methods and Weightage	Quizzes 10 Assignment/Research paper Presentations 20 Mid-Term Examination 30 Final Examination 40 **Total 100**
Textbook	Internet of Things in 5G Communication Technologies by Constandinos X. Mavromoustakis (2016).
Reference Material	IEEE and Elsevier Research Articles Powering the Internet of Things With 5G Networks (Advances in Wireless Technologies and Telecommunication (AWTT)), First Edition, (2018).
Instructor Name	**Instructor Name**: Dr. Saleem Aslam, Designation Associate professor Status ☑ Regular □ Visiting
Course Aims	This course aims at building the necessary background and foundation about communication in 5G and IoTs. Basic communication concepts covering architecture, PHY and MAC layer protocols along with enabling technologies (i.e., short and long distance communication) are the essential part of this course. Some advance applications for the merger of IoTs and 5G is also covered.
Course Objectives	This course covers latest topics in communications which are of interest to industry and academia. The course focuses on the communication technologies for the Internet of Things (IoT) and 5G networks.
Course Outcomes	At the end of this course, student will be : • Develop understanding of recent advances in communications. • Discuss and provide examples of how IoT and 5G networks can be applied to the modern day applications. • Better understand how to cope up with the pace of latest communication trends. • Think critically and with an open mind about how modern applications use communication technologies.
Course Description/Catalogue	Nil

Lecture Plan (16 Weeks)

Week #	Topic to be covered
1	Overview and scope of the course. Basic IoT Architectures
2	Internet of Things (IoT) Communication technologies for the IoT and their Standardization
3	Bluetooth and Bluetooth Smart for IoT (1)
4	Bluetooth Smart for IoT (2)
5	IEEE 802.15.4 WPAN for IoT (1)
6	IEEE 802.15.4 WPAN for IoT (2)
7	Applications of IoT and the use of appropriate communication technologies
8	Introduction to 5G Architecture and service scenarios

	9	Introduction to software defined radio and cognitive radio
	10	Opportunistic Spectrum Sharing
	11, 12	Enabling Technologies for 5G
	13	Uses Cases of 5G
	14	Mixing of IoT and 5G communication
	15	Applications from merger of IoTs and 5G (1)
	16	Applications from merger of IoTs and 5G (2)

Appendage 1712

Bachelors of Electrical Engineering

Curriculum
2018

Department of Electrical Engineering

BAHRIA UNIVERSITY

ISLAMABAD CAMPUS

Scheme of Studies

Duration	4 years
Number of Semesters	8
Number of weeks per semester	18 (16 for teaching and 2 for exams)
Total number of credit hours	136
Number of credit hours per semester	16-18
Non-Engineering Courses	15 Courses, 41 Cr Hrs, 30.1 % of total
Engineering Courses	28 Courses, 95 Cr Hrs, 69.9 % of total

Courses of Non-Engineering Domain

Knowledge Area	Sub Area	Name of Course	Lec. Cr. Hrs	Lab Cr. Hrs	Total Cr. Hrs.	Total Cou-rses	Total Cre-dits	% Area	% Overall
Humanities and Social Sciences	English	Functional English	2	0	2	3	7	17	5.1
		Comm. Skills	2	0	2				
		Technical Report Writing & Present. Skills	3	0	3				
	Culture	Islamic Studies/ Ethics	2	0	2	2	4	9.7	2.9
		Pakistan Studies	2	0	2				
	Social Sciences	Social Sciences Elective 1	3	0	3	2	6	14.6	4.4
		Social Sciences Elective 2	3	0	3				
Management Sciences		Management Sciences Elective 1	2	0	2	2	5	12.2	3.7
		Management Sciences Elective 2	3	0	3				
Natural Sciences	Math	Calculus and Analytical Geometry	3	0	3	4	12	29.2	8.8
		Linear Algebra	3	0	3				
		Differential Equations	3	0	3				
		Complex Variable and Transform	3	0	3				
	Physics	Applied Physics	3	1	4	1	4	9.8	2.9
	Electives	Elective 1*	3	0	3	1	3	7.3	2.2
Total			40	1	41	15	41	100%	30.1%

Humanities and Social Sciences Electives: (With no Pre-req)

HSS 422 **Engineering Ethics**
HSS 202 **Introduction to Sociology**
BES 103 **Critical Thinking**
HSS 456 **Organizational Behavior**
PSY 401 **Professional Psychology (New Course-New Code)**
HSS 111 **Introduction to International Relations**

Management Science Electives (With no Pre-req)

2 Credit Hour Courses

HSS 423 **Entrepreneurship**
MGT 421 **Leadership (New Course-New Code)**
MGT 422 **Personal Grooming (New Course-New Code)**

3 Credit Hour Courses

MGT 111 **Principles of Management**
MGT 423 **Engineering Management (New Course-New Code)**
MGT 424 **Engineering Economics (New Course-New Code)**
MGT 425 **Project Management in Engineering (New Course-New Code)**

Natural Science Electives

3+0 Credit Hour Courses

Pre-Req	Course Code	Course Title
GSC 110 Calculus and Analytical Geometry	GSC 211	**Multivariable Calculus**
GSC 210 Differential Equations	GSC 320	**Numerical Analysis**
None	GSC 221	**Discrete Mathematics**

2+1 Credit Hour Courses

Pre-Req	Course Code	Course Title
None	GSC 340	**Chemistry**

Courses of Engineering Domain

Knowledge Area	Name of Course	Lec. Cr. Hrs.	Lab Cr. Hrs.	Total Cr. Hrs.	Total Cou-rses	Total Cr. Hrs.	% Area	% Overall
Computing	Introduction to Computing	1	1	2	3	9	9.5	6.6
	Programming Fundamentals	2	1	3				
	Computing Elective	3	1	4				
Electrical Engineering Foundation	Linear Circuit Analysis	3	1	4	9	28	29.5	20.6
	Electrical Network Analysis	3	1	4				
	Workshop Practice	0	1	1				
	Signals and Systems	3	1	4				
	Electronic Devices & Circuits	3	1	4				
	Digital Logic Design	3	1	4				
	Electromagnetic field theory	3	0	3				
	Probability Methods in Engineering	3	0	3				
	Engineering Drawing	0	1	1				
Electrical Engineering Core (Breadth)	Communication Systems	3	1	4	7	28	29.5	20.6
	Embedded system design	3	1	4				
	Electrical Machines	3	1	4				
	Linear Control Systems	3	1	4				
	Electronic Circuit Design	3	1	4				
	Breadth Core 1	3	1	4				
	Breadth Core 2	3	1	4				
Electrical Engineering Core (Depth)	Depth Elective 1	3	1	4	5	19	20	13.9
	Depth Elective 2	3	1	4				
	Depth Elective 3	3	1	4				
	Depth Elective 4	3	1	4				
	Depth Elective 5	3	0	3				
IDEE	IDEE-1	2	0	2	2	5	5.2	3.8
	IDEE-2	3	0	3				
Senior Design Project	Senior Design Project 1	0	3	3	2	6	6.3	4.4
	Senior Design Project 2	0	3	3				
Internship (Summer)		0	0	0	0	0	0	0
Total					28	95	100	69.9%

Breadth Courses

Power Engineering

Pre-Req	Course Code	Course Title
EEN 211 (Electrical Network Analysis)	EEP 331	**Power System Analysis** Breadth Course 1
EEN 219 Electrical Machines)	EEN 433	**Power Distribution and Utilization** Breadth Course 2

Electronics Engineering

Pre-Req	Course Code	Course Title
EEN 224 Electronic Devices and Circuits	EEP 468	Power Electronics Breadth Course 1
EEN 313 Signals and Systems	EEN 325	Digital Signal Processing Breadth Course 2

Telecommunication Engineering

Pre-Req	Course Code	Course Title
None	CEN 223	Computer Communication & Networks Breadth Course 1
EEN 313 Signals and Systems	EEN 325	Digital Signal Processing Breadth Course 2

Computing Electives

Pre-Req	Course Code	Course Title

CSC 112 Programming Fundamentals	CSC 318	Object Oriented Programming
CSC 112 Programming Fundamentals	CSC 221	Data structure and Algorithm

IDEE Electives (With no Pre-req)

2 Credit Hour Courses

- ESC111 Basic Mechanical Engineering
- GSC104 Surveying and Leveling
- GSC486 Geographical Information System
- ENV 440 Energy and Environment

3 Credit Hour Courses **(With no Pre-req)**

- EEA 430 Introduction to Mechatronics
- EEN 438 Introduction to Biomedical Engineering
- CSC 320 Operating Systems
- CSC 419 Introduction to Machine Learning (New course New code)

List of Depth Electives

1. Communication/ Telecommunication Engineering

Course code	Pre-req	Course code	Course title
EEN 311	Electromagnetic Field Theory	EEN 431	RF and Microwave Engineering
	None	EET 463	Optical Fiber Communication
EEN 311	Electromagnetic Field Theory	EET 447	Navigation and Radar Systems
EET 321	Communication Systems	EEN 436	Wireless and Mobile Communication
EET 321	Communication Systems	EET 449	Satellite Communications
EEN 311	Electromagnetic Field Theory	EET 451	Wave Propagation and Antennas
CEN 223	Computer Communication & Networking	EET 452	Multimedia Communications
	None	CSC 453	Information and Coding Theory
CEN223	Computer Communication & Networking	EEN 434	Advanced Computer Networks
EET 321	Communication Systems	EET 411	Digital Communications
CEN 223	Computer Communication & Networking	EET 456	Transmission and Switching Systems
EEN 325	Digital Signal Processing	CEN 444	Digital Image Processing
CEN 120 CEN440	Digital Logic Design Embedded Systems Design	CEN 441	FPGA- Based System Design
EEN 224	Electronic Circuit Design	EEN 469	Linear Integrated Circuits and Applications
EEN 224	Electronic Circuit Design	EEN 316	Instrumentation and measurement
	None	CEN 471	Emerging Wireless Technologies and RF planning
	None	CEN 472	Telecommunication policies and standards

2. Electronic Engineering

Correct the list as per HEC list

Course code	Pre-req	Course code	Course Title
EEN 224	Electronic Circuit Design	EEN 316	Instrumentation and measurement
EEN 224	Electronic Circuit Design	EEN 462	Integrated Electronics
	None	EEN 441	Industrial Process Control
EEN 224	Electronic Devices and Circuits	EEN 442	Digital Electronics
EEN 224	Electronic Devices and Circuits	EEN 444	Opto Electronics
EEN 224	Electronic Devices and Circuits	CEN 452	VLSI Design
EEN 224	Electronic Circuit Design	EEN 445	Industrial Electronics
CEN 120	Digital Logic Design	CEN 442	Digital System Design
EEN 224	Electronic Circuit Design	EEN 469	Linear Integrated Circuits & Applications
EEN 224	Electronic Circuit Design	EEN 466	Introduction to Nano Technology
EEN 311	Electromagnetic Field Theory	EET 451	Wave Propagation and Antennas
EEN 325	Digital Signal Processing	CEN 444	Digital Image Processing
EEN 224	Electronic Devices and Circuits	EEN 435	Solid State Devices
EEN 412	Linear Control Systems	EEN 437	Digital Control Systems
EEN 219	Electrical Machines	EEN 433	Power Distribution and Utilization
CEN 120	Digital Logic Design	CEN 441	FPGA- Based System Design
EEN 219	Electrical Machines	EEN 420	Industrial Automation
EEN 224	Electronic Circuit Design	EEN 471	Microelectronics Technology
EEN 311	Electromagnetic Field Theory	EEN 431	RF and Microwave Engineering
	None	ESC 471	Biomedical Instrumentation
	None	CEN 223	Computer Communication

			& Networking
	None	ESC 472	Medical Robots

3. Power Engineering.

Course code	Pre-req	Course code	Course Title
EEN 224	Electronic Circuit Design	EEN 316	Instrumentation and Measurements
EEN 219	Electrical Machines	EEP 441	Advanced Electrical Machines
EEN 219	Electrical Machines	EEP 442	Power Generation
EEN 433	Power Distribution and Utilization	EEP 443	Electrical Power Transmission
EEN 224	Electronic Devices and Circuits	EEP 468	Power Electronics
EEP 331	Power System Analysis	EEP 444	Power System Protection
EEP 331	Power System Analysis	EEP 445	Power System Stability & Control
EEN 219	Electrical Machines	EEP 471	Electrical Machine Design and Maintenance
EEN 211	Electrical Network Analysis	EEP 446	High Voltage Engineering
	None	EEP 448	Renewable Energy Systems
EEN 313	Signals & Systems	EEN 325	Digital Signal Processing
EEN 224	Electronic Circuit Design	EEP 472	Industrial Drives
EEP 331	Power System Analysis	EEP 475	FACTS and HVDC Transmission
	None	CEN 223	Computer Communication & Networking
	None	EEP 474	Smart Grid
EEN 412	Linear Control System	EEN 437	Digital Control System
EET 321	Communication Systems	CEN 474	Digital Communication System
EEN 224	Electronic Circuit Design	EEN 469	Linear Integrated Circuits and Applications
EEN 224	Electronic Circuit Design	EEP 474	PLC and Industrial Drives
EEN 224	Electronic Circuit Design	EEN 445	Industrial Electronics
	None	EEN434	Advance Computer Networks

Minutes of the 17th FBOS – ES

Roadmap of BEE with Pre-requisites

Semester 1

Pre-Requisite	Course	Course Title	Credit
None	GSC 110	Calculus and Analytical Geometry	3+0
None	CSC 111	Introduction to Computing	1+1
None	ENG 104	Functional English	2+0
None	ISL 101	Islamic Studies/ Ethics	2+0
None		IDEE-1	2+0
None	GSC 113	Applied Physics	3+1
None	EEL 112	Workshop Practice	0+1
			13+3 = 16

Semester 2

Pre-Requisite	Course	Course Title	Credit
None	EEL 121	Engineering Drawing & CAD	0+1
GSC 110 (Calculus and Analytical Geometry)	GSC 210	Differential Equations	3+0
CSC 111 (Introduction to Computing)	CSC 112	Programming Fundamentals	2+1
None	EEN 110	Linear Circuit Analysis	3+1
None	CEN 120	Digital Logic Design	3+1
None	PAK 101	Pakistan Studies	2+0
			13+4 = 17

Semester 3

Pre-Requisite	Course	Course Title	Credit Hours
None	HSS 120	Communication Skills	2+0
EEN 110 (Linear Circuit Analysis)	EEN 224	Electronic Devices and Circuits	3+1
EEN 110 (Linear Circuit Analysis)	EEN 211	Electrical Network Analysis	3+1
CSC 112 (Programming Fundamentals)	CSC 210	Computing Elective	3+1
GSC 110 (Calculus and Analytical Geometry)	GSC 220	Complex Variables and Transforms	3+0
Total			**14+3 = 17**

Semester 4

Pre-Requisite	Course Code	Course Title	Credit Hours
None	GSC 121	Linear algebra	3+0
None	HSS XXX	Humanities & Social Sciences Elective -1	3+0
GSC 220 (Complex Variables and Transforms)	EEN 313	Signals and Systems	3+1
EEN 224 (Electronic Devices and Circuits)	EEN 225	Electronic Circuit Design	3+1
GSC 110 (Calculus and Analytical Geometry)	GSC 123	Probability Methods in Engineering	3+0
Total			**15+2 = 17**

Semester 5

Pre-Requisite	Course Code	Course Title	Credit Hours
GSC 110 (Calculus and Analytical Geometry)	EEN 311	Electromagnetic Field Theory	3+0
CEN 120 (Digital Logic Design)	CEN 440	Embedded systems Design	3+1
XXXX	XXXX	Natural Science Elective	3+0
EEN 313 (Signals and Systems)	EET 321	Communication Systems	3+1
EEN 211 Electrical Network Analysis)	EEN 219	Electrical Machines	3+1
Total			**15+3 = 18**

Semester 6

Pre-Requisite	Course Code	Course Title	Credit Hours
XXXX	EEXXXX	Breadth Core- 1	3+1
EEN 313 (Signals and Systems)	EEN 412	Linear Control Systems	3+1
None	MGTXXX	Management Science Elective 1	2+0
XXXX	EEXXXX	Elective 1	3+1
XXXX	EEXXXX	Breadth Core-2	3+1
Total			**14+4 = 18**

Semester 7

Pre-Requisite	Course Code	Course Title	Credit Hours
None	ESC 498	Senior Design Project – 1	0+3
None	HSS 320	Tech. Writing & Present. Skills	3+0
XXXX	EEXXX	Elective 2	3+1
XXXX	EEXXX	Elective 3	3+1
XXXX	XXXX	IDEE-2	3+0
Total			**12+5 = 17**

Semester 8

Pre-Requisite	Course Code	Course Title	Credit Hours
XXXX	ESC 499	Senior Design Project-2	0+3
None	HSSXXX	Humanities & SS Elective-2	3+0
None	HSSXXX	Management sciences Elective - 2	3+0
XXXX	EEXXXX	Elective 4	3+1
XXXX	EEXXXX	Elective 5	3+0/2+1
Total			**12/11+4/5 = 16**

Total Credit Hours= 136 Credit Hours

Appendage 1713

PROPOSAL FOR LAUNCHING

PhD Geophysics Program

A. ACADEMIC DETAILS	
1	**Faculty/Department:** Faculty of Engineering and Sciences, Department of Earth and Environmental Sciences
2	**Name of the Program:** PhD Geophysics – PHD (GEO-PHY)
3	**Mission of the Program:** The mission of PhD Geophysics program is to build a strong and effective graduate program that will provide appropriate training and facilities to PhD candidates within the areas of expertise. The program will enhance research and professional skills and attract geoscientists of the national and international community. The department is committed to prepare, with a futuristic approach, competent professionals/researchers in the field of geophysics through quality education, quality research, field training, state-of-the art techniques and hands on commercial software as applied by the modern world.
4	**Objectives of the Program:** The PhD program has the following objectives: A well-structured graduate teaching and training program in order to create opportunities for students with professional experience to achieve the highest educational standards. Strong links with the international community of scientists and engineers working in the various fields of geophysical studies, both in academia and industry. Advanced research possibilities in the fields of Earth Sciences and exploration of hydrocarbon particularly related to the oil and gas industry. Enhance their knowledge through advanced course work, field works and use of dedicated software labs. Development of oil, gas, minerals and water resources research programs of national, regional and international scope. Enhance ability to present and defend a substantial piece of original research that makes a distinct contribution to the improvement of professional practice or policy in the field of geophysical sciences. To provide high-potential manpower to the industry and organizations through an effective postgraduate

	learning-teaching process.
5	**Outcomes of the Program:** After completing the PhD coursework and thesis, the students will be able to: Gain Fundamentals of geological modeling and reservoir characterization and propose solutions to geological problems Apply geophysical techniques to image subsurface geology and/or the economic layers of the shallow and/or deep earth in more appropriate and acceptable modeling. Conduct independently the research to provide solutions of the problems cropping up in the exploration of oil/gas and other resources. Understand the potential theory and geophysical exploration techniques for the application of commercial industrial software in solving E & D projects. Learn new trends of processing, modeling and interpret complex research findings related to current advances in geophysics.
6	**Rationale for the Program:** Geophysics is a leading discipline of modelling the Earth and is a major tool or technology of exploring the natural resources of the Earth. PhD Geophysics program is envisioned to contribute towards national efforts for producing professionals able to strengthen the research and education. The Department of Earth and Environmental Sciences desires to make Bahria University into a centre of national status and a focal point for geophysical research in the region. The Department had consensus to start the program in compliance with the role of universities to produce skilled, knowledgeable and motivated graduates for the industries and organizations in the private/public sectors.
7	**Brief Description of the Program:** The revised trends in industries dictate a preference for highly trained and specialized technical personnel, in order to strengthen the goals of the country for industrial growth and research in energy sector. The doctorate program in geophysical sciences is intended to prepare the competent scientists who can initiate genuine research ideas and come up with indigenous ideas to enrich the spectrum of geophysics and conduct particularly the Pakistan specific research in oil/gas and other geosciences resources. The doctoral program will provide training and education to the students with the objective of creating scholar capability to conduct research independently at a high level of originality and quality. The program is comprised of course work, field visits, exposure to digital

	technologies, training of industrial softwares and research thesis. The PhD degree is recognition of successful research experience of national and international standard in the discipline. This requires collaboration both with internationally reputed scientists and engineers and with leading centers of learning and research institutions. The PhD Geophysics program will cover fundamentals of geophysical exploration as well as geological knowledge in order to produce skilled researchers and innovative individuals in the field hydrocarbons and mineral exploration. PhD Geophysics program is being proposed as per requirements of Postgraduate Academic Regulations of Bahria University and HEC.
8	**Duration:** 3 years
9	**Venue(s): On Site**~~/Off Site/Both On & Off Site~~ *(tick one/strike-through the ones not applicable; if Off Site, give details)* SIR SYED Block, Bahria University, Shangrilla Road, Sector E-8, Islamabad
10	**Programme Scheduling Format:** ~~Morning~~/**Evening**/~~Weekend~~ *(tick one/strike-through the ones not applicable)* ~~Bi-Semester~~/~~Trimester~~/~~Semester+Summer Session~~/**Annual**/~~Bi-Annual~~*(tick one/strike-through the ones not applicable)*
11	**Proposed Date of Commencement:** Fall 2019
12	**Mode of study** For the completion of the program the candidate must complete 54 credit hours (18 credit hours of course work in first two semesters and 36 credit hours for next four semesters allocated for thesis). The course work will be based on class room teaching, assignments, quizzes, presentations, mid-term and final term exams which will be used to evaluate the students in each semester. After the completion of course work with CGPA 3.0/4.0, the students will start their research theses on the approved synopses under the guidance of appointed supervisors. The students have to complete their theses within stipulated time frame. The candidates also require passing the PhD Comprehensive Examination before starting their research work.

13	**Additional Faculty Member(s) Required:** *(Indicate if there is a requirement for additional faculty members, fulltime/visiting, along with qualifications.)* One PhD Geophysics Faculty Member has been hired on IPFP to fulfill the HEC criteria of having three PhD faculty Members. As the Department already have two PhD Permanent Faculty Members.
14	**Additional Skilled-Worker(s) Required:** *(Indicate if there is a requirement for additional Skilled Staff, fulltime/part-time, along with their qualifications/skill sets.)* **None**
15	**Additional Classroom(s) required:** *(The requirement is to include the number of classrooms and their capacities.)* No extra class rooms will be required, the existing resources of SIR SYED Block will be utilized in the evening program.
16	**Additional Requirement for Laboratories:** *(The requirement is to include the number of laboratories, their equipment and their capacities.)* Establishment of a dedicated Digital Geophysical Software Lab of the Department of E&ES is in process where all the Licensed softwares available with the department will be installed and students MS and PhD programs could utilize and learn the geophysical data Interpretation in a dedicated work place. Along with the existing resources available in the department, lab facilities at other campuses of the Bahria University and of those organizations/institutions with which the Bahria has signed MOUs will be utilized.
17	**Additional Requirement for Books, Subscriptions, Memberships to Online Research Sites/ Repositories:** **None**
18	**Minimum Entry Level:** 18 years of education. MS/MPhil degree in Geophysics
19	**Admission Criteria:** HEC recognized MS/MPhil degree in Geophysics with 3.00/400 CGPA (Semester System) or 60% marks (Annual System) with Subject GAT/University Test Prior to admission.
20	**Additional/Different Examination Requirement** *(Indicate if there will be any examination requirement, additional to or different from the BU Academic Rules or Examination Policy in vogue).* No additional/different examination requirements. The examinations will be as per BU Academic Rules and Examination policy

21	**Number of Admissions Expected for First Intake:** 5 admissions for first intake
22	**Number of Admissions Planned/Expected for Subsequent Intakes:** 5 admissions per intake
23	**Referred by: FBOS**
24	**Complete Plan of Studies, inclusive of complete Roadmap:** *(Attach as Annex 'A')*
25	**Course Outlines, Descriptions, Pre-Requisites & Readings (Compulsory & Recommended)** *(Attach as Annex 'B')*

B. FINANCIAL DETAILS

1 **Source of Funding: Tuition Fee**

BU: Fully/Partially:

Public Sector (B1): Fully/Partially *(provide complete details; attach MOU, agreement etc.)*

NNGO (B1): Fully/Partially *(provide complete details; attach MOU, agreement etc.)*

INGO (B1): Fully/Partially *(provide complete details; attach MOU, agreement etc.)*

UN/IGO (B1): Fully/Partially *(provide complete details; attach MOU, agreement etc.)*

2 **Degree Duration:** 3 years

Semester System: Yes (6 Semesters)

Total Number of Credit Hours: 54

3 **Expected fee to be charged based on Cost & Benefits Analysis:** *(show working)*

Per annum fee: or Fee rate per credit hour: Rs. 5,775 /-

4 **Expected Number of students for 1st & 2nd Intakes:** 5 & 5

5 **Expected Earning from first two Intakes (B5):** *(Show working)*

Year	1st Intake				2nd Intake			
	Semester	Fee/Student	Students	Total Fee	Semester	Fee/Student	Students	Total Fee
1	Fall 2019	99,975	5	499,875	Fall 2020	99,975	5	499,875
	Spring 2020	56,975	5	284,875	Spring 2021	56,975	5	284,875
2	Fall 2020	56,975	5	284,875	Fall 2021	56,975	5	284,875
	Spring 2021	56,975	5	284,875	Spring 2022	56,975	5	284,875
3	Fall 2021	56,975	5	284,875	Fall 2022	56,975	5	284,875
	Spring 2022	56,975	5	284,875	Spring 2023	56,975	5	284,875
Total	1st Intake			1,924,250	2nd Intake			1,924,250
								3,848,500

6 **Expected Earning for the Next Five Years (B6):** *(show working)*

		Students			Fee per student		Total Fee		
Year	Semester	Fresh	Existing	Total	Fresh*	Existing**	Fresh	Existing	Total
1	Fall 2019	5	0	5	99,975	0	499,875	-	**499,875**
	Spring 2020	0	5	5	0	56,975	-	284,875	**284,875**
2	Fall 2020	5	5	10	99,975	56,975	499,875	284,875	**784,750**
	Spring 2021	0	10	10	0	56,975	-	569,750	**569,750**
3	Fall 2021	5	10	15	99,975	56,975	499,875	569,750	**1,069,625**
	Spring 2022	0	15	15	0	56,975	-	854,625	**854,625**
4	Fall 2022	5	10	15	99,975	56,975	499,875	569,750	**1,069,625**

	Spring 2023	0	15	15	0	56,975	-	854,625	**854,625**
5	**Fall 2023**	5	10	15	99,975	56,975	499,875	569,750	**1,069,625**
	Spring 2024	0	15	15	0	56,975	-	854,625	**854,625**

Year 1: Rs. 784,750 /-
Year 2: Rs. 1,354,500 /-
Year 3: Rs. 1,924,250 /-
Year 4: Rs. 1,924,250 /-
Year 5: Rs. 1,924,250 /-

Total 5 years earnings: Rs. 7,912,000 /- (7.912 million rupees)

* per credit 5775 with 9 credit hours including admission fee, caution money, degree fee and misc. charges

** per credit 5775 with 9 credit hours including misc. charges

7 **Total Estimated Salaries of all Additional Human Resources per annum (B7):** *(Show working)*

Year	Additional Human Resources (Thesis Payments)			
	Semester	Description	Per Student	for 5 students
1	**Fall 2019 and Spring 2020**	None	0	0
2	**Fall 2020 and Spring 2021**	None	0	0
3	**Fall 2021 and Spring 2022**	Payment to Supervisors	100,000	500,000
		Payment to foreign evaluators (Thesis)	60,000	300,000
		External and Internal Examiners (Proposal)	19,000	95,000
		External and Internal Examiners (Thesis)	19,000	95,000
		Miscellaneous (Field + Lab) work	100,000	500,000
			Total	**1,490,000**
4	**Fall 2022 and Spring 2023**	Payment to Supervisors	100,000	500,000
		Payment to foreign evaluators (Thesis)	60,000	300,000
		External and Internal Examiners (Proposal)	19,000	95,000
		External and Internal Examiners (Thesis)	19,000	95,000
		Miscellaneous (Field + Lab) work	100,000	500,000
			Total	**1,490,000**
5	**Fall 2023 and Spring 2024**	Payment to Supervisors	100,000	500,000
		Payment to foreign evaluators (Thesis)	60,000	300,000
		External and Internal Examiners (Proposal)	19,000	95,000
		External and Internal Examiners (Thesis)	19,000	95,000

			Miscellaneous (Field + Lab) work	100,000	500,000
				Total	**1,490,000**

Year 1: Rs. 0 /-
Year 2: Rs. 0 /-
Year 3: Rs. 1,490,000 /-
Year 4: Rs. 1,490,000 /-
Year 5: Rs. 1,490,000 /-

Total estimated expenses: Rs. 4,470,000 /-
Total estimated salaries of HR : Rs. 894,000 /- (per annum)

8 **Cost of <u>Additional</u> Laboratory Equipment/Tools (B8):** *(show working)*

None

9 **Cost of Additional Classrooms (B9):** *(Include furniture, technical aids etc)*

None

10 **Cost of Additional Books, Subscription & Memberships to on-line Sites/Repositories (B10):** (*show details)*

None

11 **Off-Site rental Expenses and Cost of other Fixtures (B11):** *(Show details)*

None

12 **Miscellaneous Expenses required for Starting the Program (B12):**

- Advertisement: 30,000 /-
- Printing & Stationery: None
- Admin Cost: None
- Any other: None
- **Total : 30,000 /-**
-

13 **Annual Recurring Expenditures in Subsequent Years (B13):**

- Salaries:
- Rentals:
- Subscriptions/Memberships:
- Advertisements:
- Printing & Stationery:
- Admin Cost
- Any other

	- **Total:**
14	**Total Cost of the Programme (B14):** [Add B(7) to B(12)] **Year 1: Rs. 30,000 /-** **Year 2: Rs. 0 /-** **Year 3: Rs. 1,490,000 /-** **Year 4: Rs. 1,490,000 /-** **Year 5: Rs. 1,490,000 /-**
15	**Net Cost of the Programme (B15):** [Subtract B(1) from B(14)] **Year 1: Rs. 30,000 /-** **Year 2: Rs. 0 /-** **Year 3: Rs. 1,490,000 /-** **Year 4: Rs. 1,490,000 /-** **Year 5: Rs. 1,490,000 /-**
16	**Net Earnings in First Year (B16:** [Subtract B(15) from B(5)] **Year 1: Rs. 754,750 /-**
17	**Projected Annual Gross Earning in Subsequent Years (B 17):** *(show details & working; add 10% towards all expenses in subsequent years.)* **Year 2: Rs. 1,489,950 /-** **Year 3: Rs. 2,116,675 /-** **Year 4: Rs. 2,116,675 /-** **Year 5: Rs. 2,116,675 /-**
18	**Projected Annual Net Earning in Subsequent Years:** *[Subtract B(15) from B(17)]* **Year 2: Rs. 1,489,950 /-** **Year 3: Rs. 626,675 /-** **Year 4: Rs. 626,675 /-** **Year 5: Rs. 626,675 /-**

Annex - A

ROADMAP FOR PHD GEOPHYSICS

Semester	Credit Hours
1	9 (Course Work)
2	9 (Course Work)
3 to onward	Comprehensive Exam. Synopsis Writing, Presentation & Final Thesis Defence
	36 (Research work)
Total Credit Hours	54

Semester - 1

Course Code	Course Title	Credit Hours
GEO 801	Tectonic Evolution of Pakistan	3
GEO 828	Contemporary Trends in Geosciences	3
GEO 8xx	Elective course I	3

Semester – 2

Course Code	Course Title	Credit Hours
GEO 803	Seismic Imaging Techniques	3
GEO 8xx	Elective course II	3
GEO 8xx	Elective course III	3

Elective Courses

Courses	Course Title	Credit Hours
GEO 804	3D Seismic Attributes for Reservoir Characterization	3
GEO 805	3D Seismic Acquisition in Offshore & Onshore	3
GEO 806	Reservoir Modeling	3
GEO 807	GIS applications in Geophysics	3
GEO 808	Signal Processing in Geophysics	3
GEO 809	Geosciences Software	3
GEO 826	Disaster Risk Management	3
GEO 811	Advanced Reflection Seismology	3
GEO 812	Mining Geophysics	3
GEO 829	Advanced Earthquake Seismology	3
GEO 813	Gravity & Magnetic Modeling	3
GEO 810	Petrophysics	3
GEO 849	**Hydrocarbon Exploration Techniques**	**3**
GEO 850	**Advanced Basin Analysis**	**3**
GEO 851	**Reservoir Characterization**	**3**
GEO 853	**Advanced Sequence Stratigraphy**	**3**
GEO 868	**Advanced Structural Geology**	**3**
GEO 869	**Geostatistics**	**3**
GEO 871	**Advanced Petroleum Geology**	**3**
ESC 701	**Advanced Research Methodology**	**3**
GEO 872	Advanced Electrical Methods **(New Course Added)**	3

Note: Courses highlighted have been included from the PhD Geology Road Map

Annex – B

CORE COURSES OUTLINE FOR PHD GEOPHYSICS

a. GEO 801 Tectonic Evolution of Pakistan

Course outline:

Physiographic and tectonic divisions and their descriptions. Geology and stratigraphy of the, Indian plate, Karakoram plate, Afghan block and Arabian plate. Kohistan, Chagai and Ras Koh magmatic arcs, oroclines and suture zones. Regional metamorphism (Himalayan and Pre-Himalayan). Main episodes of magmatism and their relations to tectonics. Economic mineral and fuel deposits of Pakistan.

Reference text Books:

- Kearey, P., Klepeis, K.A., & Vine, F. J. (2013). *Global tectonics*. John Wiley & Sons.
- Kazmi, A. H., & Abbasi, I. A. (2008). *Stratigraphy & historical geology of Pakistan*. Department & National Centre of Excellence in Geology.
- Kazmi, A. H., & Jan, M. Q. (1997). *Geology and tectonics of Pakistan*. Graphic publishers.

b. GEO 828: Contemporary Trends in Geosciences

Course outline:

The seminar topics will relate to specific areas of geophysical sciences that are not covered by existing courses. Students will give seminars and receive suggestions on literature review, methodology, geophysical modeling and research aspects. Members of the department and invited participants/speakers will also meet the students weekly to discuss current research in the world.

References: Student may take guideline from

- Supervisors, Experts from academia and Industry
- Case studies, Reports, Research papers etc.

c. GEO 803 Seismic Imaging Techniques

Course outline:

The connection between seismic velocity and fluid flow, Seismic and reservoir resolutions, optimal grids, and scaling issues, Fundamentals of geostatistics fundamentals, Seismic attributes and facies, Seismic Inversion, poststack and prestack, Use of seismic, well log, core, pressure test and other data in reservoir model building, Neural networks and multi-attributes, Basic statistics, Markov Chain Monte Carlo simulations, and stochastic inversion, Uncertainty in reservoir models using Bayesian probability, 4D seismic analysis.

Reference Text Book:

- Griese, H. M. (2010). *Seismic imaging: a review of the techniques, their principles, merits and limitations*. EAGE publications.
- Sen, M. K. (2006). *Seismic inversion*. Richardson, TX.: Society of Petroleum Engineers.

ELECTIVE COURSES OUTLINE FOR PHD GEOPHYSICS

d. GEO 810 Petrophysics

Course outline:

Introduction to Petrophysics; Electrical properties of minerals and rocks – Resistivity, Conductivity, dielectric permittivity, ability to polarization – Relations to mineral composition, porosity, water saturation, volume and type of pore fluids, structure and texture, temperature and pressure, laboratory equipment for resistivity vs. temperature and pressure measurement; Dielectric permittivity of rocks – relation to porosity and water saturation, dispersion, dielectric permittivity as a basic for GPR; spontaneous polarization –diffusion, absorption, filtration, red-ox potentials, salinity of formation waters, role of clay minerals; Reservoir parameters – porosity, permeability, shaliness, clay components; reservoir parameters as a function of mineral composition, compaction, stratigraphic position; Archie law – relation between effective porosity and formation factor, between resistivity and structure factor – m for different rocks; water saturation, resistivity index, relation to wettability factor, Relation between resistivity and saturation and shaliness for sandy- sahly rocks, resistivity models; Thermal properties of minerals and rocks, relation between surface and heat flow and thermal conductivity, specific heat and temperature conductivity coefficient; Density -- relations between porosity and bulk density, matrix density, relation with gas saturation and oil viscosity; Elastic Parameters – definition of static and dynamic parameters, lab measurement and field recording; Nuclear factor affecting geophysical measurement – natural gamma radioactivity, scattering and absorption of gamma rays in minerals and rocks; behavior of neutrons in rock formation – neutron parameter – thermal neutron absorption cross section.

Reference Text Book:

- Tiab, D., & Donaldson, E. C. (2015). *Petrophysics: theory and practice of measuring reservoir rock and fluid transport properties*. Gulf professional publishing.
- Rider, M. H. (2011). *The geological interpretation of well logs.* 3rd Edition. Rider-French publishing.
- Ellis, D. V., & Singer, J. M. (2007). *Well logging for earth scientists* (Vol. 692). Dordrecht: Springer.
- Asquith, G. B., Krygowski, D., & Gibson, C. R. (2004). *Basic well log analysis* (Vol. 16). Tulsa: American Association of Petroleum Geologists.
- Rider, M. H. (2002). *The geological interpretation of well logs.* 2nd Edition. Rider-French publishing.

e. GEO 804 3D Seismic Attributes For Reservoir Characterization

Course outline:

Types of attributes, Impact of seismic data quality on seismic attributes, Methods for preconditioning of seismic data, Introduction of various algorithms for attribute computation, their limitations and performance strengths, Attribute expression of structure and stratigraphy in terms of tectonics and diaprism, clastic and carbonate depositional systems and geologic hazards, Multiattribute analysis tools, Reservoir characterization workflows, Physical demonstration of attributes on real seismic data., An inventory of direct hydrocarbon indicators, including AVO, AVO and how it relates to the typical production zones around the world with various ages and depths of burial, Spectral decomposition and seismic attributes as other ways of extracting reservoir information from the seismic image.

Softwares: Geographix, Petrel, Opendtect

Reference Text Book:

- Brown, A. R. (2011). *Interpretation of Three-Dimensional Seismic Data.* AAPG.
- Chopra, S., & Marfurt, K. J. (2007). *Seismic attributes for prospect identification and reservoir characterization*. Tulsa, Oklahoma: Society of Exploration Geophysicists.
- Davies, R. J. (Ed.). (2007). *Seismic geomorphology: Applications to hydrocarbon exploration and production*. Geological Society of London.

- Bacon, M., Simm, R., & Redshaw, T. (2007). *3-D seismic interpretation*. Cambridge University Press.

f. GEO 805 3D Seismic Acquisition in Offshore & Onshore

Course outline:

3D acquisition geometries, classes of 3D geometries, The continuous wavefield, 3D subsets and acquisition geometry, Sampling the continuous wavefield, minimal data sets, 3D symmetric sampling, Pseudo-COV gathers, application to prestack processing, Noise suppression, Properties of low-velocity noise. Guidelines for design of 3D geometry on land. Marine seismic data acquisition. Parameters of orthogonal geometry (fold, line intervals, maximum inline and maximum crossline offset). Converted waves: Properties and 3D survey design. Factors affecting spatial resolution. DMO. Prestack migration..

Reference Text Book:

- Vermeer, G. J. (2012). *3D Seismic Survey Design*. 2nd Edition. Tulsa: Society of Exploration Geophysicists.
- Vermeer, G. J., & Beasley, C. J. (2002). *3-D seismic survey design*. 1st Edition Tulsa: Society of Exploration Geophysicists.
- Cordsen, A., Galbraith, M., & Peirce, J. (2000). *Planning land 3-D seismic surveys* (Vol. 9). Tulsa: Society of Exploration Geophysicists.

g. GEO 806 Reservoir Modeling

Course outline:

Application of Various Imaging Techniques, Principles as Applied to Exploration and Reservoir Characterization, Concepts of Structural Interpretation, Lines/Cross-Lines, Arbitrary (User Defined) Lines, Time Slices, and Phase Slices, Visualization Techniques, Including 3D Immersion, Surface Versus Volumetric Interpretation, User-tracking Versus Auto-tracking of Horizons and Faults, Structural Interpretation, Including Refined Fault Analysis, Stratigraphic Interpretation, Including Sequence Stratigraphy and Appearance of Key Stratigraphic Features, Extraction of Petrophysical Information from Seismic Data, Integration of Well Log, Well Bore Geophysics, Synthetic Seismic, Seismic Inversion, Geological Analysis to Develop Coherent Reservoir Models.

Reference Text Book:

- Pyrcz, M. J., & Deutsch, C. V. (2014). *Geostatistical reservoir modeling*. Oxford university press.
- Luthi, S. (2013). *Geological Well Logs: Their Use in Reservoir Modeling*. Springer Science & Business Media.
- Ma, Y. Z., & La Pointe, P. R. (Eds.). (2011). *Uncertainty Analysis and Reservoir Modeling: Developing and Managing Assets in an Uncertain World.* AAPG.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.
- Slatt, R. M. (2006). *Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers*. Elsevier.

h. GEO 807 GIS Applications in Geophysics

Course Outline:

GIS elements, Theory of GIS as: a science, a studies and a system, Type of geological an remote sensing data, GIS data formats, use of GIS in mineral and hydrocarbon exploration, GIS studies in geological and structural studies, spatial relationships and geological association, special case studies from Pakistan.

Reference Text Book:

- Liu, J. G., & Mason, P. J. (2016). *Image processing and GIS for remote sensing: Techniques and applications*. John Wiley & Sons.
- Burrough, P. A., McDonnell, R. A., & Lloyd, C. D. (2015). *Principles of geographical information systems*. Oxford University Press.
- Carrara, A., & Guzzetti, F. (Eds.). (2013). *Geographical information systems in assessing natural hazards* (Vol. 5). Springer Science & Business Media.
- Davis, J. C. (1989). *Digital geologic and geographic information systems*. American Geophysical Union.

Software: ArcGIS and other necessary

i. GEO 808 Signal Processing in Geophysics

Course outline:

This course emphasizes the application of time series analysis and image processing techniques to large geophysical data sets. The covered topics include Fourier series and transform, Discrete Fourier transform, Z-transform Digital signals aliasing and Nyquist concepts, Convolution and deconvolution, Inverse filtering and theory, Principle value decomposition, Signal enhancement and applications.

Reference Text Books:

- Zhou, H. W. (2014). *Practical seismic data analysis*. Cambridge University Press.
- Upadhyay, S. K. (2013). *Seismic reflection processing: with special reference to anisotropy*. Springer Science & Business Media.
- Onajite, E. (2013). *Seismic data analysis techniques in hydrocarbon exploration*. Elsevier.
- Vaseghi, S. V. (2008). *Advanced digital signal processing and noise reduction*. John Wiley & Sons.
- Yilmaz, Ö. (2001). *Seismic data analysis*. Tulsa: SEG Books.
- Robinson, E. A., & Treitel, S. (2000). *Geophysical Signal Analysis*. SEG Books.

j. GEO 809 Geosciences Software

Course outline:

Type of Formats (UKOOA, P-190 format, SEG-D, SEG—Y etc), Basic learning of UNIX and, LINUX, Scanning, Editing and QC of Data, Navigation data loading, Seismic data loading (SEG-Y files both 2D lines and 3D cube), Well data loading (Well locations, Formation tops, well logs etc), Preparation of Synthetic Seismogram, Generation of Horizon, Generation of Faults, Perform seismic visualization and interpretation, Velocity Model Building, Generation of Time and Depth Maps, 3D Visualization of Depth Surfaces, Crustal Shortening, Perform well correlation, Model faults, Model facies throughout the reservoir, Perform Petrophysical modeling, Calculate Reservoir volumes, Rock Physics Analysis, Complex trace attributes, Horizon and formation attributes, Color display and 3D visualization, Spectral decomposition and thin bed tuning, Geometric attributes, Attribute expression of structure and stratigraphy, Impact of data quality on seismic attributes, Structure-oriented filtering and image enhancement, Multi-attribute analysis tools.

k. GEO 826 Disaster Risk Management

Course outline:

Identification of Major disasters, Comparison of hazard mitigation to disaster preparedness, response, and recovery. Hazards management versus disaster management. Disaster Modeling for Hazard Mitigation: Introduction to Inspiration Software and Disaster Modelling. Utilizing disaster models for conducting hazard and risk assessments, Atmospheric hazards and mitigations, Examine example disaster models prepared, Geologic/ Seismic Hazards and Mitigation, Hydrologic Hazards and Mitigation.

Reference Text Books:

- Olson, D. L., & Wu, D. D. (2017). Natural Disaster Risk Management. In *Enterprise Risk Management Models*. Springer, Berlin, Heidelberg.
- Ranke, U. (2016). *Natural Disaster Risk Management: Geosciences and Social Responsibility*. Springer
- Baas, S., Ramasamy, S., DePryck, J. D., & Battista, F. (2008). *Disaster risk management systems analysis: A guide book*(Vol. 3). Rome, Italy: Food and Agriculture Organization of the United Nations.

l. GEO 811 Advanced Reflection Seismology

Course Outline:

Principles of seismic reflection profiling, focusing on methods of seismic data formats advanced seismic reflection theories. Geometries of seismic waves, Characteristics of Seismic events, Seismic Resolutions, Fourier Transforms, Synthetics and Velocity Functions, Traveltime curves and velocity, Seismic Source Wavelets, Wavelet Shaping and Deconvolution. Seismic equipments, Reflection field methods, Data Processing and Seismic data Interpretation.

References Text Books:

- Liner, C. L. (2016). *Elements of 3D Seismology*. SEG Books.
- Wencai, Y. (2013). *Reflection Seismology: theory, data processing & interpretation*. Elsevier.
- Ashcroft, W. (2011). *A petroleum geologist's guide to seismic reflection*. John Wiley & Sons.
- Costain, J. K., & Çoruh, C. (2004). *Basic Theory in Reflection Seismology: with MATHEMATICA Notebooks and Examples on CD-ROM* (Vol. 1). Elsevier.
- Shearer, P. M. (2009). *Introduction to seismology*. Cambridge University Press.

m. GEO 812 Mining Geophysics

Course Outline:

Geophysical methods for exploration and mining, Geophysical prospecting, Electromagnetics, Resistivity, Induced Polarization, Self Potential, radiometric methods applied to problems in search for metallic mineral deposits, working conditions, data collections, processing and interpretation.

Reference Text Books:

Parasnis, D. S. (2014). *Mining geophysics.* (Vol. 3). Elsevier.

Idziak, A. F., & Dubiel, R. (Eds.). (2011). *Geophysics in mining and environmental protection*. Springer Science & Business Media.

n. GEO 829 Advanced Earthquake Seismology

Course Contents:

Earthquake Seismology, Seismic Wave Theory; Body Waves- Ray Theory and Ray Paths, Eikonal Equation, Travel Time Curves, Seismic Waveforms; Surface Waves-Dispersion Relations, Interpretation of Dispersion Curves, Group and Phase Velocities and Applications, Ambient Noise; The Earthquake Source- Focal mechanisms, moment tensors, source time function; Earthquake Mechanics-Friction and fracture, populations, dynamics, scaling; Seismic Recording - Sensors, recorders, networks and arrays; Seismograms-Natural and synthetic, time and frequency domain, combined influence of source, ray path, recording site and instrument; Earthquake Location- Ray parameters (arrays) and the Geiger method (networks); faulting source, double couple hypothesis, elastodynamics, Haskell's function, seismic moment tensor, focal mechanism and fault plane solutions; seismic gaps; Global Earth Structure-Layered structure from travel time tables, 3D structure from seismic tomography;

Seismotectonics-Distribution of seismicity in space, regional stress and strain tensors, relationship to tectonics; Seismic Hazard; Himalayan and stable continental region earthquakes, reservoir induced seismicity

Recommended Books:

Galea, D. (2016). Earthquake Seismology: Tools, Techniques and Instrumentation. Syrawood Publishing House.
Rafferty, J. P. (Ed.). (2010). Plate Tectonics, Volcanoes, and Earthquakes. The Rosen Publishing Group.
Stein, S., & Wysession, M. (2009). An introduction to seismology, earthquakes, and Earth structure. John Wiley & Sons.
Shearer, P. M. (2009). Introduction to seismology. Cambridge University Press.
Kayal, J. R. (2008). Microearthquake seismology and seismotectonics of South Asia. Springer Science & Business Media.

o. GEO 813 Gravity & Magnetic Modeling

Course outline:

Theoretical aspects of gravity, techniques of gravity & Magnetic techniques, principles of Gravity & Magnetic Data, field data processing and Isolation of residual and regional gravity and magnetic anomalies, Gravity & Magnetic Modeling.

Reference Text Books:

- Hinze, W. J., Von Frese, R. R., & Saad, A. H. (2013). *Gravity and magnetic exploration: Principles, practices, and applications*. Cambridge University Press.
- Kearey, P., Brooks, M., & Hill, I. (2013). *An introduction to geophysical exploration*. John Wiley & Sons.
- Mishra, D. C. (2011). Gravity and magnetic methods for geological studies. *Hyderabad: BS Publications*.
- Lowrie, W. (2007). *Fundamentals of geophysics*. Cambridge university press.

p. GEO 849 Hydrocarbon Exploration Techniques

Course Contents:

Hydrocarbon Exploration methods and techniques. Applications of different geophysical methods in hydrocarbon exploration like Gravity, electrical, Seismic, radioactive and well logging. Integration of different geophysical techniques, seismic interpretation, petrophysical analysis, volumetric reserves estimation, advance seismic techniques like attribute analysis, inversion, rock physics, AVO of pre and post stack seismic data, Characterization and Modeling of Petroleum System, Play Fairway Analysis.

Recommended Books:

- Onajite, E. (2017). *Practical Solutions to Integrated Oil and Gas Reservoir Analysis: Geophysical and Geological Perspectives*. Elsevier.
- Alsadi, H. N. (2017). *Seismic Hydrocarbon Exploration*. Springer International Publishing.
- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.
- Onajite, E. (2013). *Seismic data analysis techniques in hydrocarbon exploration*. Elsevier.
- Miall, A. D. (2013). *The geology of fluvial deposits: sedimentary facies, basin analysis, and petroleum geology*. Springer.
- Kearey, P., Brooks, M., & Hill, I. (2013). *An introduction to geophysical exploration*. John Wiley & Sons.

- Sengbush, R. L. (2012). *Petroleum exploration: a quantitative introduction*. Springer Science & Business Media.

q. GEO 850 Advance Basin Analysis

Course Contents:

Basins in their plate tectonic environment, Understanding plate motion, Geophysical Processes in Sedimentary Basin Formation, Concept of structural Geology, The physical state of the lithosphere, Basins due to lithospheric stretching, Rifting and Passive margins, Rift Basin Architecture and Evolution, Quantitative Filling Model for Continental Extensional Basins, 3-D Diagram of a Rift Basin, Basin and Range province: The rise and fall of Death Valley's mountain ranges and valleys, Basins due to flexure, Gravity, Flexure and Basins relationship, Anatomy of a Mountain Belt: Foreland Thrust-and-Fold Belts, Alpine Foreland Basin in Southeastern France, Ebro Foreland Basin, Spain, Devonian Clastic Wedges of the Acadian Orogeny, N. America, Virtual field trip to the Apulia foreland basin, Basins associated with subduction zones, Basins associated with strike-slip deformation, Strike-slip faults, The sediment routing system, Basin Stratigraphy, Subsidence and thermal history, The petroleum play.

Recommended Books:

- Miall, A. D. (2013). *Principles of sedimentary basin analysis*. Springer Science & Business Media.
- Allen, P. A., & Allen, J. R. (2013). *Basin analysis: Principles and application to petroleum play assessment*. John Wiley & Sons.
- Miall, A. D. (2013). *The geology of fluvial deposits: sedimentary facies, basin analysis, and petroleum geology*. Springer.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterisation*. Elsevier.

r. GEO 851 Reservoir Characterization

Course Contents:

Importance of understanding the various scales of heterogeneity in carbonate and clastic reservoirs, Reservoir rock deposition, diagenesis, mineralogy, rock textures, and pore types, Carbonate and clastic rock pore system classification, Reservoir rock properties and core analysis, Well log response, limitations, and strengths in reservoir rocks, Determination of lithology, porosity, and permeability, Fracture identification and distribution Porosity/depth relationships in limestone, dolomite and clastic reservoirs, Importance of sequence boundaries to development of pore architecture, Variations in carbonate pore architecture and its effect on permeability, Relationship of primary depositional facies, sequence stratigraphic framework and diagenetic history to pore architecture and reservoir quality, Controls on reservoir heterogeneity, from sub-reservoir to reservoir scale, Value of analogs for development of petrophysically-based reservoir models, Value and limitations of 3D geostatistical models to understand reservoir heterogeneity and architecture.

Recommended Books:

- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.
- Lake, L. (Ed.). (2012). *Reservoir characterization*. Elsevier.
- Chopra, S., & Marfurt, K. J. (2007). *Seismic attributes for prospect identification and reservoir characterization*. Tulsa, Oklahoma: Society of Exploration Geophysicists.
- Lucia, F. J. (2007). *Carbonate reservoir characterization: An integrated approach*. Springer Science & Business Media.

- Slatt, R. M. (2006). *Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers*. Elsevier.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.
- Cubitt, J. M., England, W. A., & Larter, S. R. (Eds.). (2004). Understanding petroleum reservoirs: Towards an integrated reservoir engineering and geochemical approach. Geological Society of London.

s. GEO 853 Advanced Sequence Stratigraphy

Course Contents:

Introduction to seismic sequence stratigraphy; concepts; Eustatic controls; Assumptions; Definition of key terms., Eustatic controls on depositional stratal patterns, Accommodation and equilibrium types, Systems tract boundaries, Seismic expression of sequence, Criteria and approach for picking sequence boundaries, Interpretation of seismic reflections in depositional sequences, Definition of seismic sequence, Seismic facies, Sequence and systems tracts, Highstand, Falling stage, Lowstand, Transgressive, Shelf margin systems tracts, Sequence expression in well logs, Log characters of parasequences, Maximum flooding surfaces and criteria for picking sequence boundaries, Interpretation of systems tracts from well log character, Integration of well log sequence stratigraphy with seismic sequence stratigraphy, Clastic and carbonate depositional environments, Depositional responses to changes in relative sea level, Variation on the model: Application and exploration significance – use of global sea level curve, Introduction: review of philosophy and epistemology, Application of geophysical fundamentals (wave theory, attributes, frequency substitution, and coherency), Amplitude variation with offset (lithologies, fluids, gases, porosities, and pressures), Fault mechanical stratigraphy, Vail and Galloway sequence theory and application, High resolution sea level curve generation from micropaleo, Shallow and deep water siliciclastic sequences, Seismic facies and paleo-environmental analysis, Reservoir scale geophysics using the wavelet, Imaging hydrocarbons, Geohistory reconstruction, Optimizing exploration and development.

Recommended Books:

- Haq, B. U. (Ed.). (2013). *Sequence stratigraphy and depositional response to eustatic, tectonic and climatic forcing*. Springer Science & Business Media.
- Emery, D., & Myers, K. (Eds.). (2009). *Sequence stratigraphy*. John Wiley & Sons.
- Catuneanu, O. (2006). *Principles of sequence stratigraphy*. Elsevier.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.

t. GEO 868 Advanced Structural Geology

Course Contents:

Force, strain and stress (including Mohr diagram and strain analysis methods); Deformation dynamics, kinematics and structures; Deformation modes and mechanisms; Brittle rock deformation: faulting (including fault rock development, fault seal analysis and palaeostress analysis from fault slip data) and fracturing (including joint development) in the upper crust; Ductile rock deformation: folding and shear zone development, lithospheric extension models, development of rift basins and passive margins and stretching factors; lithospheric compression models and development of foreland fold and thrust belts;diagram techniques, construction and interpretation of block diagrams and contour maps, stereographic analysis, cross section construction, restoration and balancing, 4D cross section evolution

Recommended Books:

- Fossen, H. (2016). *Structural geology*. Cambridge University Press.
- Ghosh, S. K. (2013). *Structural geology: fundamentals and modern developments*. Elsevier.
- Park, R. G. (2013). *Foundation of structural geology*. Routledge.

- Davis, G. H., Reynolds, S. J., Kluth, C. F. (2011). *Structural Geology of Rocks and Region*. 3rd Edition. Wiley Publishing.
- Twiss, R. J., & Moores, E. M. (2006). *Structural geology*. W. H. Freeman.
- Pollard, D. D., & Fletcher, R. C. (2005). *Fundamentals of structural geology*. Cambridge University Press.

u. GEO 869 Geostatistics

Course Contents:

Introduction to geostatistics; computer application in geo-statistics, collection of data: collection of primary data, collection of secondary data, editing of data; measures of central tendency or averages, types of averages, the arithmetic mean,the median, the mode, empirical relation between mean, median and mode, relative merits and demerits of various averages; measures of dispersion range, semi-interquartile range or quartile deviation, mean deviation, standard deviation, skewness; correlation and simple regression, coefficient of correlation, scatter diagram, rank correlation, regression; geo-statistical analyst: powerful exploration and data interpretation solutions multiple tools for data representation; The variogram calculation, interpretation, linking variogram behaviour with physical causes (geology, sampling); Extension variances and estimation variances/simple calculations in one and two dimensions; Global reserve/resource estimation; Optimal estimation and introduction to kriging;

Recommended Books:

- Hohn, M. (2013). *Geostatistics and petroleum geology*. Springer Science & Business Media.
- Wackernagel, H. (2013). *Multivariate geostatistics: an introduction with applications*. Springer Science & Business Media.
- Chilès, J. P., & Delfiner, P. (2012). Geostatistics: Modeling Spatial Uncertainty. Wiley Publishing.
- Armstrong, M. (2012). *Basic Linear Geostatistics*. Springer Science & Business Media.

v. GEO 871 Advanced Petroleum Geology

Course Contents:

Review of Petroleum Geology; Petroleum Geochemistry / Source Rock Evaluation; Modeling of Thermal History and Petroleum Generation and Expulsion; Production Seismic; Basin Analysis; Reservoir Geology & Reservoir modeling; Volumetric Reserve Estimation; Field Appraisal; Integrated Geology Workshop; Sequence Stratigraphy.

Recommended Books:

- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.
- Selley, R. C., & Sonnenberg, S. A. (2014). *Elements of petroleum geology*. Academic Press.
- Gluyas, J., & Swarbrick, R. (2013). *Petroleum geoscience*. John Wiley & Sons.
- Zou, C. (2017). *Unconventional petroleum geology*. Elsevier.
- Chapman, R. E. (2000). *Petroleum geology* (Vol. 16). Elsevier.
- North, F.K. (1985). *Petroleum geology*. Springer.

w. ESC 701 Advanced Research Methodology

Course Contents:

Research paradigms; techniques and pre-requisites of scientific research; research concept development; critical thinking and developing of research question; writing research proposal and its importance for acquisition of funds/grants from various agencies; the logic of sampling; sampling design; experimental work to address relevant analytical techniques; analytical data handling and presentation skills; relevant

software utilization; thesis writing; paper review technique; techniques of research paper publication in journals of repute

Recommended Books:

- How to Research, L. Blaxter, C. Hughes, M. Tight, 4th Edition, 2010.
- Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Publisher: SAGE,3rd Edition, 2010
- Wayne C. Booth, Gregory G. Colombo, Joseph M. Williams, 2008, The Craft of Research (Chicago Guides to Writing, Editing, and Publishing). University Of Chicago Press , 336
- Creswell, J.W, 2006, Designing and Conducting Mixed Methods Research. Sage Publications (CA). 275
- Research Methodologies – A step by step guide for beginners, Ranjit Kumar, 2005.
- Dawson, C. 2002, Practical Research Methods, A user-friendly guide to mastering research. Cromwell Press, Trowbridge, Wiltshire. 169
- William R. Shadish, Thomas D. Cook, Donald T. Campbell, 2001, Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Houghton Mifflin. 623

x. GEO 872 Advanced Electrical Methods

Course Contents:

Basic principal and theory of Electrical Resistivity method . Fundamentals of current flow in the Earth. Electric potentials and fields. Static charge distributions. Resistivity Imaging study its survey designing for Geophysical Electrical Exploration. Field procedures including Instruments and electrode arrangements. Processing and interpretation of resistivity data. Its limitations, advantages and disadvantages. Basic principal and theory of Induced polarization method its field procedure, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Self potential method its field procedure, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Electromagnetic method including Telluric Method and Magneto telluric Method, survey designing, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Charge body potential Method Mise A La Masse method and its applications. Study of case histories of all electrical methods.

Recommended Books:

- Kaufman, A. A., Alekseev, D., & Oristaglio, M. (2014). *Principles of electromagnetic methods in surface geophysics*. Newnes.
- Fitch, A. A. (Ed.). (2012). *Developments in Geophysical Exploration Methods—3*. Springer Science & Business Media.
- Fitch, A. A. (Ed.). (2012). *Developments in Geophysical Exploration Methods—3*. Springer Science & Business Media.
- Kaufman, A. A., & Anderson, B. (2010). *Principles of electric methods in surface and borehole geophysics*. Elsevier.
- Yungul, S. H. (1996). *Electrical methods in geophysical exploration of deep sedimentary basins*. Springer.

Annex - A

ROADMAP FOR PHD GEOPHYSICS

Semester	Credit Hours
1	9 (Course Work)
2	9 (Course Work)
3 to onward	Comprehensive Exam. Synopsis Writing, Presentation & Final Thesis Defence
	36 (Research work)

Total Credit Hours	54

Semester - 1

Course Code	Course Title	Credit Hours
GEO 801	Tectonic Evolution of Pakistan	3
GEO 828	Contemporary Trends in Geosciences	3
GEO 8xx	Elective course I	3

Semester – 2

Course Code	Course Title	Credit Hours
GEO 803	Seismic Imaging Techniques	3
GEO 8xx	Elective course II	3
GEO 8xx	Elective course III	3

Elective Courses

Courses	Course Title	Credit Hours
GEO 804	3D Seismic Attributes for Reservoir Characterization	3
GEO 805	3D Seismic Acquisition in Offshore & Onshore	3
GEO 806	Reservoir Modeling	3
GEO 807	GIS applications in Geophysics	3
GEO 808	Signal Processing in Geophysics	3
GEO 809	Geosciences Software	3
GEO 826	Disaster Risk Management	3
GEO 811	Advanced Reflection Seismology	3
GEO 812	Mining Geophysics	3
GEO 829	Advanced Earthquake Seismology	3
GEO 813	Gravity & Magnetic Modeling	3
GEO 810	Petrophysics	3
GEO 849	**Hydrocarbon Exploration**	**3**

	Techniques	
GEO 850	**Advanced Basin Analysis**	**3**
GEO 851	**Reservoir Characterization**	**3**
GEO 853	**Advanced Sequence Stratigraphy**	**3**
GEO 868	**Advanced Structural Geology**	**3**
GEO 869	**Geostatistics**	**3**
GEO 871	**Advanced Petroleum Geology**	**3**
ESC 701	**Advanced Research Methodology**	**3**
GEO 872	Advanced Electrical Methods **(New Course Added)**	3

Note: Courses highlighted have been included from the PhD Geology Road Map

Annex – B

CORE COURSES OUTLINE FOR PHD GEOPHYSICS

y. GEO 801 Tectonic Evolution of Pakistan

Course outline:

Physiographic and tectonic divisions and their descriptions. Geology and stratigraphy of the, Indian plate, Karakoram plate, Afghan block and Arabian plate. Kohistan, Chagai and Ras Koh magmatic arcs, oroclines and suture zones. Regional metamorphism (Himalayan and Pre-Himalayan). Main episodes of magmatism and their relations to tectonics. Economic mineral and fuel deposits of Pakistan.

Reference text Books:

- Kearey, P., Klepeis, K.A., & Vine, F. J. (2013). *Global tectonics*. John Wiley & Sons.
- Kazmi, A. H., & Abbasi, I. A. (2008). *Stratigraphy & historical geology of Pakistan*. Department & National Centre of Excellence in Geology.
- Kazmi, A. H., & Jan, M. Q. (1997). *Geology and tectonics of Pakistan*. Graphic publishers.

z. GEO 828: Contemporary Trends in Geosciences

Course outline:

The seminar topics will relate to specific areas of geophysical sciences that are not covered by existing courses. Students will give seminars and receive suggestions on literature review, methodology, geophysical modeling and research aspects. Members of the department and invited participants/speakers will also meet the students weekly to discuss current research in the world.

References: Student may take guideline from

- Supervisors, Experts from academia and Industry
- Case studies, Reports, Research papers etc.

aa. GEO 803 Seismic Imaging Techniques

Course outline:

The connection between seismic velocity and fluid flow, Seismic and reservoir resolutions, optimal grids, and scaling issues, Fundamentals of geostatistics fundamentals, Seismic attributes and facies, Seismic Inversion, poststack and prestack, Use of seismic, well log, core, pressure test and other data in reservoir model building, Neural networks and multi-attributes, Basic statistics, Markov Chain Monte Carlo simulations, and stochastic inversion, Uncertainty in reservoir models using Bayesian probability, 4D seismic analysis.

Reference Text Book:

- Griese, H. M. (2010). *Seismic imaging: a review of the techniques, their principles, merits and limitations*. EAGE publications.
- Sen, M. K. (2006). *Seismic inversion*. Richardson, TX.: Society of Petroleum Engineers.

ELECTIVE COURSES OUTLINE FOR PHD GEOPHYSICS

bb. GEO 810 Petrophysics

Course outline:

Introduction to Petrophysics; Electrical properties of minerals and rocks – Resistivity, Conductivity, dielectric permittivity, ability to polarization – Relations to mineral composition, porosity, water saturation, volume and type of pore fluids, structure and texture, temperature and pressure, laboratory equipment for resistivity vs. temperature and pressure measurement; Dielectric permittivity of rocks – relation to porosity and water saturation, dispersion, dielectric permittivity as a basic for GPR; spontaneous polarization –diffusion, absorption, filtration, red-ox potentials, salinity of formation waters, role of clay minerals; Reservoir parameters – porosity, permeability, shaliness, clay components; reservoir parameters as a function of mineral composition, compaction, stratigraphic position; Archie law – relation between effective porosity and formation factor, between resistivity and structure factor – m for different rocks; water saturation, resistivity index, relation to wettability factor, Relation between resistivity and saturation and shaliness for sandy- sahly rocks, resistivity models; Thermal properties of minerals and rocks, relation between surface and heat flow and thermal conductivity, specific heat and temperature conductivity coefficient; Density -- relations between porosity and bulk density, matrix density, relation with gas saturation and oil viscosity; Elastic Parameters – definition of static and dynamic parameters, lab measurement and field recording; Nuclear factor affecting geophysical measurement – natural gamma radioactivity, scattering and absorption of gamma rays in minerals and rocks; behavior of neutrons in rock formation – neutron parameter – thermal neutron absorption cross section.

Reference Text Book:

- Tiab, D., & Donaldson, E. C. (2015). *Petrophysics: theory and practice of measuring reservoir rock and fluid transport properties*. Gulf professional publishing.
- Rider, M. H. (2011). *The geological interpretation of well logs.* 3rd Edition. Rider-French publishing.
- Ellis, D. V., & Singer, J. M. (2007). *Well logging for earth scientists* (Vol. 692). Dordrecht: Springer.
- Asquith, G. B., Krygowski, D., & Gibson, C. R. (2004). *Basic well log analysis* (Vol. 16). Tulsa: American Association of Petroleum Geologists.
- Rider, M. H. (2002). *The geological interpretation of well logs.* 2nd Edition. Rider-French publishing.

cc. GEO 804 3D Seismic Attributes For Reservoir Characterization

Course outline:

Types of attributes, Impact of seismic data quality on seismic attributes, Methods for preconditioning of seismic data, Introduction of various algorithms for attribute computation, their limitations and performance strengths, Attribute expression of structure and stratigraphy in terms of tectonics and diaprism, clastic and carbonate depositional systems and geologic hazards, Multiattribute analysis tools, Reservoir characterization workflows, Physical demonstration of attributes on real seismic data., An inventory of direct hydrocarbon indicators, including AVO, AVO and how it relates to the typical production zones around the world with various ages and depths of burial, Spectral decomposition and seismic attributes as other ways of extracting reservoir information from the seismic image.

Softwares: Geographix, Petrel, Opendtect

Reference Text Book:

- Brown, A. R. (2011). *Interpretation of Three-Dimensional Seismic Data.* AAPG.
- Chopra, S., & Marfurt, K. J. (2007). *Seismic attributes for prospect identification and reservoir characterization*. Tulsa, Oklahoma: Society of Exploration Geophysicists.
- Davies, R. J. (Ed.). (2007). *Seismic geomorphology: Applications to hydrocarbon exploration and production*. Geological Society of London.

- Bacon, M., Simm, R., & Redshaw, T. (2007). *3-D seismic interpretation*. Cambridge University Press.

dd. GEO 805 3D Seismic Acquisition in Offshore & Onshore

Course outline:

3D acquisition geometries, classes of 3D geometries, The continuous wavefield, 3D subsets and acquisition geometry, Sampling the continuous wavefield, minimal data sets, 3D symmetric sampling, Pseudo-COV gathers, application to prestack processing, Noise suppression, Properties of low-velocity noise. Guidelines for design of 3D geometry on land. Marine seismic data acquisition. Parameters of orthogonal geometry (fold, line intervals, maximum inline and maximum crossline offset). Converted waves: Properties and 3D survey design. Factors affecting spatial resolution. DMO. Prestack migration..

Reference Text Book:

- Vermeer, G. J. (2012). *3D Seismic Survey Design.* 2nd Edition. Tulsa: Society of Exploration Geophysicists.
- Vermeer, G. J., & Beasley, C. J. (2002). *3-D seismic survey design*. 1st Edition Tulsa: Society of Exploration Geophysicists.
- Cordsen, A., Galbraith, M., & Peirce, J. (2000). *Planning land 3-D seismic surveys* (Vol. 9). Tulsa: Society of Exploration Geophysicists.

ee. GEO 806 Reservoir Modeling

Course outline:

Application of Various Imaging Techniques, Principles as Applied to Exploration and Reservoir Characterization, Concepts of Structural Interpretation, Lines/Cross-Lines, Arbitrary (User Defined) Lines, Time Slices, and Phase Slices, Visualization Techniques, Including 3D Immersion, Surface Versus Volumetric Interpretation, User-tracking Versus Auto-tracking of Horizons and Faults, Structural Interpretation, Including Refined Fault Analysis, Stratigraphic Interpretation, Including Sequence Stratigraphy and Appearance of Key Stratigraphic Features, Extraction of Petrophysical Information from Seismic Data, Integration of Well Log, Well Bore Geophysics, Synthetic Seismic, Seismic Inversion, Geological Analysis to Develop Coherent Reservoir Models.

Reference Text Book:

- Pyrcz, M. J., & Deutsch, C. V. (2014). *Geostatistical reservoir modeling*. Oxford university press.
- Luthi, S. (2013). *Geological Well Logs: Their Use in Reservoir Modeling*. Springer Science & Business Media.
- Ma, Y. Z., & La Pointe, P. R. (Eds.). (2011). *Uncertainty Analysis and Reservoir Modeling: Developing and Managing Assets in an Uncertain World.* AAPG.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.
- Slatt, R. M. (2006). *Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers*. Elsevier.

ff. GEO 807 GIS Applications in Geophysics

Course Outline:

GIS elements, Theory of GIS as: a science, a studies and a system, Type of geological an remote sensing data, GIS data formats, use of GIS in mineral and hydrocarbon exploration, GIS studies in geological

and structural studies, spatial relationships and geological association, special case studies from Pakistan.

Reference Text Book:

- Liu, J. G., & Mason, P. J. (2016). *Image processing and GIS for remote sensing: Techniques and applications*. John Wiley & Sons.
- Burrough, P. A., McDonnell, R. A., & Lloyd, C. D. (2015). *Principles of geographical information systems*. Oxford University Press.
- Carrara, A., & Guzzetti, F. (Eds.). (2013). *Geographical information systems in assessing natural hazards* (Vol. 5). Springer Science & Business Media.
- Davis, J. C. (1989). *Digital geologic and geographic information systems*. American Geophysical Union.

Software: ArcGIS and other necessary

gg. GEO 808 Signal Processing in Geophysics

Course outline:

This course emphasizes the application of time series analysis and image processing techniques to large geophysical data sets. The covered topics include Fourier series and transform, Discrete Fourier transform, Z-transform Digital signals aliasing and Nyquist concepts, Convolution and deconvolution, Inverse filtering and theory, Principle value decomposition, Signal enhancement and applications.

Reference Text Books:

- Zhou, H. W. (2014). *Practical seismic data analysis*. Cambridge University Press.
- Upadhyay, S. K. (2013). *Seismic reflection processing: with special reference to anisotropy*. Springer Science & Business Media.
- Onajite, E. (2013). *Seismic data analysis techniques in hydrocarbon exploration*. Elsevier.
- Vaseghi, S. V. (2008). *Advanced digital signal processing and noise reduction*. John Wiley & Sons.
- Yilmaz, Ö. (2001). *Seismic data analysis*. Tulsa: SEG Books.
- Robinson, E. A., & Treitel, S. (2000). *Geophysical Signal Analysis*. SEG Books.

hh. GEO 809 Geosciences Software

Course outline:

Type of Formats (UKOOA, P-190 format, SEG-D, SEG—Y etc), Basic learning of UNIX and, LINUX, Scanning, Editing and QC of Data, Navigation data loading, Seismic data loading (SEG-Y files both 2D lines and 3D cube), Well data loading (Well locations, Formation tops, well logs etc), Preparation of Synthetic Seismogram, Generation of Horizon, Generation of Faults, Perform seismic visualization and interpretation, Velocity Model Building, Generation of Time and Depth Maps, 3D Visualization of Depth Surfaces, Crustal Shortening, Perform well correlation, Model faults, Model facies throughout the reservoir, Perform Petrophysical modeling, Calculate Reservoir volumes, Rock Physics Analysis, Complex trace attributes, Horizon and formation attributes, Color display and 3D visualization, Spectral decomposition and thin bed tuning, Geometric attributes, Attribute expression of structure and stratigraphy, Impact of data quality on seismic attributes, Structure-oriented filtering and image enhancement, Multi-attribute analysis tools.

ii. GEO 826 Disaster Risk Management

Course outline:

Identification of Major disasters, Comparison of hazard mitigation to disaster preparedness, response, and recovery. Hazards management versus disaster management. Disaster Modeling for Hazard Mitigation: Introduction to Inspiration Software and Disaster Modelling. Utilizing disaster models for

conducting hazard and risk assessments, Atmospheric hazards and mitigations, Examine example disaster models prepared, Geologic/ Seismic Hazards and Mitigation, Hydrologic Hazards and Mitigation.

Reference Text Books:

- Olson, D. L., & Wu, D. D. (2017). Natural Disaster Risk Management. In *Enterprise Risk Management Models*. Springer, Berlin, Heidelberg.
- Ranke, U. (2016). *Natural Disaster Risk Management: Geosciences and Social Responsibility*. Springer
- Baas, S., Ramasamy, S., DePryck, J. D., & Battista, F. (2008). *Disaster risk management systems analysis: A guide book*(Vol. 3). Rome, Italy: Food and Agriculture Organization of the United Nations.

jj. GEO 811 Advanced Reflection Seismology

Course Outline:

Principles of seismic reflection profiling, focusing on methods of seismic data formats advanced seismic reflection theories. Geometries of seismic waves, Characteristics of Seismic events, Seismic Resolutions, Fourier Transforms, Synthetics and Velocity Functions, Traveltime curves and velocity, Seismic Source Wavelets, Wavelet Shaping and Deconvolution. Seismic equipments, Reflection field methods, Data Processing and Seismic data Interpretation.

References Text Books:

- Liner, C. L. (2016). *Elements of 3D Seismology*. SEG Books.
- Wencai, Y. (2013). *Reflection Seismology: theory, data processing & interpretation*. Elsevier.
- Ashcroft, W. (2011). *A petroleum geologist's guide to seismic reflection*. John Wiley & Sons.
- Costain, J. K., & Çoruh, C. (2004). *Basic Theory in Reflection Seismology: with MATHEMATICA Notebooks and Examples on CD-ROM* (Vol. 1). Elsevier.
- Shearer, P. M. (2009). *Introduction to seismology*. Cambridge University Press.

kk. GEO 812 Mining Geophysics

Course Outline:

Geophysical methods for exploration and mining, Geophysical prospecting, Electromagnetics, Resistivity, Induced Polarization, Self Potential, radiometric methods applied to problems in search for metallic mineral deposits, working conditions, data collections, processing and interpretation.

Reference Text Books:

- Parasnis, D. S. (2014). *Mining geophysics.* (Vol. 3). Elsevier.
- Idziak, A. F., & Dubiel, R. (Eds.). (2011). *Geophysics in mining and environmental protection*. Springer Science & Business Media.

ll. GEO 829 Advanced Earthquake Seismology

Course Contents:

Earthquake Seismology, Seismic Wave Theory; Body Waves- Ray Theory and Ray Paths, Eikonal Equation, Travel Time Curves, Seismic Waveforms; Surface Waves-Dispersion Relations, Interpretation of Dispersion Curves, Group and Phase Velocities and Applications, Ambient Noise; The Earthquake Source- Focal mechanisms, moment tensors, source time function; Earthquake Mechanics- Friction and fracture, populations, dynamics, scaling; Seismic Recording - Sensors, recorders, networks and arrays; Seismograms-Natural and synthetic, time and frequency domain, combined influence of source, ray path, recording site and instrument; Earthquake Location- Ray parameters (arrays) and the

Geiger method (networks); faulting source, double couple hypothesis, elastodynamics, Haskell's function, seismic moment tensor, focal mechanism and fault plane solutions; seismic gaps; Global Earth Structure-Layered structure from travel time tables, 3D structure from seismic tomography; Seismotectonics-Distribution of seismicity in space, regional stress and strain tensors, relationship to tectonics; Seismic Hazard; Himalayan and stable continental region earthquakes, reservoir induced seismicity

Recommended Books:

- ***Galea, D. (2016). Earthquake Seismology: Tools, Techniques and Instrumentation. Syrawood Publishing House.***
- ***Rafferty, J. P. (Ed.). (2010). Plate Tectonics, Volcanoes, and Earthquakes. The Rosen Publishing Group.***
- ***Stein, S., & Wysession, M. (2009). An introduction to seismology, earthquakes, and Earth structure. John Wiley & Sons.***
- ***Shearer, P. M. (2009). Introduction to seismology. Cambridge University Press.***
- ***Kayal, J. R. (2008). Microearthquake seismology and seismotectonics of South Asia. Springer Science & Business Media.***

mm. GEO 813 Gravity & Magnetic Modeling

Course outline:

Theoretical aspects of gravity, techniques of gravity & Magnetic techniques, principles of Gravity & Magnetic Data, field data processing and Isolation of residual and regional gravity and magnetic anomalies, Gravity & Magnetic Modeling.

Reference Text Books:

- Hinze, W. J., Von Frese, R. R., & Saad, A. H. (2013). *Gravity and magnetic exploration: Principles, practices, and applications*. Cambridge University Press.
- Kearey, P., Brooks, M., & Hill, I. (2013). *An introduction to geophysical exploration*. John Wiley & Sons.
- Mishra, D. C. (2011). Gravity and magnetic methods for geological studies. *Hyderabad: BS Publications*.
- Lowrie, W. (2007). *Fundamentals of geophysics*. Cambridge university press.

nn. GEO 849 Hydrocarbon Exploration Techniques

Course Contents:

Hydrocarbon Exploration methods and techniques. Applications of different geophysical methods in hydrocarbon exploration like Gravity, electrical, Seismic, radioactive and well logging. Integration of different geophysical techniques, seismic interpretation, petrophysical analysis, volumetric reserves estimation, advance seismic techniques like attribute analysis, inversion, rock physics, AVO of pre and post stack seismic data, Characterization and Modeling of Petroleum System, Play Fairway Analysis.

Recommended Books:

- Onajite, E. (2017). *Practical Solutions to Integrated Oil and Gas Reservoir Analysis: Geophysical and Geological Perspectives*. Elsevier.
- Alsadi, H. N. (2017). *Seismic Hydrocarbon Exploration*. Springer International Publishing.
- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.

- Onajite, E. (2013). *Seismic data analysis techniques in hydrocarbon exploration*. Elsevier.
- Miall, A. D. (2013). *The geology of fluvial deposits: sedimentary facies, basin analysis, and petroleum geology*. Springer.
- Kearey, P., Brooks, M., & Hill, I. (2013). *An introduction to geophysical exploration*. John Wiley & Sons.
- Sengbush, R. L. (2012). *Petroleum exploration: a quantitative introduction*. Springer Science & Business Media.

oo. GEO 850 Advance Basin Analysis

Course Contents:

Basins in their plate tectonic environment, Understanding plate motion, Geophysical Processes in Sedimentary Basin Formation, Concept of structural Geology, The physical state of the lithosphere, Basins due to lithospheric stretching, Rifting and Passive margins, Rift Basin Architecture and Evolution, Quantitative Filling Model for Continental Extensional Basins, 3-D Diagram of a Rift Basin, Basin and Range province: The rise and fall of Death Valley's mountain ranges and valleys, Basins due to flexure, Gravity, Flexure and Basins relationship, Anatomy of a Mountain Belt: Foreland Thrust-and-Fold Belts, Alpine Foreland Basin in Southeastern France, Ebro Foreland Basin, Spain, Devonian Clastic Wedges of the Acadian Orogeny, N. America, Virtual field trip to the Apulia foreland basin, Basins associated with subduction zones, Basins associated with strike-slip deformation, Strike-slip faults, The sediment routing system, Basin Stratigraphy, Subsidence and thermal history, The petroleum play.

Recommended Books:

- Miall, A. D. (2013). *Principles of sedimentary basin analysis*. Springer Science & Business Media.
- Allen, P. A., & Allen, J. R. (2013). *Basin analysis: Principles and application to petroleum play assessment*. John Wiley & Sons.
- Miall, A. D. (2013). *The geology of fluvial deposits: sedimentary facies, basin analysis, and petroleum geology*. Springer.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterisation*. Elsevier.

pp. GEO 851 Reservoir Characterization

Course Contents:

Importance of understanding the various scales of heterogeneity in carbonate and clastic reservoirs, Reservoir rock deposition, diagenesis, mineralogy, rock textures, and pore types, Carbonate and clastic rock pore system classification, Reservoir rock properties and core analysis, Well log response, limitations, and strengths in reservoir rocks, Determination of lithology, porosity, and permeability, Fracture identification and distribution Porosity/depth relationships in limestone, dolomite and clastic reservoirs, Importance of sequence boundaries to development of pore architecture, Variations in carbonate pore architecture and its effect on permeability, Relationship of primary depositional facies, sequence stratigraphic framework and diagenetic history to pore architecture and reservoir quality, Controls on reservoir heterogeneity, from sub-reservoir to reservoir scale, Value of analogs for development of petrophysically-based reservoir models, Value and limitations of 3D geostatistical models to understand reservoir heterogeneity and architecture.

Recommended Books:

- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.

- Lake, L. (Ed.). (2012). *Reservoir characterization*. Elsevier.
- Chopra, S., & Marfurt, K. J. (2007). *Seismic attributes for prospect identification and reservoir characterization*. Tulsa, Oklahoma: Society of Exploration Geophysicists.
- Lucia, F. J. (2007). *Carbonate reservoir characterization: An integrated approach*. Springer Science & Business Media.
- Slatt, R. M. (2006). *Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers*. Elsevier.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.
- Cubitt, J. M., England, W. A., & Larter, S. R. (Eds.). (2004). Understanding petroleum reservoirs: Towards an integrated reservoir engineering and geochemical approach. Geological Society of London.

qq. GEO 853 Advanced Sequence Stratigraphy

Course Contents:

Introduction to seismic sequence stratigraphy; concepts; Eustatic controls; Assumptions; Definition of key terms., Eustatic controls on depositional stratal patterns, Accommodation and equilibrium types, Systems tract boundaries, Seismic expression of sequence, Criteria and approach for picking sequence boundaries, Interpretation of seismic reflections in depositional sequences, Definition of seismic sequence, Seismic facies, Sequence and systems tracts, Highstand, Falling stage, Lowstand, Transgressive, Shelf margin systems tracts, Sequence expression in well logs, Log characters of parasequences, Maximum flooding surfaces and criteria for picking sequence boundaries, Interpretation of systems tracts from well log character, Integration of well log sequence stratigraphy with seismic sequence stratigraphy, Clastic and carbonate depositional environments, Depositional responses to changes in relative sea level, Variation on the model: Application and exploration significance – use of global sea level curve, Introduction: review of philosophy and epistemology, Application of geophysical fundamentals (wave theory, attributes, frequency substitution, and coherency), Amplitude variation with offset (lithologies, fluids, gases, porosities, and pressures), Fault mechanical stratigraphy, Vail and Galloway sequence theory and application, High resolution sea level curve generation from micropaleo, Shallow and deep water siliciclastic sequences, Seismic facies and paleo-environmental analysis, Reservoir scale geophysics using the wavelet, Imaging hydrocarbons, Geohistory reconstruction, Optimizing exploration and development.

Recommended Books:

- Haq, B. U. (Ed.). (2013). *Sequence stratigraphy and depositional response to eustatic, tectonic and climatic forcing*. Springer Science & Business Media.
- Emery, D., & Myers, K. (Eds.). (2009). *Sequence stratigraphy*. John Wiley & Sons.
- Catuneanu, O. (2006). *Principles of sequence stratigraphy*. Elsevier.
- Veeken, P. C. (2006). *Seismic stratigraphy, basin analysis and reservoir characterization*. Elsevier.

rr. GEO 868 Advanced Structural Geology

Course Contents:

Force, strain and stress (including Mohr diagram and strain analysis methods); Deformation dynamics, kinematics and structures; Deformation modes and mechanisms; Brittle rock deformation: faulting (including fault rock development, fault seal analysis and palaeostress analysis from fault slip data) and fracturing (including joint development) in the upper crust; Ductile rock deformation: folding and shear zone development, lithospheric extension models, development of rift basins and passive margins and stretching factors; lithospheric compression models and development of foreland fold and thrust belts;diagram techniques, construction and interpretation of block diagrams and contour maps, stereographic analysis, cross section construction, restoration and balancing, 4D cross section evolution

Recommended Books:

- Fossen, H. (2016). *Structural geology*. Cambridge University Press.
- Ghosh, S. K. (2013). *Structural geology: fundamentals and modern developments*. Elsevier.
- Park, R. G. (2013). *Foundation of structural geology*. Routledge.
- Davis, G. H., Reynolds, S. J., Kluth, C. F. (2011). *Structural Geology of Rocks and Region*. 3rd Edition. Wiley Publishing.
- Twiss, R. J., & Moores, E. M. (2006). *Structural geology*. W. H. Freeman.
- Pollard, D. D., & Fletcher, R. C. (2005). *Fundamentals of structural geology*. Cambridge University Press.

ss. GEO 869 Geostatistics

Course Contents:

Introduction to geostatistics; computer application in geo-statistics, collection of data: collection of primary data, collection of secondary data, editing of data; measures of central tendency or averages, types of averages, the arithmetic mean,the median, the mode, empirical relation between mean, median and mode, relative merits and demerits of various averages; measures of dispersion range, semi-interquartile range or quartile deviation, mean deviation, standard deviation, skewness; correlation and simple regression, coefficient of correlation, scatter diagram, rank correlation, regression; geo-statistical analyst: powerful exploration and data interpretation solutions multiple tools for data representation; The variogram calculation, interpretation, linking variogram behaviour with physical causes (geology, sampling); Extension variances and estimation variances/simple calculations in one and two dimensions; Global reserve/resource estimation; Optimal estimation and introduction to kriging;

Recommended Books:

- Hohn, M. (2013). *Geostatistics and petroleum geology*. Springer Science & Business Media.
- Wackernagel, H. (2013). *Multivariate geostatistics: an introduction with applications*. Springer Science & Business Media.
- Chilès, J. P., & Delfiner, P. (2012). Geostatistics: Modeling Spatial Uncertainty. Wiley Publishing.
- Armstrong, M. (2012). *Basic Linear Geostatistics*. Springer Science & Business Media.

tt. GEO 871 Advanced Petroleum Geology

Course Contents:

Review of Petroleum Geology; Petroleum Geochemistry / Source Rock Evaluation; Modeling of Thermal History and Petroleum Generation and Expulsion; Production Seismic; Basin Analysis; Reservoir Geology & Reservoir modeling; Volumetric Reserve Estimation; Field Appraisal; Integrated Geology Workshop; Sequence Stratigraphy.

Recommended Books:

- Bjørlykke, K. (2015). *Petroleum Geosciences: From sedimentary Environments to Rock Physics*. Springer-Verlag Berlin Heidelberg.
- Selley, R. C., & Sonnenberg, S. A. (2014). *Elements of petroleum geology*. Academic Press.
- Gluyas, J., & Swarbrick, R. (2013). *Petroleum geoscience*. John Wiley & Sons.
- Zou, C. (2017). *Unconventional petroleum geology*. Elsevier.
- Chapman, R. E. (2000). *Petroleum geology* (Vol. 16). Elsevier.
- North, F.K. (1985). *Petroleum geology*. Springer.

uu. ESC 701 Advanced Research Methodology

Course Contents:

Research paradigms; techniques and pre-requisites of scientific research; research concept development; critical thinking and developing of research question; writing research proposal and its importance for acquisition of funds/grants from various agencies; the logic of sampling; sampling design; experimental work to address relevant analytical techniques; analytical data handling and presentation skills; relevant software utilization; thesis writing; paper review technique; techniques of research paper publication in journals of repute

Recommended Books:

- How to Research, L. Blaxter, C. Hughes, M. Tight, 4th Edition, 2010.
- Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Publisher: SAGE,3rd Edition, 2010
- Wayne C. Booth, Gregory G. Colombo, Joseph M. Williams, 2008, The Craft of Research (Chicago Guides to Writing, Editing, and Publishing). University Of Chicago Press , 336
- Creswell, J.W, 2006, Designing and Conducting Mixed Methods Research. Sage Publications (CA). 275
- Research Methodologies – A step by step guide for beginners, Ranjit Kumar, 2005.
- Dawson, C. 2002, Practical Research Methods, A user-friendly guide to mastering research. Cromwell Press, Trowbridge, Wiltshire. 169
- William R. Shadish, Thomas D. Cook, Donald T. Campbell, 2001, Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Houghton Mifflin. 623

vv. GEO 872 Advanced Electrical Methods

Course Contents:

Basic principal and theory of Electrical Resistivity method . Fundamentals of current flow in the Earth. Electric potentials and fields. Static charge distributions. Resistivity Imaging study its survey designing for Geophysical Electrical Exploration. Field procedures including Instruments and electrode arrangements. Processing and interpretation of resistivity data. Its limitations, advantages and disadvantages. Basic principal and theory of Induced polarization method its field procedure, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Self potential method its field procedure, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Electromagnetic method including Telluric Method and Magneto telluric Method, survey designing, data acquisition, interpretation, limitations, advantages and disadvantages. Basic principal and theory of Charge body potential Method Mise A La Masse method and its applications. Study of case histories of all electrical methods.

Recommended Books:

- Kaufman, A. A., Alekseev, D., & Oristaglio, M. (2014). *Principles of electromagnetic methods in surface geophysics*. Newnes.
- Fitch, A. A. (Ed.). (2012). *Developments in Geophysical Exploration Methods—3*. Springer Science & Business Media.
- Fitch, A. A. (Ed.). (2012). *Developments in Geophysical Exploration Methods—3*. Springer Science & Business Media.
- Kaufman, A. A., & Anderson, B. (2010). *Principles of electric methods in surface and borehole geophysics*. Elsevier.
- Yungul, S. H. (1996). *Electrical methods in geophysical exploration of deep sedimentary basins*. Springer.

Appendage 1714

CONTENTS

Preamble

These Rules called "BS Thesis Rules" shall apply to all BS degree programmes conducted in the Earth and Environmental Sciences Department of Bahria University (BU). These Rules shall be read in conjunction with the general rules/regulations of the University. In matters where these rules are silent, rules/regulations and procedures of BU shall apply. In case of any doubt regarding the interpretation of these Rules and in matters not clearly covered under these and other rules/regulations of BU, the matter shall be referred to the BS Thesis Committee and/ or DBOS for the final decision. Furthermore, BS requirements set out by the HEC from time to time shall be complied with, and shall take precedence over these Rules should there be a conflict.

Thesis/Project/Research Coordinator

2.1 Cluster Head for each programme (Geology, Geophysics and Environmental Sciences) of the Department, whose appointment based on the recommendations of the HOD shall be the Thesis/Project/Research Coordinator.

2.2 **Terms of Reference of Thesis/Project/Research Coordinator**

a. Ensure that BS Thesis/Project Rules are being followed by the Department.

b. Maintain complete record of Thesis/Project students undergoing BS programmes including:

   (1) Collection of BS *Thesis/Project **groups/individual forms on the prescribed format (BS-1A/ BS-1B).

   (2) Record of BS Thesis/Project proposals on prescribed format (BS-2).

   (3) Record of the allocated supervisors, internal and external examiners.

   (4) Record of Thesis/Project Evaluation both by Internal and External Examiner on the prescribed format (BS-7A).

c. Allocation of Supervisors after approval from the competent authority (DRC).

d. Appointment of Internal and External Examiners.

e. Arrangements for conducting the final defense.

f. Maintain a close working relation with supervisors and Data Coordinator for overall monitoring of BS Programmes.

** Thesis for BS Geology and Geophysics and Project for BS Environmental Sciences*

***For BUIC, only Thesis Group is applicable. In case of any unusual circumstances, Individual student can be allowed with prior approval from HOD. For BUKC, Thesis Group and Individual both are applicable*

Data Coordinator

3.1 Data Coordinator whose appointment based on the recommendations of the HOD, shall be responsible for the issuance, monitoring and collection of Public Domain Data (seismic and log data) for Geology and Geophysics programmes (both BS and MS) and also in case of Environmental Sciences if any kind of public domain data is required for the Thesis/Project.

3.2 **Terms of Reference of Data Coordinator**

a. Ensure that BS Thesis/Project Rules regarding issuance of Public Domain Data are being followed by the Department.
b. Allocation of data required for the thesis and make sure that different areas should be assigned to the students of same batch.
c. If the area/data for the thesis has been changed due to any constraint, reallocation of data after the consent of supervisor.
d. Collection of the issued Public Domain data from the students for the Data Repository of Department.
e. Maintain complete data record of undergoing both BS and MS programmes including:
   (1) Record of BS Thesis/Project groups along with the allocated data/area.
   (2) Collection and record of Public Domain data from the students before final defense in hard/soft form.
f. Maintain a close working relation with the Supervisors and Thesis/Project/Research Coordinator for overall monitoring of BS Programmes.

Supervisors

4.1 Detail of the Thesis/Project groups along with the field of interest will be collected by the Thesis/Project/Research Coordinator and the Principal Supervisor and Co-Supervisor (if needed) shall be appointed by the BS Thesis Committee with the consent of supervisors for each BS Thesis/Project group. The Principal Supervisor shall be a permanent faculty member in the relevant field holding a MS/MPhil degree. The HOD shall issue letter of appointment to the Principal Supervisor and the Co-supervisor on the prescribed format (BS-3 and BS-4 respectively). Documentation Procedure including BS-1, BS-2, BS-3, BS-4 and BS-5 forms shall be completed by the end of 7th semester.

4.2 If the Principal Supervisor is not available temporarily, the Co-Supervisor, or the Head of Department (HOD), may act as a Principal Supervisor. The supervisory remuneration shall be divided between the Principal Supervisor and the Co-Supervisor in the ratio of 2:1.

4.3 Students will be informed by the Thesis/Project/Research Coordinator about their allocated supervisors and they will have to submit the Thesis/Project Proposal after consultation with their allocated supervisor. The Principal Supervisor/Co-Supervisor shall not be changed except under extraordinary circumstances. In case of a serious problem between a student and the Principal Supervisor, the student may request the HOD to change the Principal Supervisor. The HOD shall investigate the matter through Thesis/Project/Research Coordinator and bring it before the BS Thesis Committee. The BS Thesis Committee shall take the final decision on the matter.

4.4 A supervisor shall be assigned 3 to 4 BS Thesis/Project groups/individuals.

Thesis/Project Proposal

5.1 Students shall start the documentation procedure as mentioned in section 4.1 in the 7th semester. The student shall submit Thesis/Project proposal to the Thesis/Project/Research Coordinator, within two weeks of allocation of supervisor.

5.2 The Thesis/Project proposal shall be submitted as per prescribed format (BS-2).

5.3 Students of BS programs are not allowed to use Digital Data (SEGY or LAS format). Students of BS Geology and Environmental Sciences are not allowed to do Thesis/Project on seismic data because they have not studied relevant course in their degree program.
5.4 The Public Domain data required for thesis should be allocated by Data Coordinator only (Geology and Geophysics students). It will be the responsibility of Data Coordinator to make sure that different areas should be assigned to the groups of same batch. Data Coordinator should also make sure that the data should not be repeated for two consecutive batches.
5.5 Depending upon the availability of the data set, each group will be allowed a maximum of 5 seismic lines with 1 well. If students are working only on well data and not using seismic data then maximum 2 wells shall be allowed.
5.6 If the area/data/supervisor for the thesis has been changed due to any constraint, the revised proposal form has to be submitted after the consent of relative person (Data Coordinator/Supervisor).
5.7 After approval of the Thesis/Project proposal, the student shall prepare Stamp paper in their name on the prescribed format (BS-5) listing the detail of Public Domain data. The Department shall issue the letter for data in the name of DGPC.
5.8 Once the data has been issued by LMKR, the student shall have to submit the data to Data Coordinator. Final thesis defense will not be conducted if data has not been submitted.

Thesis/Project Examiners

6.1 Thesis/Project shall be evaluated by two Examiners, internal and external. Internal Examiner shall be drawn from the faculty whereas the External Examiner shall be appointed from the list of External Examiners approved by BS Thesis Committee.
6.2 The Thesis/Project/Research Coordinator, in consultation with the Principal Supervisor, shall recommend names for Internal and External Examiners, after having secured their consent, to the BS Thesis Committee for approval. Identity of the Evaluators shall be kept confidential from the student.
6.3 All communication with the Evaluators shall be carried out by the Thesis/Project/Research Coordinator

Thesis/Project Evaluation and Submission Requirements

7.1 The Thesis/Project shall be developed on the prescribed format (Annex-A).

7.2 Thesis/Project Completion Certificate (BS-6A) by the Principal Supervisor shall be placed at the outset of the thesis.

7.3 The student shall submit one spiral bound hard copy of the thesis and one digital copy (CD) to the Thesis/Project/Research Coordinator along with the plagiarism report (less than 20%). The Thesis/Project/Research Coordinator shall forward one spiral bound hard copy of the thesis to the Internal Examiner for evaluation.

7.4 Internal Examiner will be given a maximum of 2 weeks for Thesis/Project evaluation. The students have to make all the corrections suggested by the Internal Examiner. Internal Examiner shall submit Thesis/Project Completion Certificate (BS-6B) after making sure that all the suggested corrections have been made by the students before the final defence.

7.5 Thesis/Project/Research Coordinator shall submit the hard copy of the thesis to the External Examiner before the final defence.

7.6 After successful Thesis/Project evaluation and defence, the student shall submit three hardbound copies and a CD containing the digital copy of thesis to the HOD who will forward one copy each to the Exam Directorates and the Campus library for record. Third copy will be submitted to DGPC (Geophysics and Geology programmes) if the students have used Public Domain data in their thesis, otherwise only two copies shall be submitted.

Thesis/Project Defence & Viva Voce Examination

8.1 Thesis/Project/Research Coordinator with the consent of HOD shall announce and circulate the schedule of the thesis defence and make necessary arrangements.

8.2 The Thesis/Project defence shall be in the form of a multimedia presentation by the students, followed by a Viva Voce Examination/QA session before the Examiners and interested Faculty members. The two may be held on the same day or the latter may be deferred after mutual consent.

8.3 The Principal Supervisor/Co-Supervisor shall remain present throughout the Thesis/Project defence. The presentation part of the Thesis/Project defence shall be open to all those interested, but the Viva voce Examination shall be conducted by the Examiners (FM's if any) in the presence of the Principal/Co-supervisor. Head of the BS Thesis Committee or the HOD may also remain present if necessary.

8.4 The Examiners shall evaluate the Thesis/Project defence of the student on the Thesis/Project Defence Evaluation Report Form (BS-7A) against the following assessment weightage having 80% marks:

a.	Thesis write-up and its quality:	40%
b.	Presentation of work:	20%
c.	Viva Voce Examination:	20%

8.5 Remaining 20% marks with be given by the Supervisor. The final result of BS Thesis/Project will be submitted by adding the average marks of the Internal and External Examiners (out of 80% marks) and marks by the Supervisor (out of 20% marks) on the prescribed format (BS-7B)
8.6 To be able to pass the Thesis/Project defence, the student must obtain at least 50% (out of 100%) marks in order to get the Thesis/Project "Approved". If the student gets less than 50% marks, the Thesis/Project shall be considered as "Not Approved"
8.7 The Thesis/Project defence evaluation reports shall be received by the Thesis/Project/Research Coordinator who shall pass them over for onward submission to the Examination Department under information and copy to the HOD.

BS-1A
Thesis Group/Individual Form*
BS Geology/Geophysics
Session _____

S#	Enrollment #	Name	Signature

Field of Study: _____

Geology/Geophysics

1. Seismic
2. Petrophysics
3. Resistivity
4. Structural Geology
5. Engineering Geology
6. Petrography
7. Petroleum Geology
8. Earthquake Seismology
9. Stratigraphy
10. Basin Analysis
11. Mineralogy
12. Petrology
13. Hydrogeology
14. GIS

Any other_____

For Official Use

Allocated Supervisor's Name: _____

Allocated Supervisor's Signature: _____

Thesis/Project/Research Coordinator's Signature: _____

Date: _____

_____
(Head of Department)

Distribution:
1. Thesis/Project/Research Coordinator 2. Data Coordinator
3. Scholar's Copy

*For BUIC, only Thesis/Project Group is applicable. In case of any unusual circumstances, Individual student can be allowed with prior approval from HOD
For BUKC, Thesis/Project Group and Individual both are applicable

BS-1B
Project Group/Individual Form*
BS Environmental Sciences
Session _____

S#	Enrollment #	Name	Signature

Field of Study: _____

Environmental Sciences

1. Environmental Policies & Laws
2. Environmental Management
3. Global Warming/Climate Change
4. Environmental Risk Assessment
5. Sustainable Development
6. Environmental Analytical Techniques
7. Heath Safety & Environment
8. Energy and Management
9. Environmental Sociology
10. Environmental Pollution
11. Solid Waste Management
12. Environmental Issues
13. Disaster Management
14. Project Management
15. Alternate Energy
16. Hydrology
17. EIA
18. NRM
19. GIS

Any other_____

For Official Use

Allocated Supervisor's Name: _____

Allocated Supervisor's Signature: _____

Thesis/Project/Research Coordinator's Signature: _____

Date: _____

_____
(Head of Department)

Distribution:
1. Thesis/Project/Research Coordinator 2. Data Coordinator
3. Scholar's Copy

*For BUIC, only Thesis/Project Group is applicable. In case of any unusual circumstances, ~~Individual student can be allowed with prior approval from HOD~~
For BUKC, Thesis/Project Group and Individual both are applicable

BS-2

Thesis/Project Proposal Form
BS _____
Session _____

S#	Enrollment #	Name	Signatur[e

Thesis Title: _____

_____

Study Area

Objectives

Methodology

Data

Expected Outcomes

For Official Use

Supervisor:

_____ _____
Name Signature

Co-Supervisor:

_____ _____
Name Signature

Data Coordinator:

_____ _____
Name Signature

Thesis/Project/Research Coordinator:

_____ _____
Signature Date:

Head of Department:

_____ _____
Signature Date:

Date of Approval: _____

BS-3

Appointment of Principal Supervisor

Name: _____

Designation: _____

Department & Campus: _____

Dear Sir/Madam,

The Department of Earth and Environmental Sciences, Bahria University _____ Campus is pleased to appoint you as the Principal Supervisor for the following students of BS _____ programme:

S#	Enrollment #	Name

You are requested to submit the Thesis/Project Proposal of the above mentioned students on BS-2 Form within 2 weeks from the date of this letter. In case of use of Public Domain data, you shall contact the Data Coordinator for issuance of data. Please follow the BS Thesis/Project Rules of E&ES Department for conducting and completion of thesis. Your presence at the time of Thesis/Project Defense is mandatory. To acknowledge your contribution, you will be paid remuneration as per BU policy for supervision of Research Work.

Date: _____

_____
(Head of Department)

Distribution:

1. Supervisor's Copy
2. Thesis/Project/Research Coordinator

BS-4

Appointment of Co-Supervisor

Name: _____

Designation: _____

Affiliation: _____

Dear Sir/Madam,

The Department of Earth and Environmental Sciences, Bahria University _____ Campus is pleased to appoint you as the Co-Supervisor for the following students of BS _____ programme:

S#	Enrollment #	Name

During the period of Thesis/Project work, you are requested to guide the students in consultation with the Principal Supervisor. To acknowledge your contribution, you will be paid remuneration as per BU policy for supervision of Thesis/Project. We hope our students will greatly benefit from your valuable research experience towards completing their research work in time.

Date: _____

_____
(Head of Department)

Distribution:

1. Co-Supervisor's Copy
2. Thesis/Project/Research Coordinator

BS-5
Template for Stamp Paper

Undertaking

We, *(Name & Enrollment # of Students)* students of BS *(Program)* are doing our Thesis/Project on *(Thesis Title)*, in the Department of Earth and Environmental Sciences, Bahria University _____ Campus. We require the following data to complete our thesis.

Well and Seismic Data
We need log data of *(Name of well)* well and seismic data of *(Names of seismic lines)* lines (hard and soft copies).
Complete log suit i.e. GR, SGR, SP, Neutron, Density, Sonic, Resistivity, Bit Size and Caliper.

The following undertaking has been given in this regard.

1. Data will be used for the intended purpose only and will not be disclosed to any other third party without the prior approval of DGPC.
2. A copy if the dissertation will be provided to DGPC free of cost.
3. There will be no commercial use of the data.

_____ _____

Data Coordinator **Head of Department**

Dated:

BS-6A
Thesis/Project Completion Certificate
Principal Supervisor

S#	Enrollment #	Name

Thesis Title: _____

_____

It is to certify that the above student's Thesis/Project of BS _____ programme has been completed to my satisfaction and to my belief, its standard is appropriate for submission for Evaluation. I have also found the Thesis/Project in a format recognized by the Department of Earth and Environmental Sciences for the BS thesis.

Principal Supervisor's Signature:_____

Date: _____ **Name:** _____

BS-6B
Thesis/Project Completion Certificate
Internal Examiner

S#	Enrollment #	Name

Thesis Title: _____

_____

It is to certify that the above student's Thesis/Project of BS _____ programme has been completed to my satisfaction and to my belief, its standard is appropriate for submission for Evaluation. I have also found the Thesis/Project in a format recognized by the Department of Earth and Environmental Sciences for the BS thesis.

Internal Examiner's Signature: _____

Date: _____ **Name:** _____

BS-7A

BS Thesis/Project Defense & Viva Voce Evaluation

(To be completed by the Department)

Date of Defence: _____

S#	Enrollment #	Name

Thesis Title: _____

_____

Examiner (Internal/External)

(to be completed by the Examiner)

Name of Examiner:

Faculty/Department:

Affiliation

Evaluation

Parameter	Weightage	Marks Awarded
Thesis Write-up and its quality	40	
Presentation	20	
Viva voce Examination	20	
Total	80	

Signature of Examiner: _____ Date: _____

BS-7B

BS Thesis/Project Defense & Viva Voce Evaluation

(To be completed by the Department)

Consolidated Result

*Date of Defence:*_____

Student Name **Enrollment #** **Programme**

Thesis Title: _____

_____

Evaluation of Examiners

Examiner	Name	Marks Allocated	Marks Awarded
Internal		80	
External		80	
		Average Marks	

Supervisor

Supervisor Name	Marks Allocated	Marks Awarded
	20	

Average Marks Awarded by Examiners	Marks Awarded by Supervisor	Total Marks

Grade:

_____ _____

(Data Coordinator) **(Head of Department)**

Date: _____ Date: _____

Annexure-A

Format of Thesis/Project

1. Layout of Thesis/Project

Thesis/Project should be submitted in English, on single sided A4 papers; normally with a 12 point font; 1.5 line spacing (paragraph before and after spacing 0 pt); with a margin of 1 inch on top, bottom and right side whereas 1.5 inch margin on left side of every page for binding; explanatory footnotes should stand at the foot of the relevant pages; and the bibliography should follow the text and any appendices. The font used should Times New Roman. Sequence of the format should be as follows:

Sections of Thesis/Project	Assigned Page Numbering
PRELIMINARY SECTION *Headings in All Caps*	
Inside Title	Without page numbers
Certificate	
Dedication	
Abstract	Page Numbers in Roman Centralized at the bottom of the Page
Acknowledgements	
Contents	
Figures	
Tables	
Abbreviations	
THE MAIN TEXT	
The main Body of the Thesis/Project shall include • Introduction • Objective of Research/Study • Materials and Methods • Methodology and basic assumption/ framework • Results/Discussions • Conclusions	Page numbers in Numeric Centralized at the bottom of the Page
SUPPLYMEMTARY SECTIONS/END MATTER	
References	Page numbers in Numeric Centralized at the bottom of the Page
Appendices (as per requirement) • Results of software (if required) • Questionnaire • Archival Resources Utilized (if any) • Official Documents Used (if any)	

2. Title of Thesis/Project

The title of Thesis/Project should have a font of size 16 and font style of upper case, Times New Roman, centralized and bold. The monogram of Bahria University should have square dimensions of 2×2 inches and centralized (Sample given).

STRUCTURAL INTERPRETATION OF ZAMZAMA BLOCK, LOWER INDUS BASIN, PAKISTAN

(Font size 16, Bold, All Caps, Centralized)

(Centralized and 2x2 inch)

By

Student Full Name
Student Full Name
Student Full Name
(in Alphabetical Order)

(Line spacing 1.15 for the Title page
Adjust in between spaces accordingly so that the Title starts from the first line of the page and session should be at the last line of the page)

Department of Earth and Environmental Sciences
Bahria University, Islamabad, Pakistan

2018 *(Ending year of session e.g 2016-2018)*

STRUCTURAL INTERPRETATION OF ZAMZAMA BLOCK, LOWER INDUS BASIN, PAKISTAN

(Font size 16, Bold, All Caps, Centralized)

(Centralized and 2x2 inch)

A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement for the degree of B.S in Geophysics

(Font size 14, un-bold, Centralized)

Student Full Name
Student Full Name
Student Full Name

(in Alphabetical Order)

(Line spacing 1.15 for the Title page
Adjust in between spaces accordingly so that the Title starts from the first line of the page and session should be at the last line of the page)

Department of Earth and Environmental Sciences
Bahria University, Islamabad, Pakistan

2018 *(Ending year of session e.g 2016-2018)*

3. Spine of Thesis/Project

The spine of Thesis/Project should be written in bold uppercase with a font size of 14. The following pattern may be followed:

BS/MS (Geology/Geophysics/Environmental Sciences) Name Session
For example

BS GEOLOGY AHMED HARIS QASIM 2011
MS GEOLOGY AHMED ALI 2011

4. Thesis/Project Script

A4 size paper, 80 grams paper should be utilized.

(a) Font style

Times New Roman (It is mandatory to use this type script throughout the Thesis/Project) and line spacing of 1.5 for the text only. Paragraph before and after spacing should be kept at 0 pt.

(b) Font size

Title/chapter headings centralized, 12, Bold and Upper Case.

Example

CHAPTER 1
INTRODUCTION

Separators are not allowed.
Headings 12 Bold and Sentence Case
All Sub headings 12 Bold
Sub-sub headings 12 Bold

i. Only fist letter of the Proper nouns is to be capitalized.
ii. If heading is comprised of two or more than two words, only first letter of the first word is to be capitalized

Example
Geological assessment
Environmental hazards

The numbered bullets are allowed after this heading such as (1) (2)…., (a) (b)….., (i) (ii)….. In parentheses only.
General Text 12 Normal

5. Indentation and Spacing

Every paragraph should have a starting tab of 0.5 inches. The general spacing for the whole text is 1.5. However a new heading, bulleted/numbered topics after a paragraph should have a spacing of 1 enter that is more than the 1.5.

Example

The minerals are having different properties and may be used for different purpose such as medicines, ornamentation, building stones etc

3.1 Building stones

The building stones consist of

……

……

……..

6. Margins

The left margin should be of 1.5" and rest of the margins of 1' (Right-top-bottom).

7. Page Numbers

The page numbers should be located at the bottom, center of the page of 12 size.

8. Captions (Figures and Tables)

The font size should be 10, Times New Roman, single spaced, left aligned and at the top and bottom of the table and figure respectively. The figure in the text within a sentence should be mentioned as figure 1.1 and without mentioning in text should be referred as (Fig. 1). The table in the text within a sentence should be mentioned as table 1.1 and without mentioning in the text should be referred as (Table 1.1).

A new paragraph starting below the figure captions should have a spacing of 1 enter that is more than the 1.5. Figures should not be stretched in any case. Photographs should be of uniform dimensions. All the figures and tables used should be discussed properly in the text.

Example

Figure 1.1. A conceptual model of the tectonic boundaries of the pacific.

9. Color of Binding

BS: Dark blue with silver writing
MS: Black with Golden writing

10. References

A uniform style for the references is adopted where first line is left aligned and from 2nd line indentation of 0.25 as mentioned below:

For journals

Qadir, A., Javed, A., Saqib, M.A. and Khan, T., 1990. The tectonic evolution of the Islamabad hydrostratigraphy. Journal of Petrology 13, no.1, 23-41.

Books

Leverson, A.I., 1995. Geology of Petroleum, Springer publisher, London. 724p.

Proceedings

Qadir, A., Javed, A., Saqib, M.A. and Khan, T., 1990. The tectonic evolution of the Islamabad hydrostratigraphy. Journal of Petrology, 13, no.1, 23-41. In: Qadir, A. and Javed, A. eds. Geology and the tectonics of Pakistan.

Citation

For citation of references in the text the format followed should be as follows

(Qadir, 1999) Single author
(Qadir and Javed, 1999) Two authors
(Qadir et al., 1999) More than two authors
Qadir et al. (1999) during discussion in the text

Example

"The Jaglot group occurs as septum within the Kohistan batholith and has been considered to represent rock assemblages of back-arc basin origin (Fig. 3) (Khan et al., 1994; Treloar et al., 1996). The group includes Thelichi formation, Gashu-confluence volcanics (GCV) and the Gilgit formation (Khan et al., 1994). The exact age of the Jaglot group is not known, however, mid Jurassic to Cretaceous is suggested on the basis of Rhabdophyllian fauna found in limestone from Kalam area (Bender and Raza, 1995).

The volcanic rocks run from Hunza in the east to Chitral in the west along northern margin of the arc (Tahirkheli, 1982; Coward et al., 1986; Pudsey, 1986). Treloar et al. (1996) divided the northern Kohistan paleo- arc volcanic rocks into Cretaceous Chalt volcanics including the Yasin volcanics and Eocene Shamran volcanics. These volcanic rocks range from basalt to rhyolite in composition with varying grade of metamorphism.

The Chalt and the Yasin groups are considered to be Albian-Aptian in age (Tahirkheli 1982; Petterson et al., 1990; Khan et al., 1996; Treloar et al., 1996). On the other hand, the Shamran and Teru volcanics yield Ar-Ar hornblende age of 58 ± 1 Ma and 61 Ma U-Pb age respectively (Treloar et al., 1989; Khan et al., 2009)."

Appendage 1715

Earth and Environmental Sciences

Vision

To become an advanced research oriented institution in the field of Earth and Environmental Sciences at par with the international standards.

Mission

To enable the graduates to meet the challenges in exploring natural resources, identifying national issues and finding mitigations of hazards, and increasing public awareness in protecting the natural environment.

Appendage 1719

HOD E & ES, Karachi Campus

Revised Objectives of BS Geophysics Program

Following objectives were discussed and amended.

1. To gain basic knowledge and conceptual aspects of Geophysics and exploration methods.
2. To familiarize the students with applied geosciences fields for the exploration of hydrocarbons, minerals, ground water and other natural resources
3. To educate the students to carry out independent research
4. To develop effective technical / professional communication and presentation skills making them able to secure admission in the well-reputed institutions of the world in order to pursue higher studies.
5. To train the geophysicists to meet emerging industrial demands in term of skills, software's & work ethics.

Revised Outcomes of BS Geophysics Program

Following outcomes were discussed and amended.

1. Understand core concepts and applications of Geophysics.
2. Ability to identify and study the national exploration issues.
3. Make individuals to observe, record, and interpret the model by processing the

subsurface uncertainties.

4. Effectively communicate and present their scientific knowledge and applied research at national and international forums.
5. Cope up with the relevant industrial demands and strengthen the out-source linkages.

Revised Objectives of BS Environmental Sciences Program

1. To gain basic conceptual knowledge of Environmental Sciences.
2. To apply the best environmental assessment practices, quantification and sustainable development of natural resources and hazards mitigations.
3. To develop effective technical / professional communication and presentation skills.
4. To establish a strong linkage between relevant industries, academic institutions and research organizations.
5. To prepare young environmentalists as per of international education standards and professionals as per Quality, Health, Safety, Environment (QHSE) standards.

Revised Outcomes of BS Environmental Sciences Program

1. Ability to identify national environmental issues and quantitatively propose the environmental solution.
2. Make individuals to observe, record, and interpret/model the environment related data sets by lab work.
3. Effectively communicate and present their scientific knowledge and applied research at national and international forums.
4. Cope up with the relevant industrial demands and strengthen the out-source linkages.
5. Perform professional and ethical responsibilities with true spirit.

Elaboration of Mapping of University Vision, Program Mission and PEOs

The University Vision, Program Mission and PEOs mapping is given in the table below. Moreover, the mapping rationales is provided for clear insight and justification.

Program Educational Objectives	University Vision	Program Mission
PEO - 1	✓	✓
PEO - 2	✓	✓
PEO - 3	✓	✓
PEO - 4	✓	✓

Vision of Bahria University: To become an internationally recognized university that contributes towards the development of nation through excellence in education and research.

Program Mission: The mission of Bachelor of Computer Engineering program is to produce ethically sound and technically competent graduates who can fulfill the evolving needs of academia, industry and society.

Rationale Statement:
The mission of BCE program is derived from the vision of the Bahria University. The program mission looks like a subset of University vision. It caters the important aspects of university vision such as excellence in education and research, society needs by producing competent graduates who work for the betterment of society nationally/internationally.

To successfully accomplish the program mission, following program educational objectives defined and approved in 31st ACM. These PEOs shall also be aligned to university vision.

PEO 1: Attain an ability to identify and solve challenging problems in their professions by applying theory, principles and modern tools learnt during degree program.

PEO 2: Demonstrate effective communication as an individual or team player with strong managerial and entrepreneurial skills.

PEO 3: Maintain highest ethical and professional standards in pursuing their careers.

PEO 4: Engage in life-long learning to continually polish their professional capabilities for their personal growth and the betterment of society.

Rationale Statement:
The PEOs reflect professional aptitude (PEO-1), Interpersonal skills (PEO-2), Engineer and Society (PEO-3) and Personal/Societal Growth (PEO-4). All these objectives are broadly reflected in Program mission and university vision.