Minutes of the 28th Meeting of the Board of Studies Faculty of Engineering Sciences held on 23-24th February 2023 through VLC

Bahria University Islamabad

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Minutes of the 28th Meeting of Faculty Board of Studies Engineering Sciences held on 23-24th Feb, 2023 through Video Conferencing

Attendance:

BUIC		
Snr. Prof. Dr. Atif Raza Jafri	Dean ES	Chair
Snr. Assoc. Prof. Dr. Said Akbar Khan	HoD(E&ES)	Member
Snr. Assoc. Prof. Dr. Arif ur Rehman	HoD(CS)	Member
Snr. Assoc. Prof. Dr. Awais Majeed	HoD(SE)	Member
Assoc. Prof. Dr. Shahzad Ahmed	HoD(CE)	Member
Assoc. Prof. Dr. Junaid Imtiaz	HoD(EE)	Member
BUKC		
Assoc. Prof. Dr. Mukesh Kumar Maheshwari	HoD(EE)	Member
Assoc. Prof. Dr. Salma Hamza	HoD(E&ES)	Member
Assoc. Prof. Dr. Syed Safdar Ali	HoD(CS)	Member
Snr. Assoc. Prof. Dr. Sohaib Ahmad	Associate Dean	Member
Snr. Asst. Prof. Dr. Shoaib Mughal	HoD(CE)	Member
Snr. Assoc. Prof. Dr. Osama Rehman	HoD(SE)	Member
BULC		
Snr. Asst. Prof. Dr. Khawaja Qasim Maqbool	HOD(CS)	Member

Proceedings

Preliminaries

FBoS-ES meeting took place on 23-24th February 2023, with the quorum complete, the proceedings commenced at 0930 hrs, with recitation from the Holy Quran.

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

New Items:

Item2801: Printing of PLO Attainments on BU Transcript
Sponsor: HoD (EE) BUKC Referral Authority: DBOS EE BUKC

Summary of the Case

- As per PEC observation, the PLO attainment should be printed on the back of transcript. The attainment of PLOs can be printed in two possible options.
  - PLO attainment chart with PLOs table
  - PLO attainment in percentage
- Proposed PLO attainment chart, Table and placement on transcript are attached as appendage 2801-A.

Discussion

- The sponsor presented the agenda point. The house had a detailed discussion about whether PLO attainments should be printed on the back of the BU official transcript or not. After thorough discussion and deliberation, the house suggested that PLO attainments should be issued to students on a separate certificate instead of the BU official transcript, as the students are being taught in an OBE-based system. Since PEC has not made it compulsory and students going abroad may require this attainment, a separate certificate may be issued by the exam directorate of the campus. The proposed certificate is attached at appendage appendage 2801-B recommended by the FBOS.

Decision 2801
The case to be forwarded for the approval in ACM.

Item 2802: Revision of Electrical Engineering PEOs
Sponsor: HOD (EE) BUKC Referral Authority: DBOS EE BUKC

Summary of the Case

- As per PEC observation during visit on 27th and 28th December 2021 and departmental MOCK audit suggestion, the PEOs of electrical engineering department need improvement. The PEVs have shown their concern in the evaluation report as:
  - "PEO Statement is not suitable/ repetition of PLOs. Few words "skillful employable graduates" in PEO 2 should be improved. PEO 1 and 2 are somehow overlapping. Minor wording correction in PEO 3 is suggested".

Discussion
The sponsor presented the agenda point, after detailed discussion and deliberation the house suggested few amendments in the proposed PEO wordings. The improved PEOs after discussion in FBOS meeting are attached as appendage 2802.

Decision 2802
The case to be forwarded for the approval in ACM.

Item 2803: Addition of New stream (Robotics and Intelligent systems) in BEE Program
Sponsor: HoD (EE) BUKC Referral Authority: DBOS EE BUKC

Summary of the Case

- Robotics has become an emerging field in the domain of Electrical Engineering. Current market trends and requirement of automation demands specialization in the field of Robotics and Intelligent systems.
- It is recommended to include a new stream "Robotics and Intelligent Systems" as specialization along-with Electronics, Power, and Telecom in Bachelor of Electrical Engineering.
- Proposed curriculum of BEE with "Robotics and Intelligent Systems" stream is attached as appendage 2803.

Discussion:

- The sponsor presented the agenda point, and a detailed discussion was conducted on the agenda. The addition of new stream required approval from PEC. The house discussed the proposed curriculum attached at appendage 2803, a serious concern was shown by the house on the course and lab outlines and availability of related lab facilities.
- Since the suggested work is in its raw state, the house suggested forming a four-person committee under the supervision of the HOD EE, BUKC, to further examine the proposal. The committee will be responsible for designating course and lab teachers who will develop detailed course and lab outlines. Additionally, the committee will benchmark with international universities to ensure that the proposed curriculum meets global standards.

Decision 2803:
Progress to be reported at 29th FBOS.

Item 2804: New Programme Proposal – BS (Power & Energy)
Sponsor: HOD (EE) BUKC — Referral Authority: DBOS EE BUKC

Summary of the Case

- A new program with the name of BS (Power & Energy) is proposed. The academic detail, financial analysis, programme viability and curriculum are attached as appendage 2804.

Discussion

The sponsor iterated and presented the agenda item, which was deliberated by the house in detail. During the discussion, the house raised a concern about the accreditation of the proposed program by PEC or HEC. It was suggested that more effort is required to develop course codes and benchmark the suggested program against global standards. Additionally, the house expressed a major concern regarding students' placement in the industry after graduation. It was suggested that a technology-based program, similar to Power and Energy, can be considered, which may be accredited by the relevant technology board. The HOD EE, BUKC, will present a viable technology-based program if the necessary resources are available.

Decision 2804
Point dropped.

Item 2805 Benchmarking of BU EE roadmap
Sponsor: HOD EE BUIC — Referral Authority: DBOS EE BUIC

Summary of the Case

- EE department follows the practice of benchmarking roadmap with internationally recognized local universities i.e., NUST and FAST.
- Summary of the benchmarking analysis of the BEE roadmap is as follows:

Bahria University	FAST	NUST
ITC is not being taught in any other roadmap.	Teaches one less HSS course in 8th semester	LA and ODE are combined in one course
We lack a mathematics course in 3rd semester	Data structures and algorithms is a compulsory course in their outline	Concept of university elective is part of roadmap
I & M is missing in our road map		TRW is taught in 4th semester
Multivariable calculus and NA both should be the part of road map		

- In addition to comparison given in above table, NUST offers specializations via electives from following domains:

1. Computer Engineering
2. Control Engineering
3. RF and Microwave Engineering
4. Power Engineering
5. Electronics Engineering

- As per PEC website, NUST's approved degree titles are
    a. Bachelor of Engineering in Electrical
    b. B.E. Electrical (Telecommunication)
    c. B.E. Electrical
    d. Bachelor of Science (B.S.) in Electrical Engineering
- Similarly, the Department of Electrical Engineering FAST-LHR offers specialized programs in new and innovative fields. These programs are as follows:
    1. BS (Robotics)
    2. BS (Internet of Things)
- As per PEC website, FAST's approved degree titles are
    a. Bachelor of Science (B.S.) in Electrical Engineering
    b. Bachelor of Science (B.S) in Electrical (Electronics/Telecommunication/Computer) Engineering
- In the light of above stated data, it will be beneficial for the department
    a. To add new domains in the BEE road map.
    b. Offer a variety of elective courses each year from the approved list of courses.
- The DBOS EE has approved the inclusion of a new domain in BEE i.e., AI & Robotics
- The proposed changes in BEE 2018 roadmap for this are attached as appendage 2805.

Discussion

The sponsor presented the agenda point which was deliberated in detail by the house. The house proposed a two-stage strategy. As the AI relevance is quite promising in Telecom and electronics, so in the first stage, relevant courses would be prepared and added as electives to existing specializations. Simultaneously, an application would be submitted to PEC for a new stream.

Decision 2805

Point dropped.

Item 2806: Changing marks distribution of midterm and final term for better learning and assessment.

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

Summary of the Case

- Traditionally midterm examination consists of 20 marks and final term examination of 50 marks, which are fixed for all courses in Engineering and other domains.
- In some courses like courses of Hardware Technical Subject and Soft skills domain, 70% assessment on paper don't justify students understanding of that course.
- After International accreditation learning domain i.e. cognitive, psychomotor and affective are made a must and integral part of the assessment methods. Assessing the learning methods via fixed assessment method is not possible
- A floating marks distribution based on CLOs can adopted but it might lead to complex implementation. Other way around to also adopt flexible weightages mechanism for mid and final only. Thus, result in increasing internals
- These weightages could be flexible for some (approved by DBOS) courses 50% percentage reduction in mid and final marks (i.e., 10 Marks for midterm and 25 for Final term) and give more weightage to Project Base learning. As Project-based learning/assessments allow students to apply what they have learned in class to real-world problems and situations, which can help to enhance their understanding and retention of the course material.

- Allowable Models:

Model	Name	Final	Mids	Internals	Total
A	Conventional Method	50	20	30 (10Q, 20A)	100
B	Final Focused Method	50	0	50(10Q, 20A, Case Study/Project (20)	100
C	Flexible Method	25	10	65(15Q, 20A, Case Study/Project (30)	100

- Similar practice is being followed at LUMS. The proof is attached as appendage 2806.

Discussion

HoD EE BUIC presented an agenda point, which was deliberated in detail by the house. The house suggested that a specific course needed to be mentioned for the proposed method. Different courses were discussed in detail, and their viability was also checked for a midterm exam in the lab. For communication-related courses, an IELTS-based approach was suggested with listening and writing practices. After a detailed discussion on the topic, the house suggested that the mechanism needs to be defined for the listening and writing exam in the lab. A specific assessment method also needs to be defined. Similarly, specific courses may be listed to which this policy can apply.

Decision 2806

Sponsor to bring the targeted courses for which marks distribution as well as assessment tool to be changed. Point Dropped.

Item 2807: Addition of IDEE/Elective Courses in BEE Roadmap

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

Summary of the Case

- In the light of the recent technological innovations, following are the new courses proposed to be added in the BEE roadmap.

S. No.	Course Code	Name	Category	Credit Hours
1	EEN 451	Introduction to Systems Engineering (new course)	IDEE	3+0
2	EEN 450	Sports Engineering (new course)	Elective (Electronics)	3+0
4	CSC 464	Computer Vision	Elective (Telecommunication /Electronics)	3+0
5	EEN 462	Fundamentals of Quantum Computing (new course)	Elective (Telecommunication)	3+1

Discussion

HoD EE BUIC presented the agenda point which was deliberated in detail by the house. Course outlines were discussed in detail and feasibility and relevance was analyzed. Outlines of these courses are attached as appendage 2807 which is recommended by FBOS.

Decision 2807

The case to be forwarded for the approval in ACM.

Item 2808: Discussion /Change/Intimation of Lab rubrics of Affective and Psychomotor domain

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

Summary of the Case

During the last PEC visit and Mock visit, the observation was raised on Lab Rubrics. Lab Rubric for Psychomotor and Affective domain are prepared for each level and attached as appendage 2808.

Discussion

HoD EE BUIC presented the agenda point which was deliberated in detail by the house. Creating rubrics for CLOs and its approval is departmental affair. Departments are required to make it and get its approval at

DBOS level. However, it is advised to seek feedback from PEC approved PEV to improve the rubrics either through training or otherwise.

Decision 2808

Department to consult PEC approved PEV to improve the rubrics. Point dropped.

Item 2809: Revision of Roadmap of BSE program

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

Summary of the Case

PEC circulated new roadmap for BSE program in October 2020. Roadmap was immediately implemented w.e.f. Fall 2020 intake. Some of the new mandatory courses have to be included and as the intake semester had already started these were adjusted in the existing roadmap. Some improvements in the semester offering of these courses is required besides addition of some new courses. The proposed revisions in roadmaps and course outlines are attached as appendage 2809.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the proposed revisions in the roadmap of BSE program.

Decision 2809

The case to be forwarded for the approval in ACM.

Item 2810: Review of Eligibility for Internship Criteria

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

Summary of the Case

- As per the "Internship Eligibility" criteria defined in the "BU Students Career Services Manual ", internship support shall be available to the students who have earned a minimum of 90 credits. In other way, the students who have completed five semesters of their program shall be eligible to undertake internship.
- However, it has been observed that students usually do not have enough time to perform internship after 5th semester and have only one summer semester break after the 6th semester. This in-turn results into multiple issues faced by the students, such as delay in submitted internship reports and struggling to attend both internship training and classes if the internship occurs within a running semester.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house suggested to change the eligibility criteria to any time after the completion of their fourth semester.

Decision 2810

The case to be forwarded for the approval in ACM.

Item 2811: Teacher and Course Feedback restrictions for students with < 60% attendance

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

Summary of the Case

Typically, students who have dropped a course or have a short attendance record are still allowed to participate in providing feedback for the course and instructor. However, students should not be allowed to participate in providing feedback to prevent any negative influence on the course and teacher's feedback.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house recommended relevant changes in CMS portal to automatically block such students from filling out feedback forms.

Decision 2811

The case to be forwarded for the approval in ACM.

Item 2812: Addition of new sections in BSCS program at BULC

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

Summary of the Case

The current infrastructure of BULC was deemed insufficient, but with the availability of an adjacent building for rent, it is now possible to accommodate additional sections. Therefore, approval for the allowance of one additional section of BS(CS) starting from the Fall 23 semester is requested.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house supported the addition of new section in BSCS at BULC based on availability of infrastructure and facilities.

Decision 2812

The case to be forwarded for the approval in ACM.

Item 2813: Progress of four years BS new programme Remote Sensing and GIS

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

Summary of the Case

Bachelor of Science in Remote Sensing & GIS is launched at BSAES-IC from Spring 2023 semester with the launch proposal presented in the 42nd ACM. Details of the programme as given at Appendage 4109 of 42nd ACM.

Discussion

The sponsor presented the case. The sponsor presented the progress of the case. 15 students submitted the fee and a special approval from Honorable Rector is initiated on February 10, 2023 through Principal BSEA-IC.

Decision 2813

The progress to be forwarded at 43rd ACM.

Item 2814: Correction in course code of Pre-requisite of Programming in Artificial Intelligence Lab

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

Summary of the Case

The BS (Artificial Intelligence) program was launched in Fall 2021 semester. Currently, two batches are enrolled in their 3rd and 4th semester respectively. The issue in currently followed roadmap is that pre-requisites of certain Labs are also labs of other courses. However, typically, pre-requisites of Labs are the same as Courses.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the suggested changes in course codes (attached as appendage 2814).

Decision 2814

The case to be forwarded for the approval in ACM.

Item 2815: Approval of PEO Assessment Forms-CQI Process (KPIs)

Sponsor: HOD (CS) BUKC | Referral Authority: DBOS CS BUKC

Summary of the Case

- To properly execute the continuous quality improvement (CQI) cycle the PEOs, PLOs and CLOs are evaluated and analyzed periodically.
- According to the approved OBE framework PEOs will be evaluated four years after the graduation of the batch. The data can be collected using employer survey forms, alumni forms and CAC feedback.
- The Key performance indicators (KPIs) would be set by each department as mentioned in the approved framework
- KPIs for the PEO attainment, employer feedback survey form and Alumni feedback form are attached as appendage 2815.

- Data will be collected after four years, if the KPIs are met overwhelmingly then the KPIs will be reset.
- If the KPIs are not met the following actions will be taken
    - Review of assessment tools
    - Review of curriculum
    - Review of PEO statements

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the proposed PEO assessment forms attached at appendage 2815.

Decision 2815

Point dropped.

Item 2816: Approval of PLO Assessment criteria-CQI Process (KPIs)

Sponsor: HOD (CS) BUKC | Referral Authority: DBOS CS BUKC

Summary of the Case

- The PLOs are attained by direct methods i.e., assessment of courses and final year projects.
- For this purpose, all the courses are mapped with respective PLOs.
- The PLOs could also be attained by indirect methods i.e., exit survey of the graduating students and internship survey form
- The Key performance indicators (KPIs) would be set by each department as mentioned in the approved framework
- PLO attainment Key performance indicators (KPIs), Exit form for indirect method analysis, indirect PLO internship survey form and indirect method assessment of Community service program (CSP) form are attached as appendage 2816.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the forms attached at appendage 2816.

Decision 2816

Point dropped.

Item 2817: Approval of CLO Assessment criteria-CQI Process (KPIs)

Sponsor: HOD (CS) BUKC | Referral Authority: DBOS CS BUKC

Summary of the Case

- The course learning outcomes are assessed by using direct assessment methods like Mid-term exam, Final exam, Assignments, Quizzes, Complex computing problem, Open ended labs / Projects/Final year Projects
- When the data is obtained after every semester, if the KPIs are met overwhelmingly then the KPIs will be reset.
- If the KPIs are not met the following actions will be taken
    - Review of student course feedback / Assignment submissions
    - Review of assessment methodologies
    - Course content review
    - Review of course learning outcome statement
    - Faculty training
- The CLO attainment Key performance indicators (KPIs) are attached as appendage 2817.

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approves the proposed CLO assessment criteria attached at appendage 2817.

Decision 2817

Point dropped.

Item 2818: Final Year Project Departmental Policy Upgradation as per OBE (Seoul Accord)

Sponsor: HOD (CS) BUKC | Referral Authority: DBOS CS BUKC

Summary of the Case

- Final year Projects are evaluated and examined in the department on regular basis.
- FYPs are scrutinized in terms of initial proposal presentations, milestone presentations (mid presentation) and final presentations along with the submission of report.
- Existing FYP policy needs to be updated and upgraded according to the OBE (Seoul Accord).

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the proposed OBE based FYP Policy attached at appendage 2818.

Decision 2818

Point dropped.

Item 2819: Revision of BCE curriculum

Sponsor: HOD (CE) BUIC | Referral Authority: DBOS CE BUIC

Summary of the Case

- As per industrial demand in the field Systems on Chip (SoC), CAO and MPI courses are swapped i.e., CAO is moved to 5th semester and MPI is moved to 4th semester. The course outlines of said courses are modified to make them in line with current trend of IC designing. Therefor revision of roadmap is proposed and the updated course outlines are attached at appendage 2819.

Current Road Map			Proposed Road Map		
Course	**Pre-requisite**	**Semester**	**Course**	**Pre-requisite**	**Semester**
CAO (CEN 221)	CEN 120	4TH	CAO (CEN 221)	CEN 120	5TH
MPI (CEN 321)	CEN 221	5TH	MPI (CEN 321)	CEN 120	4TH

- The current pre-requisite of Digital Image Processing (DIP) is Operating System with course code CSC 320 which was mistakenly added during revision. However, it should be Signal and Systems with course code EEN 313. It is therefore recommended to change the pre-requisite of DIP.
- Research and development in the field of IC designing are essential for continued advances in technology and systems and to achieve the long-term goal of strengthening domestic manufacturing and mitigating supply chain risks. Keeping this in view, the introduction of following electives is suggested in the BCE Road map:
  - Hardware Verification (Code: CEN 462) (CEDE) (New Course)
  - Compiler Construction (Code: CSC 323) (MDEE)
  - Theory of Automata (Code: CSC 315) (MDEE)
  - The revised BCE Roadmap (2023) and the course contents of aforementioned courses are attached in appendage 2819.
- In addition to aforementioned courses the course outlines of following electives are revised (appendage 2819).
  - VLSI Design (Code: CEN 457)
  - Embedded System Design (Code: CEN 440)

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the proposed revisions in BCE curriculum attached as appendage 2819.

Decision 2819
The case to be forwarded for the approval in ACM.

Item 2820: Formal approval of Direct/Indirect Assessment weightage in PLOs based evaluation	
Sponsor: HOD (CE) BUIC	Referral Authority: DBOS CE BUIC

Summary of the Case

- The weightage for PLOs direct and indirect assessment was needed to be revised as initial PLOs are targeted more in the courses i.e., Direct Assessment, however, last few PLOs are not covered in courses. Therefore, it was suggested to assess least targeted PLOs by indirect means.
- The proposed weightages are approved by the DBOS CE for PLOs assessment for Batch-2018 and onwards and attached at appendage 2820.

Discussion
The sponsor presented the case. After detailed discussion and arguments, the house approved the mapping at appendage 2820.
Decision 2820
Point dropped.

Item 2821: FYP Ethical Review Committee Forms	
Sponsor: HOD (CE) BUIC	Referral Authority: DBOS CE BUIC

Summary of the Case
During PEC Re-Accreditation visit, it was highlighted that no FYP Ethical Review forms are present to observe the ethical aspects in FYPs. Therefore, a FYP Committee was formed and with its assistance FYP Ethical Review forms were designed and attached as appendage 2821.
Discussion
The sponsor presented the case. After detailed discussion and arguments, the house approved the FYP ethical review forms for CE department only (attached at appendage 2821). The house also suggested other department to review these forms for themselves.
Decision 2821
Point dropped.

Item 2822: Changes in Course Titles and Course Codes for FYP/ UG and PG Thesis and Common Courses	
Sponsor: Dean ES	Referral Authority: Dean ES

Summary of the Case

- Normally there are multiple HSS courses with different names, course codes and credit hours at different departments of ES. Similarly, course codes of FYPs, UG and PG thesis also vary among different departments.
- Dean ES presented the amended course titles and course codes for Final Year Project (FYP) in Undergraduate and Postgraduate Programme of ES, for commonality and conformance with BU Course Codes Policy. These course titles are attached as appendage 2822

Discussion
The sponsor presented the case. After detailed discussion and arguments, the house recommends the course titles attached as appendage 2822.
Decision 2822
The case to be forwarded for the approval in ACM.

Item 2823: Approval of new curriculum for computing programs as per NCEAC Recommendations

Sponsor: HOD (CS) BUIC, BUKC and BULC | Referral Authority: DBOS CS BUIC, BUKC, BULC

Summary of the Case

Recently, the National Computing Education Accreditation Council (NCEAC) has published the new proposed curriculum for all computing programs on February 16, 2023. Keeping the newly proposed curriculum in view the Department of Computer Science at BUIC, BUKC and BULC has proposed the new curriculum of computing programs at BU (attached at appendage 2823)

Discussion

The sponsor presented the case. After detailed discussion and arguments, the house approved the proposed curriculum of computing programs BS(CS), BS(AI) and BS(IT) attached as appendage 2823.

Decision 2823

The case to be forwarded for the approval in ACM.

Item 2824: Progress of Amendment in BU Academic Rules for Inter Campus Transfer of Engineering students

Sponsor: Dean ES | Referral Authority: Dean ES

Summary of the Case

- BU Academic Rule 2.3 allows inter-Campus transfer of BU students in the same programme with complete Transfer of Credit (ToC), without a loss of any credit earned. However, PEC has raised an objection on this practice as a deviation from PEC Regulations Article 3(d), which states that the transfer of credits shall not exceed 50% of programme total credits required even for the student seeking ToC within the same programme from one campus to other campus or from one institution/ college/ university to another institution/ college/ university (Item 4218 of 42nd ACM).
- ACM suggested Dean ES to deliberate the case in the Faculty Board of Studies of Engineering Sciences to recommend multiple solutions that meet PEC Regulations and submit the progress in the next ACM.

Discussion

The sponsor presented the case. The progress was shared with the house. The case was approved on case file. The house recommended to submit the case to ACM for ratification.

Decision 2824

The progress to be forwarded at 43rd ACM.

Item 2825: Inclusion of course to the road map of MS and PhD Mathematics

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

Summary of the Case

- HOD CS proposed addition of a new course called "Lie Group Methods for Differential Equations" for inclusion to the road map of MS and PhD Mathematics programs

Discussion

The sponsor presented and iterated the case. After detailed discussion and arguments, the house approved the course (outline attached at appendage 2825)

Decision 2825

The case to be forwarded for the approval in ACM.

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 Atif Raza Jafri
Dean (ES), Head FBoS
March, 2023

Distribution:

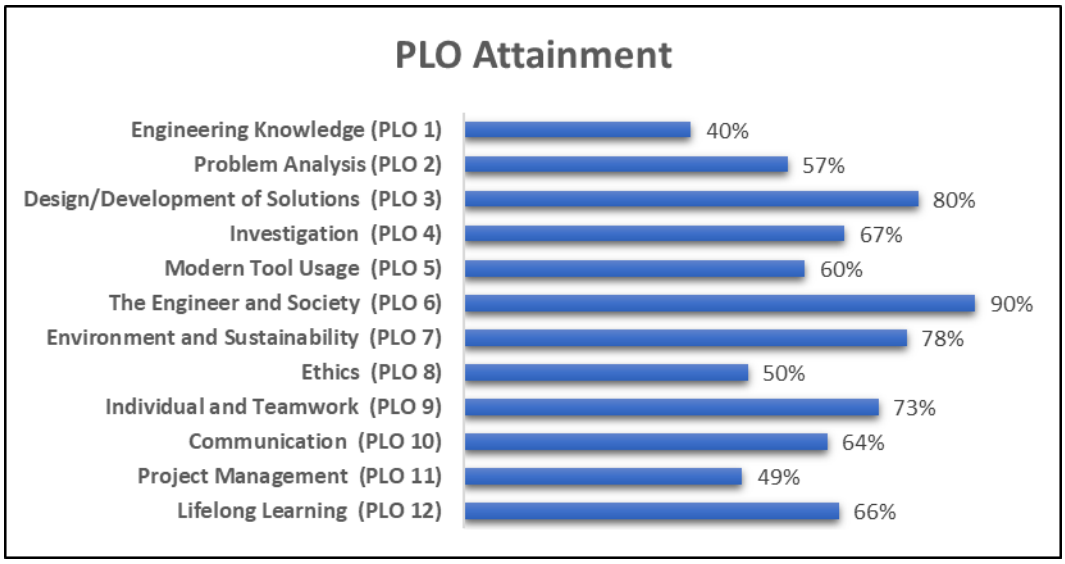
	Rector, Pro-Rector, Registrar
BUHQ:	DAA
BUIC:	DG BUIC, DIC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BUKC:	DG BUKC, DKC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BULC:	DLC, HOD(CS)

Appendages:

Appendage 2801-A

Option 1

Attainment of PLOs:



Option 2

Attainment of PLOs:

PLO 1	Engineering Knowledge	40%	PLO 7	Environment and Sustainability	78%
PLO 2	Problem Analysis	57%	PLO 8	Ethics	50%
PLO 3	Design/Development of Solutions	80%	PLO 9	Individual and Teamwork	73%
PLO 4	Investigation	67%	PLO 10	Communication	64%
PLO 5	Modern Tool Usage	60%	PLO 11	Project Management	49%
PLO 6	The Engineer and Society	90%	PLO 12	Lifelong Learning	66%

GENERAL INFORMATION

CNIC/Passport No of Student

41304-1236160-7

Basic Admission Requirement for the Program

Passed intermediate examination or its equivalent with a minimum of 60% marks in Pre-Engineering.

Previous Degree Held by the Student

HSSC Pre-Engineering from , (BISE Hyderabad Sindh)

Bahria University Charter Date

7 February 2000

Academic Honors

Students achieving high standards are awarded following honors upon completion of their degree requirements. Honors designations are indicated on the transcript:

Summa Cum Laude	3.90 - 4.00
Magna Cum Laude	3.80 - 3.89
Cum Laude	3.60 - 3.79

Criteria for Award of Academic Honors

The student should have been regular in the entire degree program and should have taken full load in all semesters required from the degree program as per road map/course outline.

Ineligibility for the Academic Honors

- Any course withdrawn or dropped.
- Any semester frozen.
- Repetition or retake of any course.
- An 'F' or an 'I' endorsement in any subject/course.
- Credit transfers
- Any of the degree requirements not completed within the roadmap time frame.

Grading System

Following grading system (absolute) is used at Bahria University:

Letter Grade	Percentage	Grade Point
A (Outstanding)	87 - 100	4.0
B+ (Very Good)	80 - 86	3.5
B (Above Average)	72 - 79	3.0
C+ (Satisfactory)	66 - 71	2.5
C (Barely Acceptable)	60 - 65	2.0
D (Poor)	50 - 59	1.5
F (Fail)	Below 50	0.0
W	Withdrawal	
I	Incomplete	

Medium of Teaching

English is the medium of teaching for all programs conducted at Bahria University.

Transcripts

Following type of transcripts are issued to the students at Bahria University:

a. Final Transcript

When all the degree requirements have been completed.

b. Interim Transcript

It is issued at the end of each semester (except final semester). Program incomplete is depicted on interim transcript. Procedure to apply for transcripts is given on Bahria University website www.bahria.edu.pk

Authentication

Final transcripts are light beige in colour. They bear embossed university seal, security water markings & Controller of Examinations signatures on its face (Alteration and/or forgery of this document is a criminal offense liable to be tried in the Court of Law).

Prepared by:

Checked by
Asst Controller Exams :

Date: 27 June 2022

Date: _____

PLO Attainment Certificate

It is to certify that Mr/Miss _____ Enrollment No: _____ has successfully attained the following Program Learning Outcomes (PLOs) in the degree program _____ of Intake Fall _____. The program is accredited by Pakistan Engineering Council (PEC) on Washington Accord.

1. Engineering Knowledge
2. Problem Analysis
3. Design/Development of Solutions
4. Investigation
5. Modern Tool Usage
6. The Engineer and Society
7. Environment and Sustainability
8. Ethics
9. Individual and Team Work
10. Communication
11. Project Management
12. Lifelong Learning

_____
Deputy Director (Academics) / Head Examination Cell
Campus Name
Bahria University, Islamabad

Description of PLOs

1. **Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/Development of Solutions:** An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
4. **Investigation:** An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.
5. **Modern Tool Usage:** An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.
6. **The Engineer and Society:** An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.
7. **Environment and Sustainability:** An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and Team Work:** An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.
10. **Communication:** An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management:** An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.
12. **Lifelong Learning:** An ability to recognize the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.

Existing PEOs	Proposed PEOs
PEO 1: To exhibit the expertise in the field of electrical engineering to compete with technical challenges and find the solutions of complex engineering problems.	**PEO 1:** To provide viable solutions to complex engineering problems based on systematic theoretical and technical approaches in the field of electrical engineering.
PEO 2: To be skillful employable graduates in different domains of design, development, operation, and maintenance, as well as explore opportunities for entrepreneurship.	**PEO 2:** To manage and develop sustainable electrical systems to meet desired objectives and explore new entrepreneurial possibilities in a multidisciplinary environment.
PEO 3: To pursue professional growth by taking up higher studies, ascertain technologies, develop proficiency in the usage of new tools.	**PEO 3:** To pursue academic and professional growth by taking up higher studies, discovering new technologies and developing proficiency in the usage of latest tools.
PEO 4: To work in a multicultural environment and communities, providing leadership in their domain, and responsive to ethical, moral, and societal issues.	**PEO 4:** To work in a multicultural environment and be responsive to ethical, moral, and societal issues showing leadership in their domain.

Mapping with Vision and Mission

Vision & Mission	Program Educational Objectives (PEOs)			
	PEO 1	PEO 2	PEO3	PEO4
University Vision To become a knowledge and creativity driven international university that contributes towards development of society.	Provide viable solutions to complex engineering problems	Develop sustainable electrical systems within realistic environmental, health, and safety restrictions.	Professional growth	Responsive to ethical, moral, and societal issues
University Mission To ensure academic excellence through deliverance of quality education and applied research in a collegiate environment having strong linkages with industry and international community to meet the societal challenges.	Solutions based on systematic technical approaches	Explore new entrepreneurial possibilities in a multidisciplinary en vironment.	Develop proficiency in the usage of new tools	Multi-cultural environment

Vision & Mission	Program Educational Objectives (PEOs)			
	PEO 1	PEO 2	PEO3	PEO4
Department's Vision Commitment to prepare students for professional and research activities with an ability to learn independently, within a diverse multi-cultural environment, and enabling them to become the global leaders in their respective fields.	To provide viable solutions to complex engineering problems based on systematic theoretical and technical approaches	To manage and develop sustainable electrical systems in a multidisciplinary en vironment.	Pursue academic and professional growth	Multi-cultural environment & Showing Leadership
Program's Mission To produce ethically sound and technically competent electrical engineers who can serve in the diverse fields of research, design and development, teaching, system installation, support and maintenance.	Provide viable solutions to complex engineering problems in the field of electrical engineering.	Manage and develop sustainable electrical systems in a multidisciplinary en vironment.	Discovering Technologie s	Responsive to ethical, moral, and societal issues

Mapping of Previous and Proposed PEOs

Program Learning Outcomes (PLOs)	Program Objectives (PEOs)			
	1	2	3	4
PLO 1: Engineering Knowledge	✓			
PLO 2: Problem Analysis	✓			
PLO 3: Design/Development of Solutions		✓		
PLO 4: Investigation	✓			
PLO 5: Modern Tool Usage			✓	
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		✓		

PLO 12: Lifelong Learning			✓	

Mapping of Previous and Proposed PEOs (Key words)

Program Learning Outcomes (PLOs)	Program Educational Objectives (PEOs)			
	PEO-1	PEO-2	PEO-3	PEO-4
PLO 1: Engineering Knowledge	Solutions to complex engineering problems in the field of electrical engineering.			
PLO 2: Problem Analysis	Solutions to complex engineering problems based on systematic theoretical and technical approaches			
PLO 3: Design/Development of Solutions		Develop sustainable electrical systems		
PLO 4: Investigation	Provide viable solutions to complex engineering problems based on systematic theoretical and technical			
PLO 5: Modern Tool Usage			Develop proficiency in the usage of new tools.	
PLO 6: The Engineer and Society				Responsive to moral and societal issues
PLO 7: Environment and Sustainability				To work in multicultural environment
PLO 8: Ethics				Responsive to ethical issues
PLO 9: Individual and Team Work				Providing leadership in their domain
PLO 10: Communication			Taking up higher studies and discovering new technologies	
PLO 11: Project Management		Manage and explore new entrepreneurial possibilities in a multidisciplinary e nvironment		
PLO 12: Lifelong Learning			Pursue professional growth by taking up higher studies	

PLOs description

REFERENCE:

1. **PEC Manual Of Accreditation, 3rd edition 2019**)
2. https://www.ieagreements.org/assets/Uploads/Documents/History/25YearsWashingtonAccord-A5booklet-FINAL.pdf

PLO 1 Engineering Knowledge:

An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PLO 2 Problem Analysis:

An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO 3 Design/Development of Solutions:

An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO 4 Investigation:

An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

PLO 5 Modern Tool Usage:

An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

PLO 6 The Engineer and Society:

An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PLO 7 Environment and Sustainability:

An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PLO 8 Professional Ethics:

Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PLO 9 Individual and Teamwork:

An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.

PLO 10 Communication:

An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PLO 11 Project Management:

An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.

PLO 12 Lifelong Learning:

An ability to recognize the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.

Performance Indicator for PEOs

PEOs #	Program Educational Objectives (PEOs)	Key Performance Indicator (KPI's)	Measurement Tools
PEO 1	To provide viable solutions to complex engineering problems based on systematic theoretical and technical approaches in the field of electrical engineering.	60% of the employers in the industry are satisfied with the technical competence of EE graduates. 5% of the graduates have presented their work at technical forums such as conference, journal, symposium, technical competitions.	Employer Survey Form Alumni Survey Form
PEO 2	To manage and develop sustainable electrical systems to meet desired objectives and explore new entrepreneurial possibilities in a multidisciplinary environment	50% of the graduates are gainfully employed in the electrical engineering related industry. 5% of the graduates have started their own businesses/startups or employed in other fields.	Alumni Survey Form Employer Survey Form

PEO 3	To pursue academic and professional growth by taking up higher studies, discovering new technologies and developing proficiency in the usage of latest tools.	15% of graduates have secured admission in MS or PhD after graduation either within Pakistan or abroad. 20% of the graduates have attended at least one professional development course after graduation.	Alumni Survey Form
PEO 4	To work in a multicultural environment and be responsive to ethical, moral, and societal issues showing leadership in their domain.	15% of graduates are part of organization that supports communities working for the betterment of society. 5% of graduates have managerial positions in their industry.	Employer Survey Form Alumni Survey Form

BEE with Robotics and Intelligent Stream Curriculum

Bahria University Pakistan (BEE Program)			
Semester	**Code**	**Course Title**	**CH**
1st	GSC110	Calculus and Analytical Geometry	3+0
	CSC111	Introduction to computing	1+1
	ENG104	Functional English	2+0
	ISL101	Islamic Studies/Ethics	2+0
	XXXX	IDEE-1	2+0
	GSC113	Applied Physics	3+1
	EEL112	Workshop practice	0+1
2nd	EEL121	Engineering Drawing & CAD	0+1
	GSC210	Differential Equations	3+0
	CSC112	Programming Fundamentals	2+1
	EEN110	Linear Circuit Analysis	3+1
	CEN120	Digital Logic Design	3+1
	PAK101	Pakistan Studies	2+0
3rd	HSS120	Communication Skills	3+0
	EEN224	Electronic Devices and Circuits	3+1
	EEN211	Electrical Network Analysis	3+1
	CSC210	Computing Elective	3+1
	GSC220	Complex Variables and Transforms	3+0
4th	GSC121	Linear Algebra	3+0
	EEN 225	Electronic Circuit Design	3+1
	HSS XXX	Humanities & Social Sciences Elective -1	3+0
	EEN313	Signal and System	3+1
	GSC 123	Probability Methods in Engineering	3+0
5th	EEN311	Electromagnetic Field Theory	3+0
	CEN 440	Embedded Systems Design	3+1
	XXXX	Natural Science Elective	3+0
	EET321	Communication Systems	3+1
	EEN 312	Electrical Machines	3+1
6th	EEXXXX	Breadth Core-I	3+1
	EEN412	Linear Control Systems	3+1
	MGTXXX	Management Science Elective 1	2+0
	EEXXXX	Elective I	3+1
	EEXXXX	Breadth core-2	3+1
7th	ESC498	Senior Design Project – 1	0+3
	HSS320	Tech. Writing & Present. Skills	3+0
	EEXXX	Elective II	3+1
	EEXXX	Elective III	3+1
	XXXX	IDEE-2	3+0
8th	ESC499	Senior Design Project – 2	0+3
	HSSXXX	Humanities & SS Elective -2	2+0
	HSSXXX	Management sciences Elective - 2	3+0
	EEXXXX	Elective IV	3+1
	EEXXXX	Elective V	3+1

Breadth Core for Robotic and Intelligent Systems Stream

Sr. No	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical
1	CEN 440	EER 431	Introduction to Robotics	3+1	3	1
2	CSC 112	EER 476	Introduction to Artificial Intelligence	3+1	3	1

List of Courses for Robotics and Intelligent Systems Stream

Sr. No	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical
1	EEN 412	EER 471	Robot Process Automation	3+0	3	0
2	EER 476	EER 481	Machine Vision & Robotics	3+1	3	1
3	None	EER 482	Introduction to Haptics	3+0	3	0
4	None	EER 483	Introduction to Humanoid Robots	3+0	3	0
5	EEN 412	EER 484	Advanced Modelling of Robotics	3+1	3	1
6	GSC 110	EER 485	Optimal Kinematic Design of Robots	3+1	3	1
7	None	EER 486	Swarm Robotics	3+0	3	0
8	CSC 112	EER 473	Introduction to R Programming	3+1	3	1
9	CSC 112	EER 474	Introduction to Deep Learning	3+1	3	1
10	CEN 440	EER 475	Human Robot Interaction	3+1	3	0
11	None	CSC 410	Introduction to Cloud Computing	3+0	3	0
12	None	EER 489	Mechanics of Materials	3+0	3	0
13	None	EER 363	Internet of Things (IoT)	3+0	3	0
14	CSC 112	EER 361	Robotic System & Programing	3+1	3	1
15	EEN 224	EER 441	Sensors & Actuators	3+1	3	1
16	GSC 210	EER 362	Robot Modelling & Control	3+1	3	1
17	CSC 112	CSC 419	Introduction to Machine Learning	3+1	3	1

Course Outlines:

Course Title: Introduction to Robotics
Course Code:
EER 431
Credit Hours:
(3+1)
Pre-Requisite:

Objectives: This course is an overview of robotic and automated systems technology. The student will be introduced to basic manufacturing techniques, robot terminology, and different types of automation, safety, basic robotic programming, interfacing robotic communications, automated work cells, and robotic applications. Robot operations and programming fundamentals will be applied by the students.

Contents: Major components of robotic systems, degree of freedom, work envelope, tool center point, classification of robotics system, arm geometry of robotic system

Recommended Book(s):
Introduction to Robotics — Colin D. Simpson

Reference Book(s):
Fundamentals of Robotics Engineering — Harry H. Poole

Course Title: Introduction to Artificial Intelligence
Course Code: EER 476
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
Artificial Intelligence (AI) is a constantly and actively growing and changing field. In this course, students will learn the basics of modern AI as well as some of the representative applications of AI

Contents:
Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, First order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint Satisfaction Problems; Adversarial Search (Min-max algorithm, Alpha beta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning) ;Uncertainty handling (Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems)

Recommended Book(s):
S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall

Reference Book(s):
Hart, P.E., Stork, D.G. and Duda, R.O. Pattern classification. John Willey & Sons.
Luger, G.F. and Stubblefield, W.A., AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley

Course Title: Robot Modelling & Control
Course Code: EER 362
Credit Hours: (3+1)
Pre-Requisite:

Objectives: The objectives of the course are to provide an introductory understanding of robotics. Emphasis on basic of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, robot kinematics and dynamics in a closed loop system.

Contents: Rigid motions and Homogeneous transformation, forward & inverse kinematics, velocity kinematics, trajectory planning.

Recommended Book(s):
Robot Modelling and Control — Mark W. Spong

Reference Book(s):

Introduction to Robotics Mechanics and Control — John J. Craig

Course Title: Introduction to Artificial Intelligence
Course Code: EER 476
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
Artificial Intelligence (AI) is a constantly and actively growing and changing field. In this course, students will learn the basics of modern AI as well as some of the representative applications of AI

Contents:
Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, First order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint Satisfaction Problems; Adversarial Search (Min-max algorithm, Alpha beta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning) ;Uncertainty handling (Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems)

Recommended Book(s):
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Reference Book(s):
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Luger, G.F. and Stubblefield, W.A., AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley

Course Title: Robot Modelling & Control
Course Code:
EER 362
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Objectives: The objectives of the course are to provide an introductory understanding of robotics. Emphasis on basic of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, robot kinematics and dynamics in a closed loop system.

Contents: Rigid motions and Homogeneous transformation, forward & inverse kinematics, velocity kinematics, trajectory planning.

Recommended Book(s):
Robot Modelling and Control — Mark W. Spong

Reference Book(s):
Introduction to Robotics Mechanics and Control — John J. Craig

Course Title: Robot System & Programming
Course Code: EER 361
Credit Hours: (3+1)
Pre-Requisite:

Objectives: This course gives the introduction to ROS, focusing on the basic concepts fundamental to use ROS from a user perspective. Three basic concepts are introduced: Nodes, Topics, and Services. Then, the specification of message types is covered. It also discusses the operationalization of these concepts, covering the creation and management of packages, the programming of nodes that subscribe/publish to nodes and that call/serve services, and some useful command line tools. The course briefly discusses some graphical tools.
Contents: Packages, nodes, topics, services

Recommended Book(s):
Robot Operating System (ROS) for Beginners — Lentin Jospeh

Reference Book(s):
Robot Operating System (ROS) — Doubaa Anis

Course Title: Swarm Robotics
Course Code: EER 486
Credit Hours: (3+0)
Pre-Requisite:

Objectives: This course is an introduction to Swarm Robotics, which is the application of methods from swarm intelligence to robotics. It goes on to present methods that allow to understand how to design large-scale robot systems by going through many example scenarios on topics such as aggregation, coordinated motion (flocking), task allocation, self-assembly, collective construction, and environmental monitoring. The course also explains the methodology behind building multiple, simple robots and how the complexity emerges from the multiple interactions between these robots such that they are able to solve difficult tasks.

Contents:
Initial approach to Swarm Robotics, Swarm performance, Self-organization, Homogeneous and Heterogeneous Swarms

Recommended Book(s):
Swarm Robotics: A formal approach — Heiko Hamann

Reference Book(s):
Evolutionary Swarm Robotics — Vito Trianni

Course Title: Advanced Modelling of Robotics
Course Code: EER 484
Credit Hours:
(3+0)
Pre-Requisite:

Objectives: The course formerly generalizes the modelling technique(Geometric, Kinematic and Dynamic) to robotic structures more complex than simpler cascade ones (e.g. branched, open/close and parallel connections) with extension to cases of presence of flexible links. Then it will be shown how the developed method can be used for calibration, simulation, kinematic/dynamic/interaction control, parametric identification and adaptive control of such more general robotic structures.

Contents: Geometric and kinematic modelling, constraint equations, fundamentals of screw theory and its application to modelling

Recommended Book(s):
Modelling and Control of Manipulators — Wisama Khalil

Course Title: Advanced Modelling of Robotics
Course Code: EER 484
Credit Hours:
(3+0)
Pre-Requisite:

Objectives: The course formerly generalizes the modelling technique(Geometric, Kinematic and Dynamic) to robotic structures more complex than simpler cascade ones (e.g. branched, open/close and parallel connections) with extension to cases of presence of flexible links. Then it will be shown how the developed method can be used for calibration, simulation, kinematic/dynamic/interaction control, parametric identification and adaptive control of such more general robotic structures.

Contents: Geometric and kinematic modelling, constraint equations, fundamentals of screw theory and its application to modelling

Recommended Book(s):
Modelling and Control of Manipulators — Wisama Khalil

Course Title: Machine Vision & Robotics
Course Code: EER 481
Credit Hours: 3+1
Pre-Requisite:

Objectives: The aim of the course is to provide the students with the understanding of the basic principles underlying the design, analysis, and synthesis of robotic systems and machine vision technology in automation. This course will lay down the foundations of the engineering principles in such a way that the students can identify the appropriate concepts required in given engineering problems and apply them to formulate the suitable engineering solutions in automation and other applications.

Contents: Applications of robotics and vision, Robot control, Image formation, transduction and simple processing, Active vision and attention, Sensors for self-monitoring, General approaches and architectures

Recommended Book(s):
Keter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer, 2011.

Reference Book(s):
Rafael C. Gonzalez, and Richard E. Woods: Digital Image Processing, Prentice Hall, 2nd Edition, 2001.
K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, Robotics - Control, Sensing, Vision, and Intelligence, McGraw-Hill Book Company, 1987.

Course Title: Introduction to R Programming
Course Code: EER 473

Credit Hours:
(3+1)
Pre-Requisite:

Objectives:
In this course students will learn how to program in R and how to use R for effective data analysis. You will learn how to install and configure software necessary for a statistical programming environment, discuss generic programming language concepts as they are implemented in a high-level statistical language. The course covers practical issues in statistical computing which includes programming in R, reading data into R, accessing R packages, writing R functions, debugging, and organizing and commenting R code. Topics in statistical data analysis and optimization will provide working examples.

Contents:
R Statistical Programming Language, RStudio Integrated Development Environment (IDE), Data importation methods, Basic R Data Types, Data processing and manipulation techniques, External add-in packages for R, Summary statistic functions, Data visualizations using ggplot, Error types.

Recommended Book(s):
The art of R programming - a tour of statistical software design, norman matloff

Reference Book(s):
Data Visualization Using R, Rahlf & Thomas, Springer

Course Title: Introduction to Deep Learning
Course Code: EER 474
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
Deep Learning is a hierarchical learning methodology based on artificial neural networks which are algorithms inspired by the structure and function of the brain. It has applications in wide-range of industries these days such as face-recognizers working at massive scales, robotics, speech translation, text analysis, improving customer experience, autonomous vehicles etc. In this course we will take a "hands-on approach" and start will implementation of basic building blocks such as training a simple perceptron and move to design and train a deep convolution neural network. Course will concentrate in developing both mathematical knowledge and implementation capabilities. The implementations will be python based using TensorFlow and Keras. After establishing our foundation in convolutional neural networks we will start looking into applications of deep learning in both spatial as well as time-series data and explore various network architectures suited for each. The objective is to help you build a career in AI and Machine learning, to make you comfortable enough that you can understand various learning problems and develop your own deep learning based solutions.

Contents:
Neural Networks, ConvNet, Object Detection, Autoencoders, GANS, Sequence Models, Memory Augmented NN, Deep Reinforcement Learning.

Recommended Book(s):
Neural Networks and Deep Learning by Charu C. Aggarwal
Reference Book(s):
Deep Learning (Adaptive Computation and Machine Learning series) Illustrated Edition by Ian Goodfellow

Course Title: Robot Process Automation
Course Code: EER 471
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
Robotic Process Automation (RPA) involves the development of software robots that can be programmed to do basic tasks across applications just as human workers do and has the potential to reduce the burden of repetitive, simple tasks on employees. This course outlines what RPA is– and what it is not. Further, it explores how best to select opportunities to apply RPA, calculating the ROI on RPA projects, implementation best practices and pitfalls to avoid. Student will acquire an understanding of the principal aspects of Robotics Process Automation and learn how to implement RPA across the organization.

Contents:
RPA and Agile and CEM, Project Selection, Customer Journey Mapping, Agile, The central role of BPM, RPA and AI,

Recommended Book(s):
The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems by Tom Taulli
Reference Book(s):
Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks and Become an RPA Consultant by Richard Murdoch

Course Title: Human Robot Interaction
Course Code: EER 475
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
Human-robot interaction (HRI) is the field of study to understand, design and evaluate robotics systems for use by or with humans. This course brings together knowledge from robotics, artificial intelligence, language processing, image analysis, cognitive psychology, and other fields to enable robots to have more natural and more efficient interactions with humans.

Contents: Introduction, a short history of robotics, Study methods and designs for evaluating Human-Robot interaction, Interaction with intelligent autonomous systems, Physical interaction and haptics, Verbal and non-verbal communication, Affective Design, Acceptance and Trust, Empathic Human-

Robot interaction, Developing long-term relationships, Applications: Domestic assistance /Eldercare, Ethical considerations.

Recommended Book(s):
Human-Robot Interaction: An Introduction 1st Edition by Christoph Bartneck, Tony Belpaeme Friederike
Eyssel .

Reference Book(s):
New Frontiers in Human-Robot Interaction, Edited by Kerstin Dautenhahn and Joe Saunders ISBN-10: 9027204551, ISBN-13: 978-9027204554
Context Aware Human-Robot and Human-Agent, Edited by Nadia M-Thalmann, Junsong Yuan, Daniel Thalmann, Bum-Jae You ISBN-10: 3319199463, ISBN-13: 978-3319199467

Course Title: Introduction to Cloud Computing
Course Code: CSC 410
Credit Hours: 3+0
Pre-Requisite:

Objectives:
The course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. Its main focus is on parallel programming techniques for cloud computing and large scale distributed systems which form the cloud infrastructure. The topics include: overview of cloud computing, cloud systems, parallel processing in the cloud, distributed storage systems, virtualization, security in the cloud, and multicore operating systems.

Contents: Introduction to Cloud Computing, Cloud Computing Platforms, Parallel Programming in the Cloud, Distributed Storage Systems, Virtualization, Cloud Security, Multicore Operating Systems

Recommended Book(s):
Cloud Computing by Lizhe Wang, Rajiv Ranjan, Jinjun Chen, Boualem Benatallah
Reference Book(s):
The Cloud Computing Book : The Future of Computing Explained by Douglas Comer

Course Title: Mechanics of Materials
Course Code: EER 489
Credit Hours: (3+0)
Pre-Requisite:

Objectives:
This course is the foundation to many advanced techniques that allow engineers to design machine components, mechanisms, predict failure and understand the physical properties of materials. Mechanics of Materials gives the student basic tools for stress, strain and deformation analysis. Methods for determining the stresses, strains and deformations produced by applied loads are presented. Engineering design concepts are integrated throughout the course.

Contents:
Introduction to Stress Analysis, Introduction to Strain Analysis, Mechanical Properties of Solids (The Constitutive relations), Stress and strain analysis for axially loaded members, Stress & Strain analysis for member under torsional loading, Bending loads (beams)

Recommended Book(s):
Mechanics of Materials by Russell Hibbeler
Reference
Book(s):
Mechanics of Materials by James M. Gere

Course Title: Introduction to Machine Learning
Course Code: CSC 419
Credit Hours: (3+1)
Pre-Requisite:

Objectives:
This course emphasizes learning algorithms and theory including concept, decision tree, neural network, computational, Bayesian, evolutionary, and reinforcement learning. Machine Learning is a key to develop intelligent systems and analyze data in science and engineering. Machine learning engines enable intelligent technologies such as Siri, Kinect or Google self-driving car, to name a few. At the same time machine learning methods help unlocking the information in our DNA and make sense of the flood of information gathered on the web, forming the basis of a new Science of Data. This course provides an introduction to the fundamental methods at the core of modern machine learning. It covers theoretical foundations as well as essential algorithms for supervised and unsupervised learning.
Contents:
Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Agglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and unlabeled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses, bagging, boosting.
Recommended
Book(s):
Machine Learning: An Algorithmic Perspective (Second Edition) by Stephen Marsland, CRC Press, 2015.
Machine Learning, Tom, M., McGraw Hill, 1997.
Reference
Book(s):
Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press, 2012

Course Title: Introduction to Humanoid Robots
Course Code: EER 483
Credit Hours: (3+0)
Pre-Requisite:

Objectives:

This course provides an overview of the fundamentals and the recent research in the field of humanoid robotics. The course will cover kinematics and dynamics, postural stability, control, gait and trajectory generation and inertial parameter estimation. Additional advanced topics in learning, human-robot interaction and manipulation and grasping and human motion modeling will be covered as time permits.

Contents:

Develop kinematic and dynamic models for anthropomorphic body structures and simulate their forward and inverse kinematics and dynamics; Develop gaits and other trajectories for humanoid robots; Implement controllers that ensure postural stability during trajectory execution for humanoid robots; Have a good overview of the current research in the field of humanoid robotics; Complete a graduate level research project in the field of humanoid robotics.

Recommended Book(s):

S. Kajita, H. Hirukawa, K. Harada and K. Yokoi, Introduction to Humanoid Robotics, Springer, 2014.

Reference Book(s):

Dragomir Nenchev Atsushi Konno Teppei Tsujita, Humanoid Robotics Automation and Control

New Programme Proposal	
A. Academic Details	
1.	**Faculty/Institute/Department:** Faculty of Engineering and Sciences, Bahria University Karachi Campus, Electrical Engineering Department
2.	**Name of the Program:** BS (Power & Energy)
3.	**Duration:** 04 Years
4.	**Venue (s):** NCMS Building, Bahria University, 13, National Stadium Road, Karachi.
5.	**Programme Format (Morning/Evening/Weekend) (Bi-Semester/Trimester):** Morning (Bi-Semester)
6.	**Faculty Requirement:** Power & Energy faculty is currently comprising of 15 members including 8 PhD and 7 MS. Details of these faculty members are as follows • Name: **Prof. Dr. Haroon Rasheed**, PhD (Electrical), AIT, Thailand. Research Interests: Smart Grid Systems, Renewable Energy Optimization, Network coding, Signal Processing, Ultra-Wide Band and Femto cell applications. • Name: **Dr. Anzar Alam, Senior Associate Professor**, PhD (Electrical), Mid Sweden University, Sweden Research Interests: Instrumentation & Control, Image & Video Processing, Power Electronics • Name: **Dr. Mukesh Kumar Maheshwari,** Senior Associate Professor, PhD (Electronics & Electrical), Sungkyunkwan University, South Korea Research Interest: Wireless Communication

	• Name: **Dr. Muhammad Raza, Associate Professor**, PhD (Power), Universitat Politècnica de Catalunya BarcelonaTech (UPC), Barcelona, Spain Research Interests: Offshore Wind Energy • Name: **Dr. Aurangzeb Rashid Masud, Senior Assistant Professor, PhD** (Electronics & Electrical), Sungkyunkwan University, South Korea Research Interests: Display devices and Materials. • Name: **Dr. Abdul Attayyab Khan, Senior Assistant Professor,** PhD (Advanced Robotics and Robot Design), University of Genova, Italy Research Interests: System Controls and Robotics, Robotic Vision, Tactile sensing in Robotics • Name: **Dr. Taimoor Zafar, Assistant Professor,** PhD (Electrical Engineering), Bahria University, Pakistan Research Interests: Integrated system health monitoring and prognostics, inverse problems, multisensory data fusion, Nondestructive testing, Reliability Analysis • Name: **Dr. Muhammad Hussain, Senior Assistant Professor,** PhD (Electrical Engineering), Bahria University, Pakistan Research Interests: Wireless communication • Name: **Engr. Muhammad Khalid, Senior Assistant Professor**, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Heterojunction and Multijunction Solar Cells. • Name: **Engr. Faraz Humayun, Senior** Assistant Professor, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Electrical Power • Name: **Engr. Burhan Ahmed, Senior** Assistant Professor, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Power Electronic, Electronic, Converters. • Name: **Engr. Faisal Siddiqui, Senior** Assistant Professor, MS (Electrical Engineering), Wayne State University, MI, USA. Research Interests: Integrated Circuits design for Wireless Application, Full Duplex Transceiver for 5G Communication.

	• Name: **Engr. Umair Shahid,** Assistant Professor, MS (Electronics & Telecommunication), Poznan University of Technology, Poland Research Interest: Wireless Communication and Digital Signal Processing • Name: **Engr. Muhammad Zuhair Arfeen,** Assistant Professor, MSc(Advanced Microelectronic Systems Engineering), University of Bristol, UK Research Interest: Embedded System • Name: **Engr. Basit Ali**, Lecturer, MS (Power Engineering), Bahria University, Islamabad, Pakistan. Research Interests: Electrical Power Research Interest: Power Electronics, Industrial Electronics
7.	**Any other HR Requirements:** None
8.	**Availability/Requirement of Classrooms (Provide details, use extra sheet if required):** There is no mandatory requirement of classes for BS (Power & Energy) program. Classrooms available to the Electrical Department are sufficient to execute the program.
9.	**Availability/Requirement of Laboratories, (provide details, use extra sheet if required):** • Power Transmission and Distribution Lab • Power Generation and Protection/ High Voltage Lab • Electrical Machine Lab. • Applied Physics Lab • Workshop Lab • Analog Electronics and Devices Lab • Digital Logic Design Lab
10.	**If existing labs suffice, requirement for any additional equipment? (Provide details, use extra sheet if required):** Nil
11.	**Minimum Entry Level:** As per BU policy, i.e. the candidates seeking admission in BS (Power & Energy) should have qualified the Intermediate examination from any Board of Intermediate and Secondary Education in Pakistan 'OR' An examination equivalent to the Intermediate for which such candidates must submit Equivalence Certificate issued by the Inter-Board Chairman Committee, Islamabad. Applicants must have scored minimum 50% marks in Pre-Engineering

	field OR Pre-Medical with additional Mathematics OR DAE in (Electrical, Electronics, Telecom; Biomedical; Computer)
12.	**Admission Criteria:** SSC, HSSC or Equivalent, Admission Test and Interview
13.	**Proposed Date of Commencement:** Fall 2023
14.	**Mode of Study/Examination:** Mode of study for BS (Power & Energy) is based on classroom teaching and labs. Assignments, quizzes, presentations, projects, mid-term exam and final term exams will be used to evaluate the students in each semester.
15.	**Brief Description & Rationale of the Programme:** Following are the salient feature of the proposed program: • Students lower than 60% marks in HSSC can be enrolled. • No involvement of PEC in the program: intake restriction, yearly re-accreditation process fees, continues investment on the infrastructure and lab equipment. • Programme will be approved by HEC, and established HEI can start any BS program with ease. • No program specific funds required for infrastructure and lab development. • Lower fees compare to BEE with almost equal opportunity and job prospects will attract more students. Student will be able to work in the field of electrical and electronics domain. • No restriction of the intake for DAE Students and they will be able to purse higher studies. • Could be beneficial for on job student since offered in evening. • More technical/field-oriented subjects.
16.	**Complete Plan of Studies:** Complete plan for BS (Power & Energy) Program is attached with this document for reference (**Annex – E**).
17.	**Course Outlines:** Course outlines for BS (Power & Energy) Program are attached with this document for reference (**Annex – F**).
18.	**Examination Policy:**

	BS (Power & Energy) Program will follow the same examination policy as followed by BE programs in the Faculty of Engineering Sciences. Details of this assessment policy are as follows: Final Term: 50% Mid Term: 20% Assignments: 20% Quizes:10%
19.	**Number of Admissions Expected for First Intake:** 30 admissions for first intake
20.	**Number of Admissions Planned/ Expected for Subsequent Intake:** 30 admissions per intake
21.	**Date of Approval by the Board of Study?**

B. FINANCIAL ANALYSIS

1. **Any Agency (Public/Private) Funding this Program (Fully/Partially)?**

   No public or private agency is funding the program.

2. **Expected Earning from First Intake:**

   Year 1: Rs. 8,250,000.00

3. **Projected Earnings for the Next Five Years:**

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh**	**Existing**	**Fresh**	**Existing**	**Total**
Fall 2023	30	0	30	100,000	0	3,000,000	0	**3,000,000**
Spring 2024	30	30	60	100,000	75,000	3,000,000	2,250,000	**5,250,000**
Fall 2024	30	60	90	100,000	75,000	3,000,000	4,500,000	**7,500,000**
Spring 2025	30	90	120	100,000	75,000	3,000,000	6,750,000	**9,750,000**
Fall 2025	30	120	150	100,000	75,000	3,000,000	9,000,000	**12,000,000**
Spring 2026	30	150	180	100,000	75,000	3,000,000	11,250,000	**14,250,000**

Fall 2026	30	180	210	100,000	75,000	3,000,000	13,500,000	**16,500,000**
Spring 2027	30	210	240	100,000	75,000	3,000,000	15,750,000	**18,750,000**
Fall 2027	30	210	240	100,000	75,000	3,000,000	15,750,000	**18,750,000**
Spring 2027	30	210	240	100,000	75,000	3,000,000	15,750,000	**18,750,000**

Year 1: Rs. 82,50,000.00
Year 2: Rs. 17,250,000.00
Year 3: Rs. 26,250,000.00
Year 4: Rs. 35,250,000.00
Year 5: Rs. 35,250,000.00

Total 5 years earnings: Rs. 122,250,000 .00

4. **Total Estimated Salaries of all Extra Human Resources (Visiting) per Annum:**

	Work load		**Per Semester Salary (Rs. 2200 per hour)**
Semester	**Course**	**Credit Hours**	**FM**
Fall 2023	7	16	563,200
Spring 2024	13	33	1,161,600
Fall 2024	18	51	1,795,200
Spring 2025	23	69	2,428,800
Fall 2025	28	87	3,062,400
Spring 2025	33	105	3,696,000
Fall 2026	38	122	4,294,400
Spring 2026	43	138	4,857,600

Year 1: Rs. 1,724,800.00
Year 2: Rs. 4,224,000.00
Year 3: Rs. 6,758,400.00
Year 4: Rs. 9,152,000.00
Year 5: Rs. 9,152,000.00

Total 5 years expenditure: Rs. 33,299,200 .00

5.	**Cost of Extra Laboratory equipment/Tools (if required):** **Year 1: Nil** **Year 2: Nil** **Year 3: Nil** **Year 4: Nil**
6.	**Cost of Extra Books for the Library (if required):** **Rs. 100,000.00**
7.	**If the Venue is Hired, provide Annual Rental Expenses and Cost of other Fixtures:** N/A
8.	**Miscellaneous Expenses Required for Starting the Program:** **None**
9.	**Total Annual Recurring Expenditures Required in Subsequent Years:** **Year 1: Rs. 1,724,800.00** **Year 2: Rs. 4,224,000.00** **Year 3: Rs. 6,758,400.00** **Year 4: Rs. 9,152,000.00** **Year 5: Rs. 9,152,000.00**
C. PROGRAMME VIABILITY	
1.	**Total Expenditures Required: Add B(4) to B(8):** **Year 1: Rs. 1,824,800.00** **Year 2: Rs. 4,224,000.00** **Year 3: Rs. 6,758,400.00** **Year 4: Rs. 9,152,000.00** **Year 5: Rs. 9,152,000.00**
2.	**Net Expenditures Required: Subtract B(1) from C(1):** Same as C1
3.	**Net Earnings in First Year: Subtract C(2) from B(2):** **Rs. 6,425,200.00**

4.	**Projected Annual Gross Earning in Subsequent Years:** **Year 2: Rs. 13,026,000.00** **Year 3: Rs. 16,491,600.00** **Year 4: Rs. 26,098,000.00** **Year 5: Rs. 26,098,000.00**

Bachelor of Science (Energy & Power)

SEMESTER-1		
Course Code	**Course Title**	**Credit Hours**
	Applied Physics – I	3+1
	Applied Mathematics – I	3+0
	Introduction to Renewable Energy System	2+0
	Introduction to Environmental Engineering	2+0
	Basic Electrical Circuit and Network Analysis	2+2
	Total	**12+3=15**

SEMESTER-2		
Course Code	**Course Title**	**Credit Hours**
	Applied Physics – II	3+1
	Applied Mathematics - II	3+0
	PCB Design and Fabrication	0+1
	Engineering Drawing, Graphics, and CAD	0+1
	Conventional Electrical Power Generations	2+1
	Programming in Embedded System	2+2
	Total	**10+6=16**

SEMESTER-3		
Course Code	**Course Title**	**Credit Hours**
	Power System Analysis	3+1
	Power Electronics	2+2
	Engineering Ethics	2+0
	Energy Economics, Policy, and Managements	3+0
	Depth Elective – I	2+2
	Total	**12+5=17**

SEMESTER-4		
Course Code	**Course Title**	**Credit Hours**
	Renewable Sources and Distributed Power Generation	2+1
	Power Transmission and Distribution	2+2
	Energy Conservation and Auditing	3+0
	Technical Report Writing and Presentation Skills	2+0
	Depth Elective - II	3+1
	Total	**12+4=16**

SEMESTER-5		
Course Code	**Course Title**	**Credit Hours**
	Project Management	3+0
	FACTs and HVDC Transmission Systems	3+1
	Power System Protection	2+2
	Depth Elective – III	3+0
	Depth Elective – IV	3+0
	Total	**14+3=17**

SEMESTER-6		
Course Code	**Course Title**	**Credit Hours**
	Quality Management	3+0
	Business Planning in Energy System	2+0
	Solar and Wind Energy System	2+2
	Depth Elective - V	3+1
	Depth Elective - VI	2+2

SEMESTER-7		
Course Code	**Course Title**	**Credit Hours**
	Supervised Industrial Training – I	0+16
	Total	**0+16=16**

	Total	**12+5=17**

SEMESTER-8		
Course Code	**Course Title**	**Credit Hours**
	Supervised Industrial Training - II	0+16
	Total	**0+16=16**

Total Credit Hours: 130

List of Electives:

S. No.	Course Code	Course Title	Credit Hours
1		High Voltage Engineering	3+1
2		Control of Power Electronics System	3+1
3		Hydropower and Energy Storage Technologies	3+1
4		Modelling and Optimization of Energy Systems	2+2
5		Smart Grid System	2+2
6		Electrical Machine	2+2
7		Heating, Ventilation, and Air Conditioning Systems	2+2
8		Production Planning and Control	3+0
9		Energy in Transportation	3+0
10		Manufacturing Engineering	3+0
11		Bio-Energy System	3+0
12		Hydrogen and Fuel Cell	3+0
13		Combine Heat and Power Energy System	3+0
14		Geothermal and Tidal Energy	3+0
15		Nuclear Energy Engineering	3+0

COURSE OUTLINES

1. Power Transmission and Distribution

Objectives: The course presents basics of electrical power transmission along with electrical and mechanical design impacts on power transmission in detail and HVDC transmission is introduced.

Course Outline: Percent and per-unit quantities, selection of base and change in base of per unit quantities, node equations, one-line diagram, choice of voltage and choice of AC/DC systems, economic comparison of various transmission systems, standard voltages in Pakistan and abroad for transmission and sub-transmission. Introduction to HV, EHV and UHV system. Conductor types; resistance, skin 48 effect, line inductance based and flux considerations. Inductance of single phase and three phase lines, inductance of composite conductor line, inductance of bundled conductors, capacitance of single phase and three-phase lines, effect of earth on capacitance, capacitance of bundled conductors, parallel circuit lines, Ferranti effect. Short, medium and long transmission lines, solution of equations. Traveling waves, surge impedance loading, equivalent circuit, and power flow through the line, voltage regulation and line surges. Line supports, sag and tension calculation, total length of conductor supports at various levels, mechanical degree of safety, effect of wind pressure and ice loading, conductor vibration and use of dampers. Insulator material, types of insulators,

voltage distribution over insulator string, string efficiency, methods of improving the string efficiency, testing of insulators, corona effect, corona loss, radio interference due to corona. Underground cables: types, calculation of inductance and capacitance, insulation resistance, insulation breakdown of cables, thermal characteristics of cables, calculation of current rating of the cables, fault locating techniques, cable jointing techniques. Introduction and classification of HVDC transmission.

Recommended Books:

1. Stevenson, "Elements of Power System", Latest Edition.
2. Grainger and Stevenson, "Power System Analysis", Latest Edition.

2. Electrical Machines

Objectives: Covers detailed and in-depth aspects of Electrical Machines.

Course Outline: Transformers: Equivalent Circuit, per unit system of measurement, voltage regulation and efficiency, three phase transformers, types of connections, testing, and parallel operation. Synchronous Generators: Equivalent circuit and operations, Characteristics of Salient and Non-Salient poles, model parameters, Single and parallel operation, ratings. Synchronous Motors: Basic Principle, Equivalent Circuit, steady state operation: Torque speed characteristics, power factor correction, starting of synchronous motors, ratings, speed control. Induction Motors: Production of rotating field and torque, Construction, Synchronous speed, Slip and its effect on rotor frequency and voltage. Equivalent circuit. Power and torque. Losses, efficiency and power factor. Torque-speed characteristic. Starting and speed control. Induction generator. Lab Outline: Based on above course contents

Recommended Books:

1. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw-Hill. (Latest Edition)
2. Hubert, "Electric Machines Theory, Operation, Applications, Adjustment and Control", (Latest Edition).

3. Conventional Electrical Power Generation

Objectives: The students learn different power plant and modes of energy conversion to generate electrical energy in this course and the concepts of fuel cells are introduced.

Course Outline: Thermal Power Plants: Sources of conventional energy and method of harnessing, specific features and cycles used in steam, gas and diesel power plants, combine cycle systems and cogeneration. Location of the above plants and selection of units, prime movers and associated equipment. Hydroelectric Power Plants: The plants and their equipment, layouts, run of the river and accumulation type station, types of hydroelectric turbines and their stations. Nuclear Power Plants: Nuclear reaction, fission and fusion reaction, critical mass chain reaction, moderators, reactor control and cooling, classification of reactors, different types of reactors, radiation damages, shielding of grays neutrons, materials for construction. Thermoelectric Generators: Thermoelectric effect, solid state description of thermoelectric effect, analysis and design of thermoelectric generators, figure of merit, device configuration, solar and radioisotope powered generators, applications. MHD Generators: Gaseous conductors, analysis and design of MHD generator, problems associated with MHD generation, possible configuration. Photovoltaic Generators: Radiation principles, optical effects in semiconductors and PN junction, analysis and design of converter, fabrication of cells, solar cells in space. Fuel Cells: Thermodynamic principles, efficiency of fuel cell factors limiting the performance, design, new development in fuel cells, possibility of future use in electric vehicles. Wind power generation.

Recommended Books:

1. Arche W. Culp, "Principles of Energy Conversion", Latest Edition.
2. M.M. Wakel, "Power Plant Technology", McGraw-Hill, Latest Edition.

4. Energy in Transportation

Objectives: Students are introduced to the basics of electrical distribution systems for transportation.
Course Outline: Introduction to distribution system. Urban, suburban and rural distribution systems. Primary, secondary and tertiary voltages. Radial and ring main systems, application of distribution transformers, estimation of load, load characteristics, substation switch gears and bus bar arrangements, calculation of voltage drop and regulation in distribution feeders. Grounding and earthing, distribution transformer neutral, earthing resistance, earthing practice in L.V. networks. Power Factor: Disadvantages and causes of low power factor, methods for improvement, application of shunt capacitors in distribution network. Batteries & Electrochemical Processes: Main types of batteries and their working, battery charging, electroplating, electrolysis and electro-metallurgical process. Cathodic protection of poles, gas pipes, oil pipes and water structures. Heating and Welding: Electric heating, resistance, induction and dielectric heating, electric furnaces, microwave heating, electric welding, resistance welding and its types. Fundamentals of Illumination Engineering: Laws, units and terms used, requirements for good lighting, illumination schemes for various situations (street lighting, commercial/industrial lighting, stadium/flood/stage/spot lighting etc.), types of lamps, their working and relative merit.
Recommended Books:

1. M. L. Anand, "A Text Book of Electrical Power", Latest Edition.
2. Turan Gonen, "Electrical Power Distribution System", Latest Edition.

5. Power System Analysis

Objectives: This course has been designed to introduce the importance of analyzing various aspects of power system. It covers power flow studies and fault analysis of both symmetrical and unsymmetrical faults in power networks. This forms the basis for power system operation, control and protection.
Course Outline: The Admittance Model and Network Calculations: Branch and Node admittances; Mutually coupled Branches in Y-bus; Equivalent Admittance Network; Modification of Y-bus; Impedance matrix and Y-bus; the method of successive elimination; Node Elimination (Kron Reduction); Triangular Factorization. The Impedance Model and Network Calculations: The bus, admittance and impedance Matrices; Thevenin's Theorem and Z-bus; Modification of an existing Z-bus; Direct determination of Z-bus; Calculation of Z-bus elements from Y-bus; Power Invariant Transformations; Mutually coupled branches in Z-bus. Symmetrical Faults: Transients in RL circuits; internal voltages of loaded machines. Under fault conditions; fault calculations using Zbus; Equivalent circuits; Selection of circuit breakers. 45 Symmetrical Components and Sequence Networks: Synthesis of unsymmetrical phasors; symmetrical components of unsymmetrical phasors; Networks of a symmetrical Transmission line; sequence Networks of the synchronous Machines; Sequence Networks of Y-impedances; sequence networks; positive, negative and zero sequence networks; Unsymmetrical Faults: Unsymmetrical faults on power systems; single line-to-ground faults; line-to-line faults. Double line-to-ground faults; Demonstration problems; open conductor faults.
Recommended Books:

1. B. S. William, "Elements of Power System Analysis", McGraw Hill, Latest Ed.
2. B. M. Weedy, "Electrical Power Systems", Pergamon Press, Latest Ed.
3. Hadi Saadat, "Power System Analysis", Latest Ed.

6. Power System Protection

Objectives: The course presents diverse types of relays, relaying schemes, circuit breakers and fuses. Topics like discrimination and coordination are also introduced.
Course Outline: Introduction to protection system, types of faults, effect of faults, fuse as protective device, types of fuses, characteristics of fuses, selection and application of fuses, discrimination and coordination, current transformer and its operation, relay construction, basic relay terminology, electromagnetic relays, thermal relays, static relays and introduction to microprocessor based

protective relays, over current protection, distance protection, impedance relay, R-X 47 diagram of impedance relay, operation of impedance relay in different zones, reactance relay, differential protection of transformers, generator protection, bus bar protection, arc voltage, arc interruption, re-striking voltage and recovery voltage, resistance switching, current chopping circuit breaker, classification of circuit breakers, oil circuit breakers, air blast circuit breakers, air break circuit breakers, SFB6B circuit breakers, vacuum circuit breakers, operational mechanism and rating of circuit breakers.

Recommended Books:

1. S. Rao, "Switchgear and Protection", Khanna Publisher, Latest Edition.
2. Paithanker & Bhide, "Fundamentals of Power System Protection", Prentice Hall, Latest Edition.

7. High Voltage Engineering

Objectives: The demand for the generation and transmission of copious amounts of electric power today, necessitates in transmission at extra-high voltages. At this juncture, a practicing electrical engineer or a student of electrical engineering is expected to possess knowledge of high voltage techniques and should have sufficient background in high voltage engineering. Upon completion of this course, the participant shall be able to understand high voltage basics and its application appreciate the design principles and critical elements of a high voltage system.

Course Outline: Introduction, testing voltages, Generation of High Voltages, Measurements of High Voltages, Electrostatic Field and field stress control, Breakdown Mechanism of Gases, Breakdown in Solids and Liquids, Breakdown in Solids and Liquids, Non-destructive testing technique, Over voltages, Testing procedure and insulation coordination, Over voltages, Testing procedure and insulation coordination, Transients in Power Systems

Recommended Book:

1. High Voltage Engineering by C.L Wadwa

Recommended Text(s)/Reference Books:

2. High Voltage Engineering by M S Naidu
3. High Voltage Engineering Fundamentals by E. Kuffel

8. Introduction to Renewable Energy

Objectives: Students are introduced to different types of renewable energy resources by engaging in various activities to help them understand the transformation of energy (solar, water, nuclear, biomass and wind) into electricity. Students explore the different roles engineers who work in renewable energy fields have in creating a sustainable environment – an environment that contributes to greater health, happiness and safety.

Course Outline: Promising renewable energy sources, their potential availability and present status, existing technologies and availability, solar energy: Sun-Earth relationship, solar geometry, sun path and solar irradiance, solar spectrum. Solar constant, atmospheric effects, global distribution, effects of tilt angle, daily and seasonal variations, resource estimation. Extraterrestrial, global, direct, diffused radiation, Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency, Photovoltaic: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power spectral response, fill factor, temperature effect; PV systems, components, modules, arrays, controllers, inverters, storage, PV system sizing, performance and applications, Wind: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect., Hydropower: Global resources, and their assessment, classification, micro, mini, small and large sources principles of energy conversion; turbines, their working and efficiency for micro to small power systems,

environmental impact, Biogas: Biomass sources; residue, farms, forest. Solid wastes; agricultural, industrial and municipal wastes etc.; applications, traditional and nontraditional uses: utilization, process, gasification, digester, types, energy forming, Environment issues, Geothermal: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects, nuclear: Global generations of reserves through reprocessing and breeder reactors, growth rate prospect of nuclear fusion, safety and hazards issue.

Recommended Book:

1. Manfred Grathwhol. World Energy Supply: Resources, Technologies and Prospective, Walter de Gruyter-Berlin, Latest edition
2. J.W Twidell and A.D. Weir. Resources, E & F.N. Spon Ltd, London, Latest edition
3. M Iqbal. An Introduction to Solar Radiation, Academic Press, Canada, Latest edition
4. Simon Roberts. A Practical Guide to Solar Electricity, Prentice Hall, Latest edition
5. Martin A G. Solar cells: Operating Principles, Technology, & System Application, Prentice Hall, Latest edition
6. T.J. Jansen. Solar Engineering Technology, Prentice Hall, Latest edition
7. Daniel H' Wind Power. A Book on Wind Energy Conversion System, Litton Educational Press, Latest edition

9. Introduction to Environmental Engineering

Objectives: This course examines the scientific and engineering aspects of energy production, transformation, and consumption, investigates the energy flows in the Earth's systems, and provides students with necessary engineering approaches and techniques for understanding, assessing, and remediating environmental problems associated with energy production, transformation, and consumption.

Course Outline: Introduction: Getting Power to the People (Energy and Environment); Sources of energy, Renewable and non-renewable energy resources, Economics of energy production and consumption Global Politics and Strategies, Making global and local decisions on the structure of utilized energy sources, Energy and Society; Thermodynamic Principles of Energy Conversion; Flue gases, NOx formation and reduction, Combustion emission control, Thermodynamic fundamentals, Natural gas combustion, Coal combustion, Estimating steam power; Global Energy Use and Supply, Renewable resources and fossil fuels, Hydraulic, geothermal, wind, tidal, solar, biomass energies, Oil, gas, coal, and oil shale energy production, Environmental consequences of the fossil fuels production and utilization; Nuclear Energy; Fundamentals of nuclear power, Nuclear power systems, Comparing fission and fusion energies, Nuclear power health effects, Safety requirements for nuclear power plants, Radioactive waste management and disposal; Alternative Fuels and Advanced Technologies (Renewable Energy).

Recommended Book:

1. James A. Fay and Dan S. Golomb, 2002, Energy and the Environment, OXFORD University Press, 198 Madison Avenue, New York, NY, 10016.
2. On Global Forces of Nature Driving the Earth's Climate. Are Humans Involved, by L.F. Khilyuk and G.V. Chilingar, 2006, Environmental Geology, 50: 899-910

10. Renewable Sources and Distributed Power Generation

Objectives: The course has been designed to help students understand the concept of distributed generation. The course will also enhance the skill of students to analyses the impact on grid integration & to study concept of microgrid and its configuration.

Course Outline: Introduction to distribution generation system, renewables application as distribution sources, concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements. Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues. Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics.

Recommended Book:

1. Integration of Distributed Generation in the Power System by Math Bollen And Fainan Hassan
2. Voltage Source Converters in Power Systems: Modeling, Control and Applications", Amir naserYezdani, and Reza Iravani, IEEE John Wiley Publications.
3. "Power Switching Converters: Medium and High Power", Dorin Neacsu, CRC Press, Taylor & Francis, 2006.

11. Energy Conservation and Auditing

Objectives: This course provides students with a good theoretical knowledge and understanding of power system economics. The basic principles of power system economics (main regulatory regimes and pricing principles) will be analysed in order to combine power system analysis and economic appraisal, providing an insight and ability to estimate future developments. Technical and economic implications of transition to a low-carbon energy systems will be discussed.

Course Outline: Power market fundamentals; pricing power, energy, and capacity; power supply and demand; Marginal cost in a power market; Market structure; Reliability and investment policy; reliability and generation; operating reserve pricing; requirement of installed capacity; Market architecture; day ahead market design; ancillary services; Market for operating reserves; defining Market power, modelling market power.

Recommended Book:

1. Power System Economics: Designing Market for Electricity by Steven Stoft
2. Fundamentals of Power System Economics by Daniel S. Kirschen, Goran Strbac

12. Modelling and Optimization of Energy Systems

Objectives: Students will understand the operation of power networks from a control and optimization perspective. They will learn how mathematical tools and computational methods are used for the design, modelling, planning, and real-time operation of power grids.

Course Outline: Introduction to optimization, Meaning of optimization, Types of problems, Linear programming, Basic solution, Simplex method and LU decomposition, Unconstrained optimization, Minimization and maximization of convex functions, Gradient descent method, Method of steepest descent, Newton's method, Multi objective optimization problems, Evolutionary optimization algorithms, Economic Dispatch, DC Optimal Power Flow, AC Optimal Power Flow, Power optimization problems such as state estimation, unit commitment, optimal power flow, and transmission planning, Efficient optimization and numerical algorithms for mixed-integer nonlinear problems, Control and optimization for renewable energy, Unit commitment.

Recommended Book:

1. An Introduction to Optimization by E.K. Chong and S.H. Zak, Wiley-Interscience.

2. Convex optimization Stephen Boyd, and Lieven Vandenberghe, Cambridge university press, 2004.
3. Allen J. Wood, Bruce F. Wollenberg, and Gerald B. Sheble, Power Generation, Operation, and Control (3rd edition), Wiley, 2013.

- Following are the changes proposed in the BEE 2018 roadmap:

Sr. No.	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical	ACM (Approved)	ACM (Updated)
1	XXXX	EEXXX	Breadth Core- 1	3+1	3	1		
2	EEN 313	EEN 412	Linear Control Systems	3+1	3	1	22nd	32nd
3	None	MGTXXX / HSS XXX	Management Science Elective 1	2+0	2	0		
4	XXXX	EEXXXX	Depth Elective 1	3+1	3	1		
5	XXXX	EEXXXX	Breadth Core-2	3+1	3	1		
Total Credit Hours in Semester-6				18	14	4		

The depth electives are now proposed to be offered from following domains:

a. Telecommunication Engineering
b. Electronics Engineering
c. **AI & Robotics**

Following are the recommended for the breadth electives for the new domain.

Sr. No.	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical	ACM (Approved)	ACM (Updated)
1	None	EEA 430	Introduction to Mechatronics	3+1	3	1	22nd	IDEE in 32nd
2	None	CSC 419	Introduction to Machine Learning	3+1	3	1	32nd	32nd

Following are the recommended depth electives for the new domain.

Sr. No.	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical	ACM (Approved)	ACM (Updated)
1	None	CSC 419	Introduction to Machine Learning	3+1	3	1	32nd	32nd

2	CSC 411	CEN 458	Robotics	3+1	3	1	26th	32nd
3	EEN 224	EEN 316	Instrumentation and measurement	3+1	3	1	22nd	32nd
4	EEN 313	CEN 444	Digital Image Processing	3+1	3	1	22nd	32nd
5	EEN 325	ESC 471	Biomedical Instrumentation	3+1	3	1	32nd	32nd
6	None	ESC 472	Medical Robots	3+1	3	1	32nd	32nd

Lahore University of Management Sciences

CS6712 – Topics in Internet Measurement

Fall 2022

COURSE DESCRIPTION
This is a graduate-level course that will introduce students to the exciting field of Internet Measurement. It involves significant paper reading and a semester long research project. The Internet is one of the most sophisticated and gigantic systems the humans have engineered. Many aspects of it's operation and usage are either opaque or in continuous evolution, and can only be understood through measurement. The questions of interest range from understanding the Internet topology, how routing on the Internet operates, to understanding the workings and use of both the Internet infrastructure (DNS, Certificate Authorities) and Internet applications (YouTube, OSNs, mobile applications). The field of Internet measurement seeks to provide answers via methodological data collection and empirical analysis. Some interesting questions that we will look at in this course are: "what fraction of the IP address space is alive?, "what is censored online and how?", "what personally identifiable information are we leaking to third parties on online social networks?", "how widely is HTTPS interception happening on the Internet?", and "what fraction of online advertising revenue is generated through fraudulent means?".

Course Distribution	
Core	No
Elective	Yes
Open for Student Category	All
Close for Student Category	None

COURSE PREREQUISITE(S)	
	Computer Networks, Basic Probability/Stats (Exceptions possible with prior instructor approval)

Course Offering Details				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 mins
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	--	Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week	--	Duration	

Instructor	Dr. Mobin Javed
Room No.	SSE 9-G10A
Office Hours	Tue and Thu 12:15-1:15PM (right after class meetings)
Email	mobin.javed@lums.edu.pk
Telephone	-
Secretary/TA	None
TA Office Hours	None
Course URL (if any)	-

Course Teaching Methodology
• **Teaching Methodology:** This is a discussion based class with a fairly small class size (~20 students). The class will be conducted in person.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
PEO-01	Demonstrate excellence in profession through in-depth knowledge and skills in the field of Computing.
PEO-02	Engage in continuous professional development and exhibit quest for learning.
PEO-03	Show professional integrity and commitment to societal responsibilities.

COURSE OBJECTIVES	
	The goal of this course is three-fold: (i) for the students to develop an appreciation for the complexity of the Internet and how we can understand its use and operation, (ii) to train students to conduct Internet measurement studies, and (iii) to familiarize them with important research literature and open problems in the field

COURSE LEARNING OUTCOMES (CLOs)	
CLO1: CLO2: CLO3: CLO4:	By the end of this course, the students will be well-versed with: • Internet measurement tools (ping, traceroute, Zmap, Scamper) • Measurement platforms (Ark, PlanetLab, RIPE Atlas) • How to conduct Internet measurement studies soundly • Important measurement studies on - Internet Routing - IP Address Utilization - Infrastructure Health (DNS, Certificate Authorities) - Internet Security - Internet Censorship - Online Privacy - Online Social Networks
CLO5: CLO6: CLO7:	Students will also develop the following research skills: • Reading and critiquing papers • Conducting a literature survey • Conducting a measurement research project and presenting research results

CLO	**CLO Statement**	**Bloom's Cognitive Level**	**PLOs/Graduate Attributes (Seoul Accord)**
CLO1	Be well-versed with commonly used Internet measurement tools (ping, traceroute, Zmap, Scamper)	C3	PLO2
CLO2	Be well-versed with prominent Measurement platforms (Ark, PlanetLab, RIPE Atlas)	C3	PLO2
CLO3	Learn how to conduct Internet measurement studies soundly	C3, C5, C6	PLO2
CLO4	Be well-versed with important measurement studies on Internet Routing , IP Address Utilization, Infrastructure Health (DNS, Certificate Authorities), Internet Security, Internet Censorship, Online Privacy, Online Social Networks	C1, C2	PLO3, PLO4

CLO5	Research skills development: reading and critiquing papers	C4, C5	PLO2, PLO3
CLO6	Research skills development: Conducting a literature survey	C2	PLO2, PLO3
CLO7	Research skills development: Conducting a measurement research project and presenting research results	C5, C6	PLO5, PLO7

Grading Breakup and Policy

Assessment	Weight (%)	Related CLOs	ACM Recommended Disposition
Assignments	18%	CLO3, CLO4, CLO5	D3, D4, D7, D9
Quizzes + Midterm	25%	CLO1, CLO2, CLO3, CLO4, CLO5, CLO6	D4, D7, D9
Class Participation	7%	CLO5	D3, D4, D7, D9
Project	50%	CLO6, CLO7	D1, D3, D4, D5, D6, D7, D8, D9, D11

This class does not have a final exam by design, since I would like the students to focus on their class projects towards the end of semester (50% of the grade). Assessment of the course material understanding will be the done throughout the course via quizzes and a midterm exam.

Assignments: The assignments are designed to help students develop research skills. The students are expected to present at least one paper (45 - 50mins) to the class, and submit written summaries and critiques of papers for 2-3 class meetings (4-6 papers). The instructor will help the students with the preparation of the class presentation, giving feedback on the structure and contents via a trial run.

Midterm: The midterm will be a take-home research exam with 8-10 days allowed to attempt the exam.

Projects: Class projects form a major component of this course. The projects should be done in teams of two (or solo with instructor approval). The instructor will provide a list of projects to choose from. Students are also welcome to propose their own projects.

Some of these projects will continue into the next semester and we will eventually submit the research results to a measurement conference.

Here is an example paper that students of the Fall 2019 offering of this course have published:

Using Application Layer Banner Data to Automatically Identify IoT Devices
Talha Javed, Muhammad Haseeb, Muhammad Abdullah, and Mobin Javed
ACM SIGCOMM Computer Communication Review (CCR), July 2020

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: Duration: Preferred Date: Exam Specifications:
Final Exam	Yes/No: No Combine Separate: Duration: Exam Specifications:

COURSE OVERVIEW

Please check the readings and timelines here

Introduction to Systems Engineering

Introduction to Systems Engineering	
Course Code:	EEN 451
Credit Hours:	3
Pre-requisite:	None
Objectives:	This course is aimed at introducing students to the fundamen principles of systems engineering (SE) and their application to t development of complex systems. It describes how SE viewpoint c be brought to address engineering challenges as well as the essen role of systems engineering in project management. Some of the k SE standards will be covered and the roles of organizations enabling engineers to develop systems will be explored. Applicatio of SE concepts and tools in various settings will be discussed throu examples and case studies. Student will get knowledge of real-wo experience and case studies of working with a system through phases of the system design process. Student will explore real-wo problems to develop an understanding of systems engineering cycle processes and analytical techniques. Students will learn apply the SE methodologies in modern complex syst development environments such as aerospace and defen transportation, energy, communications, and modern softwa intensive systems. Each student will complete a project based o system or enterprise of their choice. Students will explore the forr system modeling and simulation methods using software-bas approaches, which are replacing more traditional document-bas descriptive modeling methods. Students will use standardiz modeling techniques especially SysML (Systems Modeling Langua computer packages, allowing greater consistency in system mo representations between technologies, across industries, and ev across language barriers to represent system models in detail a provide complex system simulations with minimum effort us several different system modeling and simulation softwa platforms. The objective is to be able to determine when and h model-based systems engineering (MBSE) approaches are usef which tools to use, and which data to use as input to the MBSE to and how to use the results from the tools in decision making.
Course Learning Outcomes (CLOs):	Upon completion of this course, the student will be able to: **CLO 1:** (C1): **Define** and **identify** the steps required to describe a proposed system concept through a Concept of Operations (CONOPS) document. **CLO 2:** (C2)**: Explain** the fundamentals of systems requirement and high-level design document. **CLO 3:** (C2): **Explain** the fundamentals of comprehensive System Engineering Management Plan (SEMP). **CLO 4:** (C3): **Apply** the tools required for implementation of MBSE.

Course Outline:	• Concept of Operations (CONOPS) ➢ Purpose of CONOPS ➢ Project Scope & Overview ➢ Existing Project details & Current Operational Status ➢ Justification for changes ➢ Proposed System concept ➢ Relevant Stakeholders ➢ User Needs ➢ System Overview & Operational Environment ➢ Support Environment ➢ Operational Scenarios ➢ Summary of Impacts. • Systems requirement and high level design document ➢ "Actors" and their roles ➢ The "stories" used for requirements discussions ➢ Notes from the requirements meetings with stakeholders ➢ System Primary Objectives and Purpose ➢ High Level Design Objectives, Constraints and Principles ➢ Core System High Level Design ➢ System Components Design ➢ Decision Support System Design • System Engineering Management Plan (SEMP) ➢ System configuration management ➢ System verification plan ➢ System deployment plan ➢ Evaluation strategy ➢ Operations and maintenance plan ➢ System verification plan ➢ System deployment plan ➢ Evaluation strategy ➢ Operations and maintenance plan • Model-based systems engineering (MBSE) ➢ Tools for MBSE ➢ Data as input to the MBSE ➢ How to use the results from the tools in decision making ➢ SysML software.
Resources:	Textbook: Systems Engineering Principles and Practice 2nd Edition by Alexander Kossiakoff William N. Sweet Samuel J. Seymour Steven M. Biemer

	Reference Book: INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, 4th Edition
Tools	SysML

Mapping of CLO to PLOs

Contribution: Average:1, Moderate:2, Strong:3

CLOs	**MAPPED PLO**	**LEVEL**	**CONTRIBUTION**
CLO 1: (C1): **Define** and **identify** the steps required to describe a proposed system concept through a Concept of Operations (CONOPS) document.	PLO 1	C1	3
CLO 2: (C2)**: Explain** the fundamentals of systems requirement and high-level design document.	PLO 3	C2	3
CLO 3: (C2): **Explain** the fundamentals of comprehensive System Engineering Management Plan (SEMP).	PLO 11	C2	3
CLO 4: (C3): **Apply** the tools required for implementation of MBSE.	PLO 5	C3	3

Grading Rubric

Assessment Method	**CLO 1**	**CLO 2**	**CLO 3**	**CLO 4**
Final Exam (50)	10	15	15	10
Midterm Exam (20)	10	10	X	X
Assignments (20)	5	5	5	5
Quizzes (10)	2.5	2.5	2.5	2.5
Total (100)	27.5	32.5	22.5	17.5

Sports Engineering (Theory)

Sports Engineering (Theory)	
Course Code:	EEN-450
Credit Hours:	3
Pre-requisite:	
Objectives:	This course introduces the fundamental concepts of measurement techniques in sports engineering and biomechanics. This course addresses the data analysis and manipulation using programmatic tools. Different aspects of the biomechanics of an athlete like walking, running gait, swimming, in the context of both performance improvement and injury prevention is covered. Engineering principles and considerations around the design of specific sports equipment is discussed.
Course Learning Outcomes (CLOs):	**CLO 1:** (C2): **Comprehend** the Engineering of Sports, Biomechanics, Aerodynamics and Sports instruments. **CLO 2:** (C3): **Implement** the mathematical modelling technique for Sports Engineering **CLO 3:** (C5): Analyze the performance of an athlete in different sports and **design** the sports equipment for optimal performance
Course Outline:	• The Effect of Engineering on Sports • Projectile Aerodynamics • Vehicular Aerodynamics • Introduction to biomechanics of human body movement • Biomechanics of walking/running • Biomechanics of Throwing • Biomechanics of Swimming • Computer Simulation/Modelling in Sports • The physics of ice-hockey • The physics of Golf • The Science and Engineering of Golf Balls • Solid Mechanics and Aerodynamics of Cricket Balls • Biomechanics research and sport equipment development. • Disability in sports • Safety in Sports
Resources:	Text Book: **"Instant Notes in Sport and Exercise Biomechanics ", 1st Edition, Paul Grimshaw, Neil Fowler, Adrian Lees, Adrian Burden** Reference Books:

	• " The Engineering of Sports: Design and Development ",Steve Haake • "The Engineering of Sport 7" , Vol 2, Margaret Estivalet, Pierre Brisson, Springer
Tools	MATLAB

Mapping of CLO to PLOs

Contribution: Average:1, Moderate:2, Strong:3

CLOs	**MAPPED PLO**	**LEVEL**
CLO 1: Comprehend the Engineering of Sports, Biomechanics, Aerodynamics and Sports instruments.	PLO 1	C2
CLO 2: Implement the mathematical modelling technique for Sports Engineering	PLO 5	C3
CLO 3: Analyze the performance of an athlete in different sports and **design** the sports equipment for optimal performance.	PLO 3	C5

Grading Rubric

Assessment Method	CLO 1	CLO 2	CLO 3
Final Exam	10	20	20
Midterm Exam	10	10	0
Assignments	10	5	5
Quizzes	4	3	3
Total (100)	34	38	28

Computer Vision

Computer Vision	
Course Code:	CSC-464
Credit Hours:	3
Pre requisite:	None
Objectives:	• Describe the scope of challenges and applications addressed by computer vision • Undertake video analysis problems

	Explain the application of neural networks and convolutional neural network to computer vision
Course Learning Outcomes (CLOs):	**CLO 1:** (C2): To understand and **interpret** the basic concepts and challenges addressed by computer vision. **CLO 2:** (C4): To **apply** a variety of computer vision algorithms to extract features and interpret the results. **CLO 3: (C5):** To **analyze** the results of application of different classification algorithms for computer vision on real world problems.
Course Outline:	• Overview, computer imaging systems, lenses • Image formation and sensing • Image analysis and preprocessing • Binary image analysis • Edge detection • Edge detection performance, Hough transform, corner detection • Feature extraction, shape, histogram, color, spectral, texture • Feature analysis, feature vectors, distance /similarity measures, data preprocessing • Pattern classification • Image Classification, kNN, SVM, Softmax, Fully Connected Neural Network • Convolutional Neural Networks: Architectures, Convolution / Pooling Layers layers, spatial arrangement, layer patterns, layer sizing patterns, AlexNet/ZFNet/VGGNet case studies, computational considerations
Resources:	• Digital Image Processing and Analysis: Application with MATLAB and CVIPtools, 3rd EditionTensorFlow, by Aurélien Géron (2017) • Computer Vision: A Modern Approach Pearson Education by David A. Forsyth, Jean Ponce
Tools	• Matlab, Anaconda/Python/google colaboratory

Mapping of CLO to PLOs

Contribution: Average:1, Moderate:2, Strong:3

CLOs	MAPPED PLO	LEVEL	CONTRIBUTION
CLO 1: (C2): To understand and interpret the basic concepts and challenges addressed by computer vision.	PLO 1	C2	3
CLO 2: (C4): To apply a variety of computer vision algorithms to extract features and interpret the results.	PLO2	C4	3
CLO 3: (C5): To analyze the results of application of different classification algorithms for computer vision on real world problems.	PLO4	C5	3

Grading Rubric

Assessment Method	CLO 1	CLO 2	CLO 3
Final Exam	20	25	5
Midterm Exam	15	5	x
Assignments	x	5	15
Quizzes	2	4	4
Total (100)	37	39	24

Fundamentals of Quantum Computing

Fundamentals of Quantum Computing	
Course Code:	EEN 462
Credit Hours:	3+1
Pre-requisite:	
Objectives:	Quantum computing is an area of computing focused on developing computer technology based on the principles of quantum theory, which explains the behavior of energy and material on the atomic and subatomic levels. The objective of this course is to develop the basis of quantum computing concepts and its applications.
Course Learning Outcomes (CLOs):	CLO 1: [C2] **Describe** the basic of vector algebra and spin concept. CLO 2: [C4] **Analyze** the working of quantum gates and circuits. CLO 3: [C3] **Implement** the quantum computing algorithms.
Course Outline:	1. Spin 2. Linear Algebra 3. Spin and Qubit 4. Entanglement 5. Bell's Inequality 6. Classical Logic 7. Gates and Circuits 8. Quantum Gates and Circuits 9. Quantum Algorithms

	10. Impact of Quantum Computing
Resources:	Text Book: • "Quantum Computing for Everyone", Chris Bernhardt ,1st edition. Reference Book: • "Quantum Computing for Computer Scientists", Noson S. Yanofsky, Brooklyn College, City University of New York, Mirco A. Mannucci, HoloMathics, LLC, Virginia. 1st Edition

Mapping of CLO to PLOs

Contribution: Average:1, Moderate:2, Strong:3

CLOs	MAPPED PLO	LEVEL	CONTRIBUTION
CLO1: Describe the basic of vector algebra and spin concept.	PLO 1	C2	3
CLO2: Analyze the working of quantum gates and circuits.	PLO 5	C4	3
CLO 3: Implement the quantum computing algorithms.	PLO4	C3	2

Grading Rubric

Assessment Method	CLO 1	CLO 2	CLO3
Final Exam	X	30	20
Midterm Exam	5	15	X
Assignments	5	10	5
Quizzes	2.5	5	2.5
Total (100)	12.5	70	17.5

Fundamentals of Quantum Computing (Lab)

Fundamentals of Quantum Computing (Lab)	
Course Code:	EEL 462
Credit Hours:	1
Pre-requisite:	
Objectives:	This laboratory is designed to provide the student with practi demonstrations of the fundamental principles of Quantu Computing. It uses IBM Qiskit to design the quantum circuits.
Course Learning Outcomes (CLOs):	**CLO 1:** (C1): Basic **knowledge** of Quantum gates. **CLO 2:** (C4): Develop the ability to simulate, **analyze** the operations of different blocks in IBM Qiskit. **CLO 3:** (P5): **Construct** different type of applications using Qiskit library.
Course Outline:	• Virtual Quantum Lab- Spin experiment (CLO1) • Virtual Quantum Lab- laser beam experiment (CLO1) • Virtual Quantum Lab- H-gate experiment (CLO2) • IBM Qiskit- Setup (CLO2)

	• IBM Qiskit- basic gate implementation (CLO2) • IBM Qiskit- Results analysis (CLO2) • IBM Qiskit- Circuit design (CLO3) • C Coding- Application 1 emulator design (CLO2) • IBM Qiskit- Application 1 implementation (CLO3) • C Coding - Application 2 emulator design (CLO2) • IBM Qiskit- Application 2 implementation (CLO3) • C Coding - Application 3 emulator design (CLO2) • IBM Qiskit- Application 3 implementation (CLO3)
Resources:	Text Book: • "Quantum Computing for Everyone", Chris Bernhardt Reference Book: • "Quantum Computing for Computer Scientists", Noson S. Yanofsky, Brooklyn College, City University of New York, Mirco A. Mannucci, HoloMathics, LLC, Virginia.

Mapping of CLO to PLOs

Contribution: Average:1, Moderate:2, Strong:3

CLOs	MAPPED PLO	LEVEL	CONTRIBUTION
CLO 1: Basic knowledge of Quantum gates.	PLO 1	C1	3
CLO 2: Develop the ability to simulate, analyze the operations of different blocks in IBM Qiskit.	PL05	P4	3
CLO 3: Construct different type of applications using Qiskit library.	PLO3	P5	3

Grading Rubric

Assessment Method	CLO 1	CLO 2	CLO3
Final Viva (10)	x	5	5
Mid Viva (10)	4	4	2
Project (20)	5	5	10
Lab Assessment (40)	6	17	17
Lab Journal (20)	3	8	9
Total (100)	18	39	43

Appendage 2808

Rubric for Psychomotor Domain Assessment

Rubric for Psychomotor Domain Assessment Level: Perception (P1)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Describe functionality of tools/ Equipment	Sufficiently describe the functionality of tools / equipment	Appropriately describe the functionality of tools / equipment.	Partially describe the functionality of tools / equipment.	Cannot describe the functionality of tools / equipment.	
Identify the appropriate tool to solve problems based on given scenario	Identify all the tools / equipment to solve the problem correctly	Appropriately Identify tools / equipment to solve the problem	Partially Identify the appropriate tools / equipment to solve the problem	Cannot identify appropriate tool / equipment to solve the problem	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Set (P2)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Prepare and make necessary arrangement for experiment	Perfectly Prepares and make necessary arrangement for experiment.	Prepares and make necessary arrangement for experiment with less mistakes	Prepares and make necessary arrangement for experiment with few mistakes	Cannot prepare and make necessary arrangement for experiment.	
Demonstrate the procedure regarding usage of tools / equipment.	Demonstrate the procedure regarding usage of tools / equipment correctly	Demonstrate the procedure regarding usage of tools / equipment with less mistakes	Partially demonstrate the procedure regarding usage of tools / equipment with few mistakes	Cannot demonstrate the procedure regarding usage of tools / equipment	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Guided Response (P3)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Able to perform an experiment and solve the problem using tools by following instructions & practicing.	Follows the instructions to perform the experiment with accurate results and solve the problem using tools by practicing efficiently.	Follows the instructions to perform the experiment with good results and solve the problem using tools by practicing with better efficiency.	Follows the instructions to perform the experiment with satisfactory results and solve the problem using tools but does not practice	Follows the instructions to perform the experiment with no results and cannot solve the problem using tools by following instructions	
Attempts to minimize the error by practicing.	Completely minimize the errors by practicing.	Almost minimize the errors by practicing	Partially minimize the errors	Does not practice to minimize the errors.	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Mechanism (P4)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Display proficiency in handling of equipment / tools and measurement of system performance	Excellent display of proficiency in handling of equipment / tools. Measures system performance with confidence and no mistakes.	Display proficiency in handling equipment / tools with focus & commitment. Measures system performance with confidence, however, make some mistakes	Display proficiency in handling of equipment / tools with few mistakes. Measures system performance but results are not consistent	Unable to display proficiency in handing of equipment / tools. Unable to measure system performance	
Organizes the conduction of experiment effectively.	Organizes conduction of experiment within effective manner with full commitment.	Organizes conduction of experiment within effective manner with focus and energy	Organizes conduction of experiment with an effective manner with less focus and energy.	Unable to organize conduction of experiment in an effective manner.	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Complete Overt Response (P5)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Determine data to gather and interpreting data leading to findings	Comprehensive data gathering with complete interpretation leading to justifiable findings.	Correct data gathering with proper interpretation leading to justifiable findings.	Satisfactory data gathering with reasonable interpretation	Contain incorrect data gathering and didn't interpret data.	
Able to perform experiment with confidence	Can perform experiments with high accuracy	Can perform experiments with sufficient accuracy	Can perform experiments with partial accuracy	Perform experiment with less accuracy	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Adaptation (P6)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Propose viable solutions to account for problematic situations	Propose viable solutions using clear and structured justifiable findings to account for problematic situations.	Propose acceptable solutions with proper justifications to account for problematic situations.	Propose weak solutions to account for problematic situations	Unable to propose any viable solution to account for problematic situations.	
Able to use tools for special requirement	Able to modify the experiment to fit special and produce correct results.	Able to modify the experiment to fit special and produce partial results.	Able to modify the experiment to fit special requirement but cannot produce results	Cannot modify the experiment to fit special requirement	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Psychomotor Domain Assessment Level: Origination (P7)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Propose new movement patterns to account for new situations.	Propose new movement patterns using clear and structured justifiable findings to account for problematic/ new situations.	Propose new movement patterns using clear and justifiable findings to account for new situations.	Propose weak solutions/ new movement patterns to account for problematic/ new situations	Unable to propose any viable solution/ new movement patterns to account for problematic/ new situations.	
Able to create own strategy in solving problems	Able create own strategy having perfect efficiency with reliable results	Able create own strategy having partial efficiency with reliable results	Able create own strategy having less efficiency but results are not reliable	Unable to create own strategy in solving problems.	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Affective Domain Assessment

Rubric for Affective Domain Assessment Level: Receiving (A1)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Receive the information/instructions	Always listens and is open to new ideas	Mostly listens and is mostly open to new ideas	Often listens and is seldomly open to new ideas	Rarely listens and is reluctant to new ideas	
Follow the information/instructions	Follows the instructions all the time and is always attentive	Follows the instructions most of the time and is mostly attentive	Often follows the instructions is and is sometimes attentive	Rarely follows the instructions and is never attentive	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Affective Domain Assessment Level: Responding (A2)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Participate and respond in the learning process	Always shares the information and supports the efforts of others. Tries to keep people working well together	Usually shares the information, and supports the efforts of other, does not cause" ripples" in the group	Often shares the information, and supports the efforts of others, but sometimes is not a good team member	Rarely shares the information and supports the efforts of others. Mostly is not a good team member	
Communicate/answers effectively	Speaks clearly and distinctly all the time and mispronounces no words. Answers all the questions correctly.	Speaks clearly and distinctly most of the time and mispronounces some words. Answers more than half of the questions correctly.	Speech is not clear most of the time and mispronounces many words. Answers half the questions correctly.	Often mumbles or cannot be understood OR mispronounces most of the words. Answers less than half questions correctly or doesn't answer correctly at all	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Affective Domain Assessment Level: Valuing (A3)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Express opinion to offer a better solution to a problem	Routinely provides useful ideas when participating in the group discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group discussion. A strong group member who tries hard!	Sometimes provides useful ideas when participating in group discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group discussion. May refuse to participate.	
Justify the solution for a problem while performing tasks and convince other	Provides logical justification for personal opinions and can convince others	Usually provides logical justification for personal opinions and can usually convince others	Sometimes provide logical justification for personal opinions and can convince others seldomly	Rarely provides logical justification for personal opinions and can't convince others	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Affective Domain Assessment Level: Organization (A4)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Develop an environment conducive for learning	Always prioritizes values and resolves conflicts between group members.	Usually prioritizes values and resolves conflicts between group members.	Often prioritizes values and resolves conflicts between group members.	Rarely prioritizes values and resolves conflicts between group members.	
Focus on the task and attentiveness	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Lets others do the work.	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Rubric for Affective Domain Assessment Level: Characterization (A5)					
Criteria	**Grading scale**				**Total (30)**
	Excellent (15-12)	**Good (11.9-9)**	**Satisfactory (8.9 – 4.5)**	**Needs improvement (4.4 – 1)**	
Attitude towards problem solving	Actively looks for and suggests solutions to problems.	Refines solutions suggested by others.	Does not suggest or refine solutions but is willing to try out solutions suggested by others.	Does not try to solve problems or help others solve problems. Let's others do the work.	
Practice Time management	Submission of Task on time and be able to work excellently as an individual and always participates & supports the efforts of team members.	Submission of Task on time and be able to work good as an individual and usually participates & supports the efforts of team members.	Submission of Task late and be able to work satisfactory as an individual and often participate & supports the efforts of team members.	Submission of Task very late and not be able to work as an individual and rarely participate & supports the efforts of team members	

Lab No: _____

Total marks: _____

Marks obtained: _____

Teacher's signature: _____

Bachelor of Software Engineering

(Roadmap Applicable from Fall 2023 semester)

Campuses: Islamabad and Karachi
Regular Program Duration: 4 Years, 8 Semesters
Available Specialization: None
Program Timing: Morning

Eligibility Criteria:
Passed intermediate examination or its equivalent with a minimum of 60% marks in Pre-Engineering Group, or with Mathematics, Physics and Computer Science.

Program Education Objectives (PEOs):
PEO-1: Graduates should demonstrate competence in applying Software Engineering principles & practices in various phases of software/system development life cycle in their respective professional career.
PEO-2: Graduates should demonstrate effective team member or leadership skills with strong managerial skills and a sound sense of social responsibility for the sustainable development of society.
PEO-3: Graduates should demonstrate sustained career development and progression through ethical engineering practices, effective communication skills and continuous learning.

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.

Program Learning Outcomes (PLOs):
1. **Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

2. **Problem Analysis:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. **Design/Development of Solutions:** An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

4. **Investigation:** An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

5. **Modern Tool Usage:** An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

6. **The Engineer and Society:** An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

7. **Environment and Sustainability:** An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

9. **Individual and Team Work:** An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.

10. **Communication:** An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project Management:** An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.

12. **Lifelong Learning:** An ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

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	134
Number of credit hours per semester	15-18
Non-Engineering Courses	14 Courses, 36 Cr Hrs, 26.87 % of total
Engineering Courses	31 Courses, 98 Cr Hrs, 73.13 % 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	3	0	3	3	7	22.22%	5.97%
		Effective Communicatio n Skills	2	0	2				
		Technical Writing & Presentatio n Skills	3	0	3				
	Culture	Islamic Studies/Ethics	2	0	2	2	4	11.11%	2.99%
		Pakistan Studies and Global Perspective	2	0	2				
	Social Sciences	Social Sciences Elective 1	2	0	2	2	4	11.11%	2.99%
		Social Sciences Elective 2	2	0	2				
Management Sciences		Management Sciences Elective 1	3	0	3	2	5	13.89%	3.73%
		Management Sciences Elective 2	2	0	2				
Natural Sciences	Math	Applied Calculus & Analytical Geometry	3	0	3	4	12	33.33%	8.96%
		Linear Algebra	3	0	3				
		Probability & Statistics	3	0	3				
		Numerical Analysis	2	1	3				
	Physics	Applied Physics	2	1	3	1	3	8.33%	2.24%
Total			34	2	36	14	36	100%	26.87%

Courses of Engineering Domain

Knowledge Area	Course Title	Lec	Lab	Total	Total Courses	Total Cr. Hrs.	% Area	% Overall
Computing and	Computing Fundamentals	2	1	3	2	7	7.14%	5.22%

Information Sciences	Computer Programming	3	1	4				
Core Breadth of Engineering discipline	Introduction to Software Engineering	3	0	3	10	30	30.61%	22.39%
	Software Requirement Engineering	3	0	3				
	Design and Analysis of Algorithms	3	0	3				
	Software Design & Architecture	2	1	3				
	Software Construction	2	1	3				
	Software Quality Engineering	3	0	3				
	Human Computer Interaction	3	0	3				
	Cloud Computing	2	1	3				
	Software Project Management	3	0	3				
	Information Security	3	0	3				
Core Depth of Engineering discipline	Engineering Elective-I*	-	-	3	6	18	18.37%	13.43%
	Engineering Elective-II*	-	-	3				
	Engineering Elective-III*	-	-	3				
	Engineering Elective-IV*	-	-	3				
	Engineering Elective-V*	-	-	3				
	Engineering Elective-VI*	-	-	3				
Engineering Foundation	Discrete Structures	3	0	3	8	30	30.61%	22.39%
	Object Oriented Programming	3	1	4				
	Computer Architecture and Logic Design	3	1	4				
	Operating Systems	3	1	4				
	Database Management System	3	1	4				
	Computer Communication & Networks	3	1	4				
	Formal Methods in Software Engineering	3	0	3				
	Data Structures & Algorithms	3	1	4				
Multi-Disciplinary Engineering Courses	Occupational Health and Safety	1	0	1	3	7	7.14%	5.22%
	MDEE-I*	-	-	3				
	MDEE-II*	-	-	3				

Senior Design Project	Project I	0	3	3	2	6	6.12%	4.48%
	Project II	0	3	3				
Internship (Summer)		0	0	0	0	0	0	0
Total					31	98	100%	73.13%

**Course is either 2-1-3 or 3-0-3 depending on the offered elective course.*

Semester wise Roadmap of BSE

Semester 1

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
None	CSC 110	Computing Fundamentals	2	1	3
None	CSC 113	Computer Programming	3	1	4
None	ENG 101	Functional English	3	0	3
None	GSC 110	Applied Calculus & Analytical Geometry	3	0	3
None	GSC 114	Applied Physics	2	1	3
None	ENV 101	Occupational Health and Safety	1	0	1
				Total	17

Semester 2

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
None	CSC 115	Discrete Structures	3	0	3
Computer Programming (CSC 113)	CSC 210	Object-Oriented Programming	3	1	4
None	SEN 120	Introduction to Software Engineering	3	0	3
Functional English (ENG 101)	ENG 134	Effective Communication Skills	2	0	2
None	ISL 101	Islamic Studies/Ethics	2	0	2
None	GSC 121	Linear Algebra	3	0	3
				Total	17

Semester 3

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
Object Oriented Programming (CSC 210)	CSC 221	Data Structures & Algorithms	3	1	4

Introduction to Software Engineering (SEN 120)	SEN 211	Software Requirement Engineering	3	0	3
None	GSC 122	Probability & Statistics	3	0	3
-	-	Social Science Elective-I	2	0	2
None	CEN 220	Computer Architecture and Logic Design	3	1	4
None	PAK 103	Pakistan Studies and Global Perspective	2	0	2
				Total	18

Semester 4

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
Computer Architecture and Logic Design (CEN 220)	CSC 320	Operating Systems	3	1	4
Computer Programming (CSC 113)	CSC 220	Database Management System	3	1	4
Data Structures & Algorithms (CSC 221)	CSC 321	Design and Analysis of Algorithms	3	0	3
Software Requirement Engineering (SEN 211)	SEN 221	Software Design & Architecture	2	1	3
-	-	Management Science Elective-I	3	0	3
				Total	17

Semester 5

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
None	CEN 223	Computer Communication & Networks	3	1	4
Applied Calculus & Analytical Geometry (GSC 110)	SEN 323	Formal Methods in Software Engineering	3	0	3
Software Design & Architecture (SEN 221)	SEN 311	Software Construction	2	1	3

-	-	Engineering Elective-I*	-	-	3
-	-	MDEE-I*	-	-	3
-	-	Social Science-II	2	0	2
				Total	18

Semester 6

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
Introduction to Software Engineering (SEN 120)	SEN 321	Software Quality Engineering	3	0	3
None	SEN 212	Human Computer Interaction	3	0	3
None	ENG 320	Technical Writing & Presentation Skills	3	0	3
-	-	Engineering Elective-II*	-	-	3
-	-	Engineering Elective-III*	-	-	3
None	SEN 401	Cloud Computing	2	1	3
				Total	18

Semester 7

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
-	FYP 400	Final Year Project I	0	3	3
Introduction to Software Engineering (SEN 120)	SEN 410	Software Project Management	3	0	3
None	CSC 407	Information Security	3	0	3
Applied Calculus & Analytical Geometry (GSC 110)	GSC 321	Numerical Analysis	2	1	3
-	-	Engineering Elective-IV*	-	-	3
-	-	Management Science Elective-II	2	0	2
				Total	17

Semester 8

Pre-requisite Courses	Course Code	Course Title	Lec	Lab	Total
-	FYP 400	Final Year Project II	0	3	3
-	-	Engineering Elective-V*	-	-	3
-	-	Engineering Elective-VI*	-	-	3

-	-	MDEE-II*	-	-	3
				Total	12
		Total Program Credit Hrs	**134**		

**Course is either 2-1-3 or 3-0-3 depending on the offered elective course.*

Engineering Electives

****At least 2 courses with lab components will be offered***

Pre-Req	Course Code	Course Title Total	Credit Hours	Theory	Lab
CSC 113	CSC 313	Visual Programming	3	2	1
CSC 113	CSC 445	Principles of Programming Languages	3	3	0
CSC 210	SEN 328	Game Application Development	3	2	1
CSC-113	SEN 441	Mathematical Tools For Software Engineering	3	3	0
GSC 122	CSC 441	Natural Language Processing	3	3	0
CSC 210	CSC 456	Distributed Computing	3	2	1
CSC 220	CSC 460	Data Mining	3	2	1
CSC 220	CSC 454	Data Warehousing	3	3	0
SEN 120	CSC 458	Management Information Systems	3	3	0
CSC 220	SEN 326	Advanced Database Management Systems	3	2	1
CSC 220	SEN 327	Distributed Database Systems	3	3	0
GSC 121	CEN 445	Digital Image Processing	3	2	1
CEN 445	CSC 464	Computer Vision	3	3	0
SEN 120	SEN 335	Object Oriented Software Engineering	3	2	1
SEN 311	SEN 411	Software Re-Engineering	3	3	0
CSC 113	SEN 310	Web Engineering	3	2	1
CSC 113	SEN 461	Secure Programming	3	2	1
None	SEN 448	Software Applications For Mobile Devices	3	2	1
None	SEN 324	Software Metrics & Estimation	3	3	0
None	SEN 450	Design Pattern	3	3	0
None	SEN 452	Agile Development	3	3	0
None	CSC 411	Artificial Intelligence	3	2	1
None	SEN 443	Introduction to Soft Computing	3	2	1
None	SEN 331	Scientific Computing	3	3	0
None	SEN 330	Agent Based Computing	3	3	0
None	SEN 459	Mobile and Pervasive Computing	3	3	0
None	CEN 451	Data Encryption & Security	3	3	0
None	CSC 495	Introduction to Data Science	3	2	1
None	SEN 332	Big Data Analytics	3	3	0
None	SEN 455	Knowledge Based Management Systems	3	3	0
None	SEN 453	Information System Audit	3	3	0
None	CSC 444	Computer Graphics	3	2	1

None	SEN 329	Digital Animation	3	3	0
None	SEN 493	Multimedia Systems	3	3	0
None	SEN 424	Semantic Web	3	2	1
None	SEN 456	Usability Engineering	3	3	0
SEN 120	SEN 429	DevOps	3	3	0
CSC 113	AIC 301	Machine Learning	3	2	1

Multi-Disciplinary Engineering Elective (MDEE) Courses

Pre-Req	Course Code	Course Title Total	Credit Hours	Theory	Lab
GSC 110	GSC 210	Differential Equations	3	3	0
GSC 110	GSC 220	Complex Variables and Transforms	3	3	0
GSC 122	GSC 445	Operations Research	3	3	0
GSC 122	CEN 450	Simulation and Modeling	3	2	1
GSC 114	GSC 446	Physics-II (Mechanics)	3	3	0
GSC 122	GSC 440	Stochastic Processes	3	3	0
CSC 320	CEN 449	System Programming	3	2	1
CSC 320	CEN 453	Real Time Systems	3	3	0
CSC 315	CSC 323	Compiler Construction	3	2	1
GSC 110	CSC 453	Information Theory	3	3	0
CSC 113	SEN 460	IoT Application Development	3	2	1
None	CEN 122	Digital Design	3	2	1
None	CSC 448	Introduction to Bio-Informatics	3	3	0
None	CEN 463	Robotics	3	2	1
None	CSC 315	Theory of Automata	3	3	0
None	CEN 439	Embedded System Design	3	2	1
None	SEN 429	Fault-Tolerant Systems	3	3	0
None	SEN 449	Business Process Automation	3	3	0
None	HSS 422	Engineering Ethics	3	3	0

Humanities and Social Sciences Electives

Pre-Req	Course Code	Course Title Total	Credit Hours	Theory	Lab
Humanities and Social Sciences					
None	HSS 217	Introduction to Sociology	2	2	0
None	HSS 119	Introduction to International Relations	2	2	0
None	HSS 121	Introduction to Media Studies	2	2	0
None	HSS 218	Introduction to Anthropology	2	2	0
None	HSS 457	Organizational Behavior	2	2	0
None	PSY 102	Introduction to Psychology	2	2	0
None	HSS 413	Sociology for Engineers	2	2	0
None	SEN 442	Software Engineering Economics	2	2	0

None	ENG 121	English Literature	2	2	0
None	HSS 462	Foreign Language	2	2	0
None	HSS 463	Accounting & Finance	2	2	0

Management Science Electives

Management Science Electives					
Pre-Req	**Course Code**	**Course Title Total**	**Credit Hours**	**Theory**	**Lab**
None	HSS 423	Entrepreneurship	2	2	0
None	MGT 111	Principles of Management	3	3	0
None	HSS 453	Human Resource Management	3	3	0
None	MGT 423	Engineering Management	3	3	0
None	MTM 101	Introduction to Maritime Industry	3	3	0

Course Descriptions of Newly added Course

Course Name: DevOps
Course Code: SEN 429
Credit Hours: 3 (3+0)
Prereq: SEN 120 (Introduction to Software Engineering)

Course Description
This course is designed to provide students with an in-depth understanding of advanced DevOps concepts and practices. Through hands-on learning and real-world case studies, students will develop the skills and knowledge necessary to design, implement, and manage complex DevOps initiatives at scale. Topics covered in this course may include advanced automation and orchestration, continuous integration and delivery (CI/CD), containerization, infrastructure as code (IaC), microservices, monitoring and logging, security and compliance, cloud computing, and emerging trends in DevOps. Students will also explore the challenges and solutions associated with implementing DevOps in large organizations, and develop the leadership and management skills necessary to lead and manage DevOps initiatives in complex enterprise environments.

Books:

1. Gene Kim, Patrick Debois, John Willis, Jez Humble, John Allspaw, *"The DevOps Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations"*, 2nd Ed, IT Revolution Press 2021
2. Nicole Forsgren, Jez Humble, Gene Kim, "*Accelerate: The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations*", IT Revolution Press, 2018.
3. Jennifer Davis, Ryn Daniels, *Effective DevOps: Building a Culture of Collaboration, Affinity, and Tooling at Scale* 1st Ed, 2016.

Proposed Changes in Course Codes of BS (Artificial Intelligence) program:

Existing Pre-Requisite	Corrected Pre-Requisite	Course Code	Course Title	Lec	Lab	CR
	Semester 4					
AIC 201	AIC 201	AIC 202	Programming for Artificial Intelligence	2	0	2
AIL 202	AIC 201	AIL 202	Programming for Artificial Intelligence Lab	0	1	1
	Semester 5					
AIC 202	AIC 202	AIC 301	Machine Learning	2	0	2
AIL 202	AIC 202	AIL 301	Machine Learning Lab	0	1	1
CSC 320	CSC 320	AIC 302	Parallel & Distributed Computing	2	0	2
CSL 320	CSC 320	AIL 302	Parallel & Distributed Computing Lab	0	1	1
	Semester 6					
AIC 202	AIC 202	AIC 303	Artificial Neural Networks	2	0	2
AIL 202	AIC 202	AIL 303	Artificial Neural Networks Lab	0	1	1

KPIs for PEOs:

PEOs	KPIs	Assessment Tool
PEO 1-Applying Computing Knowledge and skills to design and develop effective solution for complex real-life problems.	At least 60% of the employers are satisfied with the core computing knowledge and competence level of CS graduates. 60% Graduates are satisfied with the curriculum, complex computing knowledge, skills and designing capabilities achieved during the studies.	Employer feedback form & Alumni Feedback form
PEO 2-Demonstrate ethical and moral conduct in professional practices.	60% of the employers are satisfied with the moral norms, ethical standards and code of conduct followed by the CS graduates at professional level. 60% of graduates consider that the curriculum of CS degree program supports them to maintain character building and professional computing practice.	Employer feedback form & Alumni Feedback form
PEO 3-Manifest life-long learning and inter-personal skills for sustainable career development and professional growth.	10% of the total student per academic year should be enrolled to pursue higher studies MS/PhD and attend professional courses for their professional development. 10% of the total student academic per year would be working for the betterment of welfare and humanity 60% of the graduates exhibit inter-personal skills and professional development skills.	Alumni Feedback form Alumni Information & Employer Feedback

EMPLOYER'S FEEDBACK SURVEY FORM

OUTCOME BASED EDUCATION (OBE) FOR ATTAINMENT OF PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

(To be filled by Manager of the Company)

Introduction

To bridge the gap between academia and industry this questionnaire is requested. Computer Sciences has implemented Outcome Based Education (OBE) system which prepares CS graduates to meet the required expectations and challenges of their professional career in industry. Our main stakeholder is Industry as it provides employment to our computer sciences graduates. Therefore, your opinion about the performance and conduct of our students as employees of your organization is requested. This feedback is used as an assessment tool for evaluation of our teaching-learning processes and opportunity for improvements in making our students better prepared for meeting the requirements of industry.

A. Organization details

Name:_____ Type(Production/R&D etc.):_____

Location: _____ Contact No.: _____

B. Employee/Student details

Name:_____ Enrollment Number:_____

Degree Program: _____ Contact No. _____.
Batch: _____ Email:_____

B. Employees' Performance evaluation (by Manager of organization)

Please respond to the following by encircling the most appropriate choice about the Graduates.

5: Very strong **4:** Strong **3:** Moderate **2:** Weak **1:** Very Weak

Q1	Graduate is able to apply computing knowledge in their professional job.	PEO-1	5	4	3	2	1
Q2	Graduate is capable to analyze and solve complex computing problems.	PEO-1	5	4	3	2	1
Q3	Graduate is able to use modern tools necessary for professional computing practices.	PEO-1	5	4	3	2	1
Q4	Graduate has the ability to understand social, cultural and health issues.	PEO- 2	5	4	3	2	1
Q5	Graduate has the capability to recognize and address ethical problems encountered in professional career.	PEO- 2	5	4	3	2	1
Q6	Graduate has leadership skills to accomplish the professional task within given time frame.	PEO- 2	5	4	3	2	1
Q7	Graduate is always willing to learn and perform new challenging tasks.	PEO-3	5	4	3	2	1
Q8	Graduate has aptitude for self-learning through professional development courses and higher education.	PEO-3	5	4	3	2	1

PEO 1: Apply computing knowledge and skills to design and develop effective solutions for complex real-life problems.

PEO 2: Demonstrate ethical and moral conduct in professional practices.

PEO 3: Manifest life-long learning and inter-personal skills for sustainable career development and professional growth.

Evaluator's Name, designation and contact information **Signature with stamp & date**

Alumni Survey-PEO Attainment
(To be filled by Alumni – after the completion of each academic year)

I. Alumni Information

i. Name _____
ii. Program Entry Date _____
iii. Year of graduation _____
iv. Job Experience in Years _____
v. Name of present organization _____
vi. Position in present organization _____
vii. Enrolment in National University for Higher Education_____
viii. Enrolment in International University for Higher Education_____

The purpose of this survey is to obtain alumni input to further improve the quality of education they received at Computer Sciences Department, Bahria University Karachi Campus. The basic motive of this survey is to assess and uplift the quality of the academic program at departmental level. Therefore, we humbly request you to kindly grade the questionnaire accordingly.

Please respond to the following by encircling the most appropriate choice about the Graduates.

5: Very strong **4:** Strong **3:** Moderate **2:** Weak **1:** Very Weak

II. PEO 1: Apply computing knowledge and skills to design and develop effective solutions for complex real-life problems.

1. Was the curriculum effective in developing fundamental CS knowledge to get the Job?

   (5) (4) (3) (2) (1)

2. Did the program help to solve the complex industrial problems?

   (5) (4) (3) (2) (1)

3. Was the curriculum found helpful and beneficial in developing and designing innovative ideas using your analytical skills?

   (5) (4) (3) (2) (1)

III. PEO 2: Demonstrate ethical and moral conduct in professional practices.

4. Did the program enhance leadership qualities and decision making?
   (5) (4) (3) (2) (1)

5. Did the program create the morality and professional work ethics in your personality?
   (5) (4) (3) (2) (1)

6. Are you satisfied with your communication and interpersonal skills?
   (5) (4) (3) (2) (1)

7. Are you engaged in any welfare organization for the betterment of humanity?
   (5) (4) (3) (2) (1)

IV. PEO 3: Manifest life-long learning and inter-personal skills for sustainable career development and professional growth.

8. Did the program motivate you to become a life-long learner?
   (5) (4) (3) (2) (1)
9. Did the program motivate you to participate in research and developments?
   (5) (4) (3) (2) (1)
10. Did the curriculum help you to pursue higher education?
   (5) (4) (3) (2) (1)

5. University Status

1. Faculty_____
2. Infrastructure_____
3. Library Facilities_____
4. Reputation at National Level_____
5. Reputation at International Level_____

6. Comments Required

Please make any additional comments or suggestions, which you think would help strengthen our programs. (New courses that you would recommend and courses that you did not gain much from)

_____

_____

_____

KPI for PLOs

PLOs	KPIs	Assessment Tool
Program PLO Assessment	The KPIs is set at 60% that the students must achieve 60% at cohort level.	Exit Survey/Graduate Attribute Survey Community Support Program Survey Internship feedback (Indirect Assessments)
Students PLO Assessments.	The KPIs is set at 60% that the students must achieve 60% at cohort level.	Course Learning outcomes, Course assessments, Final year projects, Assignments (Direct Assessment)

GRADUATING STUDENTS ATTRIBUTES SURVEY
DEPARTMENT OF COMPUTER SCIENCES

OUTCOME BASED EDUCATION (OBE) FOR ATTAINMENT OF PROGRAM LEARNING OUTCOMES (PLOs)

(To be filled by the Final year Graduating students)

This feedback is designed to evaluate students' perception about teaching-learning processes in the Computer Sciences department. These teaching-learning processes are used to develop many attributes that are required for successful Computer scientist career for our university graduates. The attributes are known as Program Learning Outcomes (PLOs) as per Seoul accord, are systematically inculcated in the students over a 4-years period of their study in the department. Your Feedback will be used as a yardstick for bringing improvements in the teaching-learning processes and resources of the department**.**

PLO1: Academic Education
PLO2: Knowledge for Solving Computing Problems
PLO3: Problem Analysis
PLO4: Design/Development of Solutions
PLO5: Modern Tool Usage
PLO6: Individual and Team Work
PLO7: Communication
PLO8: Computing Professionalism and Society
PLO9: Ethics
PLO10: Life-long Learning

A. Graduating student's Profile

Batch:_____ Discipline:_____

Student Name:_____Email: _____

Enrollment No:_____Degree Program: _____
Year of Graduation:_____Batch: _____

B. Student's evaluation of Program studied

Please encircle the most preferred choice.

5: Very satisfied **4:** Satisfied **3:** Neutral **2:** Dissatisfied **1:** Very dissatisfied

Q1	Depth of fundamental knowledge for core Computing discipline.	PLO- 1	5	4	3	2	1
Q2	Analytical and programming capabilities to understand complex computing problem and develop its solution.	PLO- 2,3	5	4	3	2	1
Q3	Your understanding of societal issues and their modern technology-based solution.	PLO- 4,5	5	4	3	2	1
Q4	Your level of confidence to work: (i) independently (ii)collaboratively/ team work	PLO- 6	5	4	3	2	1
Q5	Are you able to communicate effectively?	PLO- 7	5	4	3	2	1
Q6	Ability to understand social, cultural, health and safety issues relevant to professional computing practice.	PLO- 8	5	4	3	2	1
Q7	Your understanding for ethical code of conduct and norms of professional computing practice.	PLO- 9	5	4	3	2	1
Q8	Your independent learning capability for continual development	PLO- 10	5	4	3	2	1

Remarks about the overall experience in the department of Computer Sciences:

_____

_____

Student's Signature with Name and Date

Internship Survey Form – PLO Attainment
Department of Computer Sciences

(To be filled by the Manager/in charge/Supervisor/Team Lead)

Introduction

_____

_____

_____

a. Evaluator Profile

Name:_____ Email:_____

Contact:_____ Designation: _____

Organization: _____

b. Internee Profile:

Student Name:_____ Enrollment No:_____

Duration of Internship:_____ Batch: _____

PLO1: Academic Education
PLO2: Knowledge for Solving Computing Problems
PLO3: Problem Analysis
PLO4: Design/Development of Solutions
PLO5: Modern Tool Usage
PLO6: Individual and Team Work
PLO7: Communication
PLO8: Computing Professionalism and Society
PLO9: Ethics
PLO10: Life-long Learning

c. Internee Performance evaluation:

Please respond to the following by encircling the most appropriate choice.

5: Very strong **4:** Strong **3:** Moderate **2:** Weak **1:** very Weak

Sno.	Statements	PLOs	5	4	3	2	1
1	Demonstrate and show the ability to acquire the fundamental computing knowledge.	PLO- 01					
2	Demonstrate the ability to analyze computing problem(s).	PLO- 02					
3	Demonstrate the ability to design and solve a system problem.	PLO- 03					
4	Demonstrate the ability to design and develop the computing knowledge based solution.	PLO- 04					
5	Demonstrate the ability to use modern tools during internship	PLO- 05					
6	Self-confidence to accomplish task(s) independently and collaboratively with the team.	PLO- 06					
7	Effective communication skills with positive attitude to comprehend design computing documentation.	PLO- 07					
8	Demonstrate the ability to understand societal, health and cultural issues.	PLO- 08					
9	Exhibit the morality and ethical values in professional computing practice.	PLO- 09					
10	Demonstrate capability to be engaged in independent learning for professional development.	PLO- 10					

d. General remarks:

_____

_____

_____

Signature of Manager/In charge/Supervisor/Team Lead/Career Service Coordinator and Date

Community Support Program Form – OBE
Department of Computer Sciences

(To be filled at the completion of CSP activity For PLO Attainment)

To be filled by Manager/ Supervisor/ CSP Coordinator:

Name: _____

Organization: _____

Designation: _____

a. Information of the student:

Student Name:_____Email: _____

Enrollment No:_____Degree Program: _____

Year of Graduation:_____Batch: _____

CSP Activity:_____CSP Duration: _____

b. Please respond to the following by selecting the most appropriate choice for candidate

5: Very strong **4:** Strong **3:** Moderate **2:** Weak **1:** very Weak

Sno.	Statements	PLOs	5	4	3	2	1
1	Ability to assess **societal issues**, keeping in view **safety**, **legal** and **cultural constraints**.	PLO- 09					
2	Demonstrate sensitivity towards various social and environmental problems.	PLO- 09					
3	Ability to demonstrate **ethical principles** and **societal norms**.	PLO- 09					
4	Ability to **work independently** as well as in a **team**.	PLO- 06					
5	Ability to **communicate effectively**.	PLO- 07					
6	Ability to demonstrate **management skills** and to **accomplish given task** in specific time.	PLO- 07					
7	Demonstrate the **initiative** and **drive** to learn new things.	PLO- 10					

c. Any Other Remarks/Suggestions:

_____

Signature of Manager/ Supervisor/ CSP Coordinator and Date

KPI for CLOs

CLOs	KPIs	Assessment Tool
Course and Lab wise CLO assessments	CLO is considered to be attained if at least 60% KPI is achieved at cohort level. Students must achieve 60% in each CLO at cohort level.	Quizzes, Assignments, Projects, Complex Computing Problems, Mid-term examinations, Final-term examinations.

BAHRIA UNIVERSITY Karachi Campus

Computer Sciences/IT/AI Department, Final Year Project (FYP) 2023-2024

CLOs for the final year project are elaborated as the part of the FYDP policy. The progress of FYDP is examined in various steps throughout the project duration.

CLO	Description	BT Level	GAs/PLO	Assessment Tool
CLO 1	**Explain** objectives and technical knowledge of their selected project topic.	**C2**	**GA 1/PLO 1:** Academic Education	Report, Presentation, Supervisor report
CLO 2	**Examine** the existing studies and concepts of project/research work in accordance with the existing literature.	**C4**	**GA 2/PLO 2:** Knowledge for Solving Computing Problems	FPY Report, Supervisor report
CLO 3	An ability to **formulate** problem statement and **develop** a software, algorithm application, component, or process using latest technologies to meet computing standards.	**C6**	**GA 3/PLO 3:** Problem Analysis	Report, Supervisor report
CLO 4	**Build** the solution by means of simulation/ existing literature relevant to his/her project.	**P4**	**GA 4/PLO 4:** Design/Development of Solutions	Project Demo, Supervisor report
CLO 5	An ability to **adapt** latest computer-based techniques and use modern computing tools/software for complex computing practice.	**P3**	**GA 5/PLO 5:** Modern Tool Usage	Project Demo, Presentation
CLO 6	An ability to **combine** & communicate effectively in a project team.	**A4**	**GA 6/PLO 6:** Individual and Teamwork	FYP Report, Supervisor report
CLO 7	**Organize** FYP project/research work in logical/well-planned way in thesis report and in oral presentation by appropriate communication and professional skills.	**A4**	**GA 7/PLO 7:** Communication	FYP Report, Supervisor report
CLO 8	**Assess** ethical and professional norms for the implementation of computing projects.	**C5**	**GA 8/PLO 8:** Computing Professionalism & Society	FYP Report, FYP coordinator report, Supervisor report
CLO 9	**Demonstrate** the compliance of code of ethics and code of conduct and **Follow** the social, cultural, global and environmental responsibilities of an engineer.	**A3**	**GA 9/PLO 9:** Ethics	Report, FYP coordinator report. Supervisor report
CLO 10	**Represent** the project in its future directions for continued professional development.	**C2**	**GA 10/PLO 10:** Life Long Learning	FYP Report, Supervisor report

Level	Needs Improvement	Satisfactory Performance	Good Performance	Excellent Performance
Points	**0-1 points**	**2 points**	**3-4 points**	**5 points**
Subject Knowledge (CLO-1)	Unable to Explain the proposed Project	Explain the Project by catering limited set of requirements	Explain the Project by catering complete set of requirements	Explain the Project by catering complete set of requirements and adding extra features
Literature review / Knowledge for Solving Computing Problem	Unable to relate the proposed project concept with the existing computing knowledge.	The project lacks necessary computing knowledge with reference to the existing related literature review.	Covers necessary computing knowledge justification with reference to the literature review.	Problem statement is analyzed and covers sufficient justification with reference to the literature review.
Problem Statement (CLO-3)	Problem statement is analysed but not entirely clear.	Problem statement analysis lacks necessary justification with reference to the literature review.	Problem statement is analyzed and covers necessary justification with reference to the literature review.	Problem statement is analyzed and covers sufficient justification with reference to the literature review.
Design & Development (CLO-4)	Selected Design doesn't follow engineering approach and has serious deficiencies in the theoretical framework of design.	Selected Design has few deficiencies and is implemented without verifications.	Selected Design fulfill most of the requirements with some recommended improvements.	Selected Design follows systematic approach in all aspects.
Modern Tools (CLO-5)	Incorrect imitation of IT tool.	Imitation of IT tools is very trivial with too many limitations. Or require more familiarization with the selected IT tool.	Imitation of IT tools is appropriate however; its potentials have not be explored and applied fully.	Appropriate IT tools are imitated and applied with proper understanding of their limitations.
Ability to work effectively at an individual level and as a team member in multidisciplinary environments (CLO-6)	Show no concern to complete his tasks Passive member of team Avoid multifaceted problems and thinks linearly	Show concern occasionally to completes his own tasks · Sometimes shares simple alternatives to existing solutions.	Shows some degree of concern in diverse environments · Does not contribute to team conflicts and occasionally helps resolve team conflicts	Show positive concern to competes his own tasks and helps other members achieve their goals· Helps the team move forward by proposing innovative, constructive options to multidisciplinary problems.
Communication & Documentation (CLO-7)	Does not organize presentation and documentation in proper way and No Format and No Report structured is followed	Presentation and Report has clear organizational structure with some points are unclear and spelling mistakes.	Format and Report structure is sufficient and Presentation is organized with some points missing.	Presentation has a clear organizational structure effective use of multimedia and Well organize the format and report. Graphs, Tables and diagrams used appropriately.
Understand morality, safety professional ethics and cultural issues while implementing computing based final year project (CLO-8)	No morality, professional and ethical behavior were taken into consideration while doing final year project.	Sometimes late for meetings. · Sometimes missed deadlines Worked hard at times, but not maintain consistently.	Rarely late for meetings · Mostly maintain all deadlines (occasionally would not inform about missing a deadline) · Mostly worked hard as a professional · Never took credit for somebody else's work.	Punctual and regular in meetings · Maintain all deadlines (in rare and genuine cases, informed as early as possible of a delay) · Always worked hard and gave 100% · Never took credit for somebody else work
Commitment to behave professionally and ethically (CLO-9)	Maintain no real commitment to professional and ethical behavior Tried once to pass off copied work as his/her own	Sometimes late for meetings. · Sometimes missed deadlines Worked hard at times, but not maintain consistently.	Rarely late for meetings · Mostly maintain all deadlines (occasionally would not inform about missing a deadline) · Mostly worked hard and professionally · Never took credit for somebody else's work.	Punctual and regular in meetings · Maintain all deadlines (in rare and genuine cases, informed as early as possible of a delay) · Always worked hard and gave 100% · Never took credit for somebody else work
Lifelong Learning (CLO-10)	Doesn't Evaluate the topic with interest. Used old and	Evaluate the topic with less interest in the subject. Use predefined	Evaluate the topic in detail with significant interest in the subject.	Evaluate the topic in detail with effective interest in the subject. Use

	previously learnt knowledge for the solution.	ideas for the solution of problem.	Use less innovative ideas for the solution of problem.	innovative and creative ideas for the solution of problem.

Grading Rubric:

Rubrics required for FYP assessment are mentioned below:

Assessment Method	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8	CLO 9	CLO 10	Total Marks
FYP Coordinator								5	5		**10**
FYP Supervisor	2	2	2	2	2	2	2	2	2	2	**20**
Initial Defense Presentations	2	2	2	2	2						**10**
Midterm Defense Presentations		3	3	3	3	3	3	2			**20**
Final Defense Presentations	2	2	2	2	2	2	2	2	2	2	**20**
FYP Report	2	2	2	2	2	2	2	2	2	2	**20**
Total (100)	**8**	**11**	**11**	**11**	**11**	**9**	**9**	**13**	**11**	**6**	**100**

Evaluation Criteria for achievement of CLOs

- Average in CLO 1 should be 50% and above
- Average in CLO 2 should be 50% and above
- Average in CLO 3 should be 50% and above
- Average in CLO 4 should be 50% and above
- Average in CLO 5 should be 50% and above
- Average in CLO 6 should be 50% and above
- Average in CLO 7 should be 50% and above
- Average in CLO 8 should be 50% and above
- Average in CLO 9 should be 50% and above
- Average in CLO 10 should be 50% and above

OUTLINES FOR NEW ELECTIVES

1. HARDWARE VERIFICATION

Course Code: CEN 462
Credit Hours: 3+1
Pre-Requisite: DSD (CEN-442)
Course content:
System design and verification flow, Overview of formal verification techniques, System modeling and BDDs, Combinational equivalence checking, Sequential equivalence checking, Temporal logic and properties specification, Verification with model checking, System modeling with predicate logic, Verification with theorem proving, Formal verification systems (e.g. VIS, SMV, HOL, PVS, FormalCheck, Formality, Conformal), Verification case studies (e.g. pipelined processors, ATM switches)

Text book:
T. Kropf: Introduction to Formal Hardware Verification, Springer Verlag, 1999. (ISBN: 3540654453)
Reference book:

1. W.K. Lam: Hardware Design Verification: Simulation and Formal Method-Based Approaches. Prentice Hall, 2005. (ISBN: 0131433474)
2. M.R.A Huth and M.D. Ryan: Logic in Computer Science. Modelling and Reasoning about Systems. Cambridge University Press, 2000. (ISBN: 0521652006/0521656028)
3. C. Baier, J.-P. Katoen: Principles of Model Checking, MIT Press, 2008 (ISBN: 0262026499)
4. T.F. Melham: Higher Order Logic and Hardware Verification, Cambridge Tracts in Theoretical Computer Science, No 31, Cambridge University Press, 1993. (ISBN: 052141718X)

2. COMPILER CONSTRUCTION

Course Code: CSC 323
Credit Hours: 2+1
Pre-Requisite: SE (SEN-220)
Course Content:
Introduction to interpreter and compiler. Compiler techniques and methodology; Organization of compilers, Phases of compiler, Lexical and syntax analysis; Parsing techniques. Types of parsers; top-down parsing, Recursive decent parser, Context free grammar, left factoring, Left Recursion, Ambiguity, Backus norm form, Extended Backus norm form, Operator Associativity and Precedence Predictive parser or LL (1) parser, bottom-up parsing, Shift reduce parser, LR (0) parser, SLR parser, LALR parser. Semantic analyzer, Type checking, Scope symbol table, Syntax directed translation and definition. Intermediate code generation; Polish notation, Three address code, Quadruple, triples and indirect triples. Translation of Array. Optimization, peephole optimization, Semantic-Preserving Transformations, Algebraic Simplification, Copy Propagation, Code Motion, Dead Code Elimination, Common Subexpression Elimination (Local), Common Subexpression Elimination (Global). Target code generation; Assembly language, detection, and recovery from errors.
Text Book:

1. Compilers: Principles, Techniques, and Tools, A. V. Aho, R. Sethi and J. D. Ullman, Addison-Wesley, 2nd ed., 2006
2. Modern Compiler Design, D. Grune, H. E. Bal, C. J. H. Jacobs, K. G. Langendoen, John Wiley, 2003.
3. Modern Compiler Implementation in C, A. W. Appel, M. Ginsburg, Cambridge University Press, 2004.

3. THEORY OF AUTOMATA

Course Code: CSC 315
Credit Hours: 3+0
Pre-Requisite: SE (SEN-220)
Course Content:
Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars, CFGs, Derivations, derivation trees and ambiguity, PDA, Simplifying CFLs, Chomsky Normal form, grammars and parsing, Turing Machines, TM encoding, Universal Turing Machine, Defining Computers by TMs, Introduction to Decidability.
Text Book:
1. Michael Sipser, Introduction to the Theory of Computation (2nd Edition)
2. Introduction to computer theory, Daniel I. A. Cohen, 2nd Edition
3. Introduction to Automata Theory Languages and Computation by Hopcroft, Ulman

REVISED COURSE OUTLINES

1. VLSI Design

Course Code: CEN-457
Credit Hours: 2+1
Pre-Requisite: EDC (EEN 224)

Course Content:

- **Introduction to VLSI Systems**
- MOS transistor theory and VLSI design abstraction
- **CMOS processing technology**
- Linear delay model
- Power in VLSI integrated circuits
- **Layout design rules**
- **Circuit characterization and performance estimation**
- **Combinational and sequential circuit design**
- Datapath subsystems
- Design methodology and tools
- Special purpose subsystems

Text Book: CMOS VLSI Design, 4th Edition, Addison-Wesley, 2011., Weste and Harris
Reference Book: Digital Integrated Circuits - A Design Perspective, 2nd Edition, Prentice-Hall, 2003. J. M. Rabaey, A. Chandrakasan, and B. Nikoli

2. Embedded System Design

Course Code: CEN 440
Credit Hours: 3+1
Pre-Requisite: MPI (CEN 321)
Course Content:
Introduction to Embedded Systems, Embedded Products (i.e., Cell Phones, Robots, GPS, Cameras, Transaction Terminals, and Industrial Controllers), Analysis of The Design and Development Process for a new embedded product. Introduction to the Software Development and Debug Tool Flows. Hardware for Embedded Systems Design, Processors, Chipsets, and Memory, ARM and X86 ISA, I/O devices and bus interfaces, Example Design (i.e. basic parallel I/O port). Introduction to the Common Bus Standards (i.e., ISA, PCI, AMBA, PCI Express) and Common I/O interface Standards (i.e., Parallel, RS-232, SPI, I2C, and USB). Analysis of Analog I/O using A/D and D/A convertors, Driving high current and high voltage I/O devices (i.e., high-power LEDs, speakers, motors, and solenoids). Using PWM to efficiently control external I/O devices (i.e., dimmable lights, speakers, and motor speed control) Basic concepts of Programmed I/O, Interrupt driven I/O, Using DMA for I/O transfers, Example System

Designs (i.e., small 32-bit ARM and X86-based systems). Introduction of Software for Embedded Systems Design, Role of an Embedded Operating System, Hard and Soft Real-time systems, Multitasking, Threads, and Synchronization. Operating Systems used in Embedded Devices (Windows Embedded, Linux, Android) Overview of an example RTOS, Building an OS for a new device, Application Development using OS APIs for I/O devices and GUIs, I/O device examples (i.e., A/D, RS-232, cameras, GPS, displays, wired and wireless networks, and touch input). BSPs and developing OS Device Drivers for new I/O devices, Developing Software for Safety Critical Systems. Development Tools, Firmware Architecture, Design and Debugging, Real Time Embedded Systems.

Text Book:

- Frank Vahid, HTony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons
- Naimi, Sepehr, Sarmad Naimi, and Muhammad Ali Mazidi. "The AVR Microcontroller and Embedded Systems Using Assembly and C: Using Arduino Uno and Atmel Studio", MicroDigital latest Edition.
- M. Wolf, "Computer as Components: Principles of Embedded Computing System Design", latest Edition, Morgan Kaufman Publishers.

Reference Book:

- J. Yiu, "The Definitive Guide to the ARM Cortex-M3", latest Edition, Elsevier.
- Ganssle, Jack. "The firmware handbook". Elsevier, latest edition.
- Alan Burns and Andy Wellings, "Real-time Systems and Programming Languages", Addison-Wesley latest edition

3. MPI

Course Code: CEN 321
Credit Hours: 3+1
Pre-Requisite: DLD (CEN 120)
Course Content:

Introduction to Microprocessors, ARM Processor Architecture, Assembly Language Programming for ARM Processors, C Language, Programming for ARM Processors, Interfacing with ARM-based Processors, Advanced Assembly Language Programming for ARM Processors, Advanced C Language Programming for ARM Processors, Interrupt Handling for ARM Processors, ARM-based Embedded Systems, ARM Cortex-M Processors, ARM-based Processor Applications, Real-world Interfacing and Case Studies

Text Book:

- ARM System Developer's Guide: Designing and optimizing System Software" by Andrew N. Sloss, Dominic Symes, and Chris Wright

Reference Book:

- Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers
- The Definitive Guide to ARM® Cortex®-M3 and Cortex-M4 Processors by Joseph You
- Programming and Customizing the ARM® Microcontroller" by Predko and Myatt

4. CAO

Course Code: CEN 221
Credit Hours: 3+1
Pre-Requisite: DLD (CEN 120)
Course Content:

- Introduction and motivation
- From Transistors to a Microprocessor
- Instruction Set Architecture – RISC-V Assembly Language
- Design Metrics and Performance Evaluation
- Designing Arithmetic Logic Unit (ALU)

- RISC-V Single Cycle Datapath and Control
- Pipelining and Pipelining Hazards
- RISC-V Pipelined Implementation
- Basics of Caches
- Measuring and Improving Cache Performance
- Virtual Memory
- Handling Exceptions and Multicycle Operations

Multi Issue, Static Scheduling and Dynamic Scheduling

Text Book: D. Harris and S. Harris, "Digital Design and Computer Architecture (2nd Edition)."

Reference Book:

- D. Harris and S. Harris, "Digital Design and computer Architecture (1st Edition)."
- Y.N. Patt and S.J. Patel, "Introduction to Computing Systems."

UPDATED BCE CURRICULUM

Semester Wise Course Offering

S. No.	Pre-Req.	Course No.	Course Title	Theory Credits Hours	Lab Credit Hours	Total Credit Hours
Semester-I						
1	None	GSC 110	Applied Calculus & Analytical Geometry	3	0	3
2	None	ISL 101 /HSS 116	Islamic Studies / Ethics	2	0	2
3	None	CSC 110	Computing Fundamentals	2	1	3
4	None	GSC 113	Applied Physics	3	1	4
5	None	ENG 105	Functional English	3	0	3
6	None	EEL 112	Workshop Practices	0	1	1
Total:				13	3	16

Semester-II						
1	None	GSC 120	Linear Algebra	2	0	2
2	GSC 113	CEN 121	Circuit Analysis	3	1	4
3	None	CSC 113	Computer Programming	3	1	4
4	None	PAK 103	Pakistan Studies & Global Perspective	2	0	2
5	None	ENV 101	Occupational Health & Safety	1	0	1
6	None	CEN 120	Digital Logic Design	3	1	4
Total:				14	3	17

Semester-III						
1	None	CSC 115	Discrete Structures	3	0	3
2	GSC 113	EEN 224	Electronic Devices & Circuits	3	1	4
3	CSC 113	CSC 210	Object Oriented Programming	3	1	4
4	None	HSS 118	Communication Skills	2	0	2
5	GSC 110	GSC 220	Complex Variables & Transforms	3	0	3
6	-	-	Social Science Elective-I	2	0	2
Total:				16	2	18

Semester-IV						
1	GSC 110	GSC 210	Differential Equations	3	0	3
2	CSC 210	CSC 221	Data Structures & Algorithms	3	1	4
3	None	EEN 313	Signals & Systems	3	1	4
4	CEN 120	CEN 321	Microprocessors & Interfacing	3	1	4
5	-	-	MS-Elective-I	3	0	3
Total:				15	3	18

Semester-V						
1	CEN 221	CSC 320	Operating Systems	3	1	4
2	ENG 105	HSS 321	Technical Writing	2	0	2
3	CEN 120	CEN 221	Computer Architecture & Organization	3	1	4
4	EEN 313	EEN 325	Digital Signal Processing	3	1	4
5	None	CEN 223	Computer Communication & Networks	3	1	4
Total:				14	4	18

Semester-VI						
1	-	-	CEDE-I	3	1	4
2	CSC 210	CSC 220	Database Management Systems	3	1	4
3	CSC 221	SEN 220	Software Engineering	3	0	3
4	None	GSC 122	Probability & Statistics	3	0	3
5	-	-	MDEE-I	3/2	0/1	3
Total:				15/14	3	17

Semester-VII						
1	CEN 221	CEN 442	Digital System Design	3	1	4
2	None	HSS 423	MS-Elective-II	2	0	2
3	-	-	CEDE-II	3	1	4
4	-	ESC 498	Project-I	0	3	3
5	GSC 120	GSC 321	Numerical Analysis	2	1	3
Total:				10	6	16

Semester-VIII						
1	-	ESC 499	Project-II	0	3	3
2	-	-	CEDE-III	3	1	4

3	-	-	CEDE-IV	3	1	4
4	-	-	MDEE-II	3/2	0/1	3
5	-	-	Social Science Elective-II	2	0	2
Total:				11/9	5/6	16
Grand Total:				108	28	136

Multi-Disciplinary Engineering Electives (MDEE) (6 Credit Hours)						
S. No.	**Pre-Req.**	**Course No.**	**Course Title**	**Theory Credits Hours**	**Lab Credit Hours**	**Total Credit Hours**
1	None	SEN 320	Human Computer Interaction	3	0	3
2	None	CEN 429	Introduction to Block Chain Technologies	3	0	3
3	None	CSC 449	Neural Networks & Fuzzy Logic	3	0	3
4	EEN 313	CEN 458	Robotics	2	1	3
5	None	CSC 341	Mobile Application Development	2	1	3
6	None	CEN 426	Introduction to Virtual Reality	3	0	3
7	None	SEN 420	Software Quality Assurance	3	0	3
8	EEN 224	CEN 457	VLSI Design	2	1	3
9	None	CSC 457	Data Mining & Warehousing	2	1	3
10	None	GEO 437	GIS & Remote Sensing	3	0	3
11	None	GEO 436	Health Safety & Environment	3	0	3
12	None	CEN 427	Biomedical Engineering	3	0	3
13	None	SEN 449	Business Process Automation	3	0	3
14	None	EEN 467	Control Engineering	3	0	3
15	SEN 220	CSC 323	Compiler Construction	2	1	3
16	SEN 220	CSC 315	Theory of Automata	3	0	3

Computer Engineering Depth Electives (CEDE) (16 Credit Hours)						
S. No.	**Pre-Req.**	**Course No.**	**Course Title**	**Theory Credits Hours**	**Lab Credit Hours**	**Total Credit Hours**
1	CSC 320	CEN 411	Cloud & Distributed Computing	3	1	4
2	CEN 321	CEN 449	Internet of Things	3	1	4
3	CEN 321	CEN 440	Embedded System Design	3	1	4
4	EEN 313	CEN 409	Artificial Intelligence & Machine Learning	3	1	4

5	EEN 313	CEN 444	Digital Image processing	3	1	4
6	CSC 113	CEN 408	System & Network Security	3	1	4
7	CSC 320	CEN 454	System Programming	3	1	4
8	CSC 320	CEN 407	High Performance Computing	3	1	4
9	CSC 221	CEN 326	Algorithm Design and Analysis	3	1	4
10	EEN 325	CEN 425	Hardware Design for DSP & ML	3	1	4
11	CEN 442	CEN 462	Hardware Verification	3	1	4

Management Science Electives (MS Elective - I) (3 Credit Hours)						
S. No.	**Pre-Req.**	**Course No.**	**Course Title**	**Theory Credits Hours**	**Lab Credit Hours**	**Total Credit Hours**
1	None	EMG 201	Engineering Project Management	3	0	3
2	None	MGT 423	Engineering Management	3	0	3
3	None	MTM 101	Introduction to Maritime Industry	3	0	3

Management Science Electives (MS Elective - II) (2 Credit Hours)						
S. No.	**Pre-Req.**	**Course No.**	**Course Title**	**Theory Credits Hours**	**Lab Credit Hours**	**Total Credit Hours**
1	None	EMG 222	Principles of Management	2	0	2
2	None	HSS 423	Entrepreneurship	2	0	2

Social Science Electives (SSE) (4 Credit Hours)						
S. No.	**Pre-Req.**	**Course No.**	**Course Title**	**Theory Credits Hours**	**Lab Credit Hours**	**Total Credit Hours**
1	None	HSS 412	Engineering Economics	2	0	2
2	None	HSS 413	Sociology for Engineers	2	0	2
3	None	HSS 424	Engineering Ethics	2	0	2
4	None	HSS 541	Organizational Behavior	2	0	2

Appendage 2820

PLOs Direct & Indirect Assessments Criteria

Program Learning Outcomes (PLOs)	Assessment Tools	Assessment Share	Key Performance Indicator (KPIs)	Assessment Time
Indirect Assessment	A. Exit/Graduate Survey	10% for All PLOs	A & B & C A. ≥ 60% B. ≥ 60% C. ≥ 60%	End of degree
	B. CSP Feedback	10 % for PLOs (6,7,8,9,10,11,12)		
	C. Internship Feedback	10% for All PLOs		
Direct Assessment	Aggregate score of mapped CLOs	80% for PLOs (1,2,3,4,5) 70% for PLOs (6,7,8,9,10,11,12)	≥ 60%	At the end of 6th, 7th, and 8th Semesters

FYP Ethical Review for BCE Projects

This Form is designed to ensure that the departmental Final year project (FYP) operates an ethical review process that falls within the University guidelines. Any student undertaking project on live human subjects needs to fill this Form. If all questions in this Form are answered 'No', ethical approval shall automatically be granted. This part of the Form shall be reviewed by the FYP Ethical Review Committee (ERC). Students shall be informed about the decision of the ERC as soon as possible. If needed, the student may be asked to submit further information and appear before FYP ERC for discussion meeting.

Title of the Project:	
Supervisor Name:	

Student's Name:	Reg. No:	Signature

Aim/purpose of study, source(s), Method(s) of Data Collection, benefits of study, duration of the study (*not more than one page, use extra sheet if required*).

Please answer all of the questions below by ticking (✓) 'Yes' or 'No' in the box provided

		Yes	No	Reasons
1.	Does the study involve participants who are particularlyvulnerable or unable to give informed consent? (e.g. people under the age of 18, people with disabilities etc.)			
2.	Will it be necessary for the participants to take part in the study without their knowledge and consent?			
3.	Does the study involve audio or visual recording of people in public places?			
4.	Will the study involve the discussion of sensitive topics? (e.g.sexual activity, drug use, illegal activities, death, whistle-blowing etc.)			
5.	Does the research involve the use of drugs, radiation agents experimental surgical / harmful procedures, blood or tissuessamples			
6.	Is physical pain or psychological stress being part of this research work is likely to cause harm or negativeconsequences to the participants?			

7.	Will the study involve prolonged or repetitive testing on the participants?			
8.	Will financial inducements be involved in the study and (other than expenses) be offered to participants?			
9.	Will the study involve recruitment of patients or staff?			

Verified by

Supervisor: **Committee Head**

Signature: _____ Signature: _____

Date: _____ Date: _____

A. *Student is also required to do the following:*

1. Prepare an information letter for their participants. The letter needs to introduce the student and provide a simple explanation of the research. It needsto make clear what the participants are asked to do, how long the research workwill take. The letter shall also include whether it will be/not be anonymous and/or confidential and who will have access to the data.
2. Prepare a Consent Form containing the phrases "I agree to participate in the research work_____and I understand my information will be/will not be treated as confidential, and/or anonymous."

Student's Name:	Reg. No:	Signature

CHANGES IN COURSE TITLES AND COURSE CODES FOR FYP/ UG AND PG THESIS AND COMMON COURSES

Oral Communication Course Related Changes

	BS ES, GEO-PHY, GEO
Existing Title	Oral Communication
Course Code	ENG 232
Cr Hr	3
New Title	Oral Communication and Presentation Skills
New Code	ENG 213
Cr Hr	3

UG Final Year Project and UG Thesis Related Changes

	BS CS, AI, IT, EE, CE and SE	BS ES	BS GEO and GEO-PHY	BS GIS & RS
Existing Title	Project I , Project II	Thesis	Thesis	Thesis
Course Code	ESC 498 , ESC 499	ENV 435	GEO 460	RGS 490
Cr Hr	3, 3	6	6	6
New Title	Final Year Project	UG Thesis	UG Thesis	UG Thesis
New Code	FYP 400	THS 400	THS 400	THS 400
Cr Hr	6	6	6	6

MS Thesis Related Changes

	MS CS, IS, DS, EE, CE	MS ES, GEO-PHY, GEO	MS SE, EM	MS Math	MS T&N
Existing Name	Thesis I, Thesis II	Thesis, Thesis	Thesis I, Thesis II	Thesis I, Thesis II	Thesis, Thesis
Course Code	ESC 500	THS 701	ESC 600	MAT 500	ESC 502
Cr Hr	3, 3	3,3	3,3	3,3	3,3
New Name	MS Thesis	MS Thesis	MS Thesis	MS Thesis	MS Thesis
New Code	THS 600	THS 600	THS 600	THS 600	THS 600
Cr Hr	6	6	6	6	6

BS Computer Science

CURRICULUM DOCUMENT

DEPARTMENT OF COMPUTER SCIENCE, BAHRIA UNIVERSITY

Vision and Mission

Vision and Mission of Bahria University

Vision: To become a knowledge and creativity driven international university that contributes towards development of society.

Mission: To ensure academic excellence through deliverance of quality education and applied research in a collegiate environment having strong linkages with industry and international community to meet the societal challenges.

Vision of the Computer Science Department

To become a center of excellence in Computer Science education, research, and globalized technologies

Mission of the BS Computer Science Program

To produce graduates having good problem-solving skills and knowledge to use computers creatively and effectively along with team building and professional skills.

Program Educational Objectives (PEOs)

PEO 1: Apply computing knowledge and skills to design and develop effective solutions for complex real-life problems.

PEO 2: Demonstrate ethical and moral conduct in professional practices.

PEO 3: Manifest life-long learning and inter-personal skills for sustainable career development and professional growth.

Program Learning Outcomes (PLOs)

PLO1 **Academic Education:** To prepare graduates as computing professionals.

PLO2 **Knowledge for Solving Computing Problems:** Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the 16 abstraction and conceptualization of computing models from defined problems and requirements.

PLO3 **Problem Analysis:** Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.

PLO4 **Design/ Development of Solutions:** Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO5 **Modern Tool Usage:** Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.

PLO6 **Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PLO7 **Communication:** Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions.

PLO8 **Computing Professionalism and Society:** Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.

PLO9 **Ethics:** Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.

PLO10 **Life-long Learning:** Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

Mapping of PLOs to PEOs

No	Program Learning Outcomes (PLOs)	PEOs		
		PEO-1	PEO-2	PEO-3
1	Academic Education	✓	✓	
2	Knowledge for solving Computing Problems	✓		
3	Problem Analysis	✓		
4	Design/ Development of Solutions	✓		✓

5	Modern Tool Usage	✓	✓	
6	Individual and Teamwork		✓	✓
7	Communication			✓
8	Computing Professionalism and Society		✓	✓
9	Ethics		✓	
10	Life-long Learning			✓

Program Eligibility Criteria

- Minimum 50% marks in Intermediate (HSSC) examination (Pre-Medical/Pre-Eng.) or equivalent qualification with Mathematics certified by IBCC.
- For pre-Medical students, two deficiency courses of mathematics will be taught during first year

Curriculum Model for BS in Computer Science

The generic structure for computing degree program is mapped with the BSCS program in the following table.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	49	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**133**	**44**

BS (Computer Science) Road Map

SEMESTER 1						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	GSC 114	Applied Physics	2	0	2	16
None	GSL 114	Applied Physics Lab	0	1	1	
None	CSC 114	Introduction to Information & Communication Technology	2	0	2	
None	CSL 114	Introduction to Information & Communication Technology Lab	0	1	1	
None	ENG 101	Functional English	3	0	3	

None	CSC 113	Computer Programming	3	0	3	
None	CSL 113	Computer Programming Lab	0	1	1	
None	GSC 221	Discrete Mathematics	3	0	3	

SEMESTER 2

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
None	CSC 220	Database Management Systems	3	0	3	17
None	CSL 220	Database Management Systems Lab	0	1	1	
CSC 113	CSC 210	Object Oriented Programming	3	0	3	
CSC 113	CSL 210	Object Oriented Programming Lab	0	1	1	
GSC 114	CEN 122	Digital Design	2	0	2	
GSC 114	CEL 122	Digital Design Lab	0	1	1	
None	GSC 110	Applied Calculus and Analytical Geometry	3	0	3	
None	GSC 121	Linear Algebra	3	0	3	

SEMESTER 3

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
None	GSC 122	Probability and Statistics	3	0	3	17
GSC 110	GSC 211	Multivariable Calculus	3	0	3	
None	CEN 223	Computer Communication & Networks	3	0	3	
None	CEL 223	Computer Communication & Networks Lab	0	1	1	
CSC 113	CSC 221	Data Structure & Algorithm	3	0	3	
CSC 113	CSL 221	Data Structure & Algorithm Lab	0	1	1	
None	SEN 220	Software Engineering	3	0	3	

SEMESTER 4

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
None		Social Sciences Elective	3	0	3	18
CEN 122	CEN 323	Computer Organization and Assembly Language	2	0	2	
CEN 122	CEL 323	Computer Organization & Assembly Language Lab	0	1	1	
None	CSC 325	Artificial Intelligence	3	0	3	
None	CSL 325	Artificial Intelligence Lab	0	1	1	
None	CSC 315	Theory of Automata	3	0	3	
CSC 220	CSC 470	Advanced Databases	2	0	2	
CSC 220	CSL 470	Advanced Databases Lab	0	1	1	
None	ENG 134	Communication Skills	2	0	2	

SEMESTER 5						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
CSC 221	CSC 320	Operating Systems	3	0	3	16
CSC 221	CSL 320	Operating Systems Lab	0	1	1	
None	ENG 320	Technical writing and presentation skills	3	0	3	
None	CSC 407	Information Security	3	0	3	
CEN 323	CSC 327	Computer Architecture	2	0	2	
CEN 323	CSL 327	Computer Architecture Lab	0	1	1	
SEN 220	SEN 321	Human Computer Interaction	2	0	2	
SEN 220	SEL 321	Human Computer Interaction Lab	0	1	1	

SEMESTER 6						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
CSC 315	CSC 323	Compiler Construction	2	0	2	17
CSC 315	CSL 323	Compiler Construction Lab	0	1	1	
CSC 320	AIC 302	Parallel & Distributed Computing	2	0	2	
CSC 320	AIL 302	Parallel & Distributed Computing Lab	0	1	1	
		Elective 1 (2+1)	2	1	3	
		Elective 2 (3+0 or 2+1)	3/2	0/1	3	
		Elective 3 (3+0 or 2+1)	3/2	0/1	3	
None	ISL 101	Islamic Studies/Ethics	2	0	2	

SEMESTER 7						
Prerequisite	**Course code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	FYP 400	Final Year Project	0	3	3	17
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3	
		Elective Supporting Course	3	0	3	
		Elective 4 (2+1)	2	1	3	
		Elective 5 (2+1)	2	1	3	
None	HSS 423	Entrepreneurship	2	0	2	

SEMESTER 8						
Prerequisite	**Course code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	FYP 400	Final Year Project	0	3	3	15
None	PAK 101	Pakistan Studies	2	0	2	
None	CSC 308	Professional Practices & Ethics	2	0	2	
None	HSS 217	Introduction to Sociology	2	0	2	
		Elective 6 (3+0 or 2+1)	3/2	0/1	3	

		Elective 7 (2+1)	2	1	3	
Total Credit Hours:						**133**

List of Courses

Computing Core Courses (49 credit hours)

Pre-requisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 113	Computer Programming	3	1	4
CSC 113	CSC 210	Object Oriented Programming	3	1	4
None	CSC 220	Database Management Systems	3	1	4
GSC 114	CEN 122	Digital Design	2	1	3
CSC 113	CSC 221	Data Structure & Algorithm	3	1	4
None	CSC 407	Information Security	3	0	3
CSC 210	CSC 325	Artificial Intelligence	3	1	4
None	CEN 223	Computer Communication & Networks	3	1	4
None	SEN 220	Software Engineering	3	0	3
CEN 122	CEN 323	Computer Organization and Assembly Language	2	1	3
CSC 221	CSC 320	Operating Systems	3	1	4
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3
None	FYP 400	Final Year Project	0	6	6

Computer Science Core Courses (18 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 315	Theory of Automata	3	0	3
CSC 220	CSC 468	Advanced Databases	2	1	3
SEN 220	SEN 320	Human Computer Interaction	2	1	3
CEN 323	CSC 327	Computer Architecture	2	1	3
CSC 315	CSC 323	Compiler Construction	2	1	3
CSC 320	AIC 302	Parallel & Distributed Computing	2	1	3

List of Computer Science Elective Courses (21 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
CSC 321	CSC 521	Advanced Design and Analysis of Algorithm	3	0	3
CEN 223	CEN 451	Data Encryption and Security	3	0	3
CSC 220	CSC 452	Data Mining	3	0	3
CSC 220	CSC 454	Data Warehousing	3	0	3

CSC 220	CSC 490	Introduction to Cloud Computing	3	0	3
CSC 325	SEN 455	Knowledge Based Management System	3	0	3
SEN 220	CSC 458	Management Information System	3	0	3
CSC 325	CSC 441	Natural Language Processing	3	0	3
CSC 325	CSC 449	Neural Networks & Fuzzy Logic	3	0	3
SEN 310	SEN 422	Semantic Computing	3	0	3
SEN 220	SEN 458	Software Requirement Engineering	3	0	3
CSC 323	CSC 451	Theory of Programming Languages	3	0	3
SEN 320	SEN 456	Usability Engineering	3	0	3
CEN 223	CSC 489	Ubiquitous Computing	3	0	3
SEN 220	SEN 410	Software Project Management	3	0	3
SEN 220	SEN 420	Software Quality Assurance	3	0	3
SEN 220	SEN 447	Software Testing	3	0	3
CEN 223	ITC 411	Cyber Security	3	0	3
CSC 325	CSC 464	Computer Vision	3	0	3
CSC 221	CSC 404	Blockchain Technologies	3	0	3
CSC 325	CSC 448	Introduction to Bioinformatics	3	0	3
CEN 223	CEN 449	Internet of Things	3	0	3
CSC 220	CSC 488	Big Data Analytics	2	0	2
CSC 220	CSL 488	Big Data Analytics Lab	0	1	1
CSC 210	CSC 444	Computer Graphics	2	0	2
CSC 210	CSL 444	Computer Graphics Lab	0	1	1
SEN 310	CSC 484	Content Management	2	0	2
SEN 310	CSL 484	Content Management Lab	0	1	1
CSC 210	CEN 444	Digital Image Processing	2	0	2
CSC 210	CEL 444	Digital Image Processing Lab	0	1	1
CSC 313	CSC 319	Game Development and Design	2	0	2
CSC 313	CSL 319	Game Development and Design Lab	0	1	1
CSC 325	CSC 466	Introduction to Biometrics	2	0	2
CSC 325	CSL 466	Introduction to Biometrics Lab	0	1	1
CSC 220	CSC 487	Introduction to Data Science	2	0	2
CSC 220	CSL 487	Introduction to Data Science Lab	0	1	1
CSC 210	CSC 341	Mobile Application Development	2	0	2
CSC 210	CSL 341	Mobile Application Development Lab	1	0	1
None	SEN 493	Multimedia Systems	2	0	2
None	SEL 493	Multimedia Systems Lab	0	1	1
CSC 325	CEN 458	Robotics	2	0	2
CSC 325	CEL 458	Robotics Lab	0	1	1
CSC 210	SEN 448	Software Application for Mobile Device	2	0	2

CSC 210	SEL 448	Software Application for Mobile Device Lab	0	1	1
SEN 220	SEN 457	Software Design and Architecture	2	0	2
SEN 220	SEL 457	Software Design and Architecture Lab	0	1	1
CSC 210	CSC 313	Visual Programming	2	0	2
CSC 210	CSL 313	Visual Programming Lab	0	1	1
CSC 113	SEN 310	Web Engineering	2	0	2
CSC 113	SEL 310	Web Engineering Lab	0	1	1
CSC 325	AIC 301	Machine Learning	2	0	2
CSC 325	AIL 301	Machine Learning Lab	0	1	1
CSC 325	AIC 401	Deep Learning	2	0	2
CSC 325	AIL 401	Deep Learning Lab	0	1	1
None	CSC 400	Quantum Computing	2	0	2
None	CSL 400	Quantum Computing Lab	0	1	1

Mathematics & Supporting Courses (12 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
GSC 110	GSC 211	Multivariable Calculus	3	0	3
None	GSC 121	Linear Algebra	3	0	3
None	GSC 122	Probability & Statistics	3	0	3
None	ENG 320	Technical writing and presentation skills	3	0	3

Elective Supporting Courses (3 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	MKT 110	Principles of Marketing	3	0	3
None	FIN 201	Fundamentals of Finance	3	0	3
None	MGT 111	Principles of Management	3	0	3
None	MGT 242	Organizational Theory and Behavior	3	0	3

General Education Courses (30 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 114	Introduction to Information & Communication Technology	2	1	3
None	ENG 101	Functional English	3	0	3
None	ENG 134	Communication Skills	2	0	2

None	GSC 221	Discrete Mathematics	3	0	3
None	GSC 110	Applied Calculus & Analytical Geometry	3	0	3
None	ISL 101	Islamic Studies	2	0	2
None	PAK 101	Pakistan Studies	2	0	2
None	GSC 114	Applied Physics	2	1	3
None	CSC 308	Professional Practices and Ethics	2	0	2
None	HSS 217	Introduction to Sociology	2	0	2
None	HSS 423	Entrepreneurship	2	0	2
Social Sciences Electives					
None	HSS 107	Introduction to Psychology	3	0	3
None	HSS 115	Introduction to Media studies	3	0	3
None	BES 103	Critical Thinking	3	0	3

Course Name: ***Professional Practices and Ethics***
Credit Hours: 2 (2+0)
Contact Hours: 2+0
Pre-requisites: None
Course Code: CSC 308
Content:
Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology); Definitions of Computing (software engineering, Computer Science, Information Technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities, software related contracts, Software house organization. Intellectual Property Rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse and the Criminal Law, Regulation and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct,
ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.

Reference Materials:
1. Professional Issues in Software Engineering by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, CRC Press; 3rd Edition (2000). ISBN-10: 0748409513
2. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition (January 3, 2009). ISBN-10: 0131112414
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (3rd Edition) by Sara Baase, Prentice Hall; 3rd Edition (2008). ISBN-10: 0136008488
4. Applied Professional Ethics by Gregory R. Beabout, University Press of America (1993). ISBN-10: 0819193747.

Name: Computer Architecture
Credit Hours: 3 (2+1)
Contact Hours: 2+3
Pre-requisites: Computer Organization and Assembly Language
Course Code: CSC 327
Content:
Introduction to Computer Architecture, Evolution of microprocessors from vacuum tubes to VLSI, gate level integration complexity, Internal Architecture of x86 and ARM processors, Instruction set architecture, Implementation of Interrupt service routine (ISR) and Interrupt vector table (IVT), Microprocessor without Interlocked Pipelined stages-MIPS Processor, MIPS-ISA, MIPS Assembly Instructions, Minimization of performance and memory gap, design improvements, External memory, Magnetic Disk, Redundant array of independent disks(RAID),DMA controller, Concept of pipelining, Parallelism, Instruction level parallelism, data level parallelism, Thread level parallelism.

Reference Materials:

1. Patterson, David A., Hennessy, John L., (2014), *Computer Organization and Design: the Hardware /Software Interface,* (5th Edition). Morgan Kaufmann Publishers, ISBN-13: 978-0124077263, ISBN-10: 0124077269.
2. Patterson, David A., Hennessy, John L., (2014), *Computer Organization and Design: the Hardware /Software Interface,* (5th Edition). Morgan Kaufmann Publishers, ISBN-13: 978-0124077263, ISBN-10: 0124077269.

BS Information Technology

CURRICULUM DOCUMENT

DEPARTMENT OF COMPUTER SCIENCE, BAHRIA UNIVERSITY

Vision and Mission

Vision and Mission of Bahria University

Vision: To become a knowledge and creativity driven international university that contributes towards development of society

Mission: To ensure academic excellence through deliverance of quality education and applied research in a collegiate environment having strong linkages with industry and international community to meet the societal challenges

Vision of the Computer Science Department

To become a center of excellence in computer science education, research and globalized technologies

Mission of the BS Computer Science Program

To produce graduates having good problem-solving skills and knowledge to use computers creatively and effectively along with team building and professional skills

Program Educational Objectives (PEOs)

PEO 1: Apply principle and practices of information technology and computing knowledge to solve challenging problems in relevant profession

PEO 2: Demonstrate the ability to use modern tools learnt during degree program to design and develop effective solutions

PEO 3: Exhibit managerial capabilities with ethical and moral values

Program Learning Outcomes (PLOs)

PLO1 **Academic Education:** To prepare graduates as computing professionals.

PLO2 **Knowledge for Solving Computing Problems:** Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the 16 abstraction and conceptualization of computing models from defined problems and requirements.

PLO3 **Problem Analysis:** Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.

PLO4 **Design/ Development of Solutions:** Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO5 **Modern Tool Usage:** Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.

PLO6 **Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PLO7 **Communication:** Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions.

PLO8 **Computing Professionalism and Society:** Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.

PLO9 **Ethics:** Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.

PLO10 **Life-long Learning:** Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

Mapping of PLOs to PEOs

No.	Program Learning Outcomes (PLOs)	PEOs		
		PEO-1	PEO-2	PEO-3
1	Academic Education	✓	✓	
2	Knowledge for solving Computing Problems	✓		
3	Problem Analysis	✓		
4	Design/ Development of Solutions	✓	✓	
5	Modern Tool Usage	✓	✓	

6	Individual and Teamwork	✓		✓
7	Communication			✓
8	Computing Professionalism and Society			✓
9	Ethics			✓
10	Life-long Learning	✓	✓	

Curriculum Model for BS in Information Technology

The generic structure for computing degree program given before is mapped with the BSIT program in the following tables.

Generic Structure for Computing Disciplines:

Areas	**Credit Hours**	**Courses**
Computing Core	48	14
Domain Core	19	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**133**	**44**

BS (Information Technology) Road Map

SEMESTER 1						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	GSC 114	Applied Physics	2	0	2	16
None	GSL 114	Applied Physics Lab	0	1	1	
None	CSC 114	Introduction to Information & Communication Technology	2	0	2	
None	CSL 114	Introduction to Information & Communication Technology Lab	0	1	1	
None	ENG 101	Functional English	3	0	3	
None	CSC 113	Computer Programming	3	0	3	
None	CSL 113	Computer Programming Lab	0	1	1	
None	GSC 221	Discrete Mathematics	3	0	3	
SEMESTER 2						

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
None	CSC 220	Database Management Systems	3	0	3	
None	CSL 220	Database Management Systems Lab	0	1	1	
CSC 113	CSC 210	Object Oriented Programming	3	0	3	
CSC 113	CSL 210	Object Oriented Programming Lab	0	1	1	
GSC 114	CEN 122	Digital Design	2	0	2	17
GSC 114	CEL 122	Digital Design Lab	0	1	1	
None	GSC 110	Applied Calculus and Analytical Geometry	3	0	3	
None	GSC 121	Linear Algebra	3	0	3	
SEMESTER 3						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	GSC 122	Probability and Statistics	3	0	3	
GSC 110	GSC 211	Multivariable Calculus	3	0	3	
None	CEN 223	Computer Communication & Networks	3	0	3	
None	CEL 223	Computer Communication & Networks Lab	0	1	1	17
CSC 113	CSC 221	Data Structure & Algorithm	3	0	3	
CSC 113	CSL 221	Data Structure & Algorithm Lab	0	1	1	
None	SEN 220	Software Engineering	3	0	3	
SEMESTER 4						
Prerequisite	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
CSC 210	ITC 226	Web Systems & Technologies	2	0	2	
CSC 210	ITL 226	Web Systems & Technologies Lab	0	1	1	
CEN 122	CEN 323	Computer Organization and Assembly Language	2	0	2	
CEN 122	CEL 323	Computer Organization & Assembly Language Lab	0	1	1	
CSC 210	CSC 411	Artificial Intelligence	2	0	2	
CSC 210	CSL 411	Artificial Intelligence Lab	0	1	1	17
CEN 223	CSC 407	Information Security	3	0	3	
CSC 220	ITC 327	Database Administration & Management	2	0	2	
CSC 220	ITL 327	Database Administration & Management Lab	0	1	1	
None	ENG 134	Communication Skills	2	0	2	
SEMESTER 5						

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
CSC 221	CSC 320	Operating Systems	3	0	3	17
CSC 221	CSL 320	Operating Systems Lab	0	1	1	
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3	
CEN 223	ITC 411	Cyber Security	3	0	3	
CEN 223	ITC 312	System & Network Administration	3	0	3	
CEN 223	ITL 312	System & Network Administration Lab	0	1	1	
None		Social Sciences Elective	3	0	3	

SEMESTER 6

Prerequisite	Course Code	Course Title	Theory	Lab	CR	CR/Sem
ITC 312	ITC 324	Information Technology Infrastructure	3	0	3	18
HSS 118	ENG 320	Technical Writing and Presentation Skills	3	0	3	
CSC 320	AIC 302	Parallel & Distributed Computing	2	0	2	
CSC 320	AIL 302	Parallel & Distributed Computing Lab	0	1	1	
		Elective 1 (2+1)	2	1	3	
		Elective 2 (2+1)	2	1	3	
		Elective 3 (3+0 or 2+1)	3/2	0/1	3	

SEMESTER 7

Prerequisite	Course code	Course Title	Theory	Lab	CR	CR/Sem
None	FYP 400	Final Year Project	0	3	3	17
		Elective Supporting Course	3	0	3	
		Elective 4 (2+1)	2	1	3	
		Elective 5 (2+1)	2	1	3	
		Elective 6 (3+0 or 2+1)	3/2	0/1	3	
None	HSS 423	Entrepreneurship	2	0	2	

SEMESTER 8

Prerequisite	Course code	Course Title	Theory	Lab	CR	CR/Sem
None	FYP 400	Final Year Project	0	3	3	14
None	PAK 101	Pakistan Studies	2	0	2	
None	CSC 308	Professional Practices & Ethics	2	0	2	
None	HSS 217	Introduction to Sociology	2	0	2	
		Elective 7 (3+0 or 2+1)	3/2	0/1	3	
None	ISL 101	Islamic Studies	2	0	2	
Total Credit Hours:						**133**

List of Courses

Computing Core Courses (48 credit hours)

Pre-requisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 113	Computer Programming	3	1	4
CSC 113	CSC 210	Object Oriented Programming	3	1	4
None	CSC 220	Database Management Systems	3	1	4
GSC 114	CEN 122	Digital Design	2	1	3
CSC 113	CSC 221	Data Structure & Algorithm	3	1	4
None	CSC 407	Information Security	3	0	3
CSC 210	CSC 411	Artificial Intelligence	2	1	3
None	CEN 223	Computer Communication & Networks	3	1	4
None	SEN 220	Software Engineering	3	0	3
CEN 122	CEN 323	Computer Organization and Assembly Language	2	1	3
CSC 221	CSC 320	Operating Systems	3	1	4
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3
None	FYP 400	Final Year Project	0	6	6

Information Technology Core Courses (19 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
ITC 312	ITC 324	Information Technology Infrastructure	3	0	3
CEN 223	ITC 312	System & Network Administration	3	1	4
CEN 223	ITC 411	Cyber Security	3	0	3
CSC 210	CSC 411	Artificial Intelligence	2	1	3
CSC 210	ITC 226	Web Systems & Technologies	2	1	3
CSC 320	AIC 302	Parallel & Distributed Computing	2	1	3

List of Information Technology Elective Courses (21 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
ITC 226	ITB 471	E Commerce	3	0	3
None	ITC 425	Business Processing Re-engineering	3	0	3
None	ITC 457	Knowledge Management System & Technologies	3	0	3
CSC 220	CSC 452	Data Mining	3	0	3
CSC 220	CSC 454	Data Warehousing	3	0	3
SEN 310	SEN 421	Semantic Web	3	0	3
SEN 220	SEN 411	Software Testing	3	0	3
SEN 320	SEN 456	Usability Engineering	3	0	3
CSC 220	CSC 426	Business Intelligence and Analytic	3	0	3
None	SEN 427	Information Systems Auditing and Assurance	3	0	3
SEN 220	SEN 428	Service Oriented Architecture	3	0	3
SEN 220	SEN 420	Software Quality Assurance	3	0	3
CEN 222	EET 455	Wireless Communication	3	0	3

None	SEN 320	Human Computer Interaction	3	0	3
CSC 221	CSC 404	Blockchain Technologies	3	0	3
CSC 221	CSC 448	Introduction to Bioinformatics	3	0	3
CEN 222	CSC 450	Internet of Things	3	0	3
CEN 222	SEN 459	Software Defined Network	3	0	3
SEN 320	CSC 489	Ubiquitous Computing	3	0	3
GSC 221	GSC 445	Operation Research	3	0	3
None	CSC 458	Management Information System	3	0	3
SEN 220	SEN 410	Software Project Management	3	0	3

Prerequisite	Course Code	Course Title	Lec	Lab	CR
CSC 210	CSC 313	Visual Programming	2	0	2
CSC 210	CSCL 313	Visual Programming Lab	0	1	1
CSC 220	CSC 487	Introduction to Data Science	2	0	2
CSC 220	CSL 487	Introduction to Data Science Lab	0	1	1
CSC 210	CEN 444	Digital Image Processing	2	0	2
CSC 210	CEL 444	Digital Image Processing Lab	0	1	1
CSC 210	CSC 444	Computer Graphics	2	0	2
CSC 210	CSL 444	Computer Graphics Lab	0	1	1
CSC 220	CSC 468	Advanced Databases	2	0	2
CSC 220	CSL 468	Advanced Databases Lab	0	1	1
CSC 210	CSC 341	Mobile Application Development	2	0	2
CSC 210	CSL 341	Mobile Application Development Lab	1	0	1
None	SEN 493	Multimedia Systems	2	0	2
None	SEL 493	Multimedia Systems Lab	0	1	1
SEN 220	SEN 457	Software Design and Architecture	2	0	2
SEN 220	SEL 457	Software Design and Architecture Lab	0	1	1
CSC 113	SEN 310	Web Engineering	2	0	2
CSC 113	SEL 310	Web Engineering Lab	0	1	1
CSC 220	CSC 468	Advanced Databases	2	0	2
CSC 220	CSL 468	Advanced Databases Lab	0	1	1
CSC 220	CSC 488	Big Data Analytics	2	0	2
CSC 220	CSL 488	Big Data Analytics Lab	0	1	1
SEN 310	CSC 484	Content Management	2	0	2
SEN 310	CSL 484	Content Management Lab	0	1	1
CSC 411	CSC 413	Introduction to Machine Learning	2	0	2
CSC 411	CSC 413	Introduction to Machine Learning	0	1	1

Mathematics & Supporting Courses (12 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
GSC 110	GSC 211	Multivariable Calculus	3	0	3
None	GSC 121	Linear Algebra	3	0	3
None	GSC 122	Probability & Statistics	3	0	3
HSS 118	ENG 320	Technical Writing and Presentation Skills	3	0	3

Elective Supporting Courses (3 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	MKT 110	Principles of Marketing	3	0	3
None	FIN 201	Fundamentals of Finance	3	0	3
None	MGT 111	Principles of Management	3	0	3
None	MGT 242	Organizational Theory and Behavior	3	0	3

General Education Courses (30 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 114	Introduction to Information & Communication Technology	2	1	3
None	ENG 101	Functional English	3	0	3
ENG 105	ENG 134	Communication Skills	2	0	2
None	GSC 221	Discrete Mathematics	3	0	3
None	GSC 110	Applied Calculus & Analytical Geometry	3	0	3
None	ISL 101	Islamic Studies	2	0	2
None	PAK 101	Pakistan Studies	2	0	2
None	GSC 114	Applied Physics	2	1	3
None	CSC 308	Professional Practices and Ethics	2	0	2
None	HSS 217	Introduction to Sociology	2	0	2
None	HSS 423	Entrepreneurship	2	0	2
Social Sciences Electives					
None	HSS 107	Introduction to Psychology	3	0	3
None	HSS 115	Introduction to Media studies	3	0	3
None	BES 103	Critical Thinking	3	0	3

Course Title: Blockchain Technologies
Course Code: CSC 404
Credit Hours: 3
Pre-requisite (if any): CSC 221

Course Description

This is a beginners-level course that focuses on the foundational technologies behind blockchain. We will cover the concepts of distributed ledger, consensus mechanisms, authentication techniques, and relevant protocols. The course will provide case studies of blockchain applications such as cryptocurrencies, supply chain management, and B2B/B2C/C2C scenarios. The course will also provide hands-on experience with building and deploying smart contracts

Course Objectives

The course aims to introduce basic blockchain concepts. You will learn about the decentralized peer-to-peer network, an immutable distributed ledger and the trust model that defines a blockchain. This course enables you to explain basic components of a blockchain (transaction, block, block header, and the chain) its operations (verification, validation, and consensus model) underlying algorithms, and essentials of trust (hard fork and soft fork). Content includes the hashing and cryptography foundations indispensable to blockchain programming, which is the focus of two subsequent specialization courses, Smart Contracts and Decentralized Applications (Dapps). You will work on a virtual machine image, specifically created for this course, to build an Ethereum test chain and operate on the chain. This hands-on activity will help you understand the workings of a blockchain, its transactions, blocks and mining.

Course Learning Outcomes

CLO: 1. Acquire the basic concepts and uses of blockchain with different applications/Systems [C1 – Knowledge]

CLO: 2. Describe and apply different stages of blockchain development using different algorithms [C3 – Application]

CLO: 3. Identify the problems and apply blockchain solutions. [C2 – Comprehension]

CLO: 4. Build blockchain environment using tools. [P3 – Comprehension]

Recommended Text Books/Reference Books (latest edition)

1. Antony Lewis The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them (5th Edition)

Web Resources/Other Course Materials

1. Slides, and reference material, whitepapers, online resources

Course Title: Introduction to Bioinformatics
Course Code: CSC 448
Credit Hours: 03
Pre-requisite: CSC 221

Course Description

This course is designed to give students both a theoretical background and a working knowledge of the techniques employed in bioinformatics. Emphasis will be placed on biological sequence (DNA, RNA, protein) analysis and its applications.

Course Objectives

1. A basic understanding of the biological data and biological processes
2. Familiarity with the biological databases and their use
3. Understanding of the biological problems that can be solved using computational techniques
4. Understanding and implementation of the algorithms used to solve biological problems
5. Analyses of the biological data and biological techniques

Course Learning Outcomes

1. Students will become familiar with different biological databases
2. Students will be able to extract and analyze the data from the different biological resources
3. Students will become familiar with the different biological techniques used to solve biological problems (such as structure prediction)
4. Students will be able to compare and analyze sequential data (DNA, RNA, and Proteins)
5. Students will be able to solve the biological problems (by applying computational techniques) using different types of information extracted from the biological data

Course Contents:

1. Introduction to Bioinformatics
2. DNA Replication, Transcription, and Translation
3. Introduction to biological databases and retrieval of information from these databases
4. Sequence Alignment (Local and Global)
5. Introduction to structure prediction of the proteins
6. Advance problems in Bioinformatics that can be solved by computational techniques
7. Use of protein sequence and structure to solve biological problems

Recommended Text Books/Reference Books (latest edition)

1. Introduction to Bioinformatics by Arthur M. Lesk (2019
2. An Introduction to Bioinformatics Algorithms by NC Jones, and PA Pevzner (2004)

Web Resources/Other Course Materials

1. Different Databases and Tools such as Uniprot, PDB, SwissProt, etc.
2. Research Articles

Course Title: **Introduction to Machine Learning**
Course Code: CSC 413
Credit Hours: **3 (Theory)**
Pre-requisite (if any): CSC 411

Course Description

Machine learning is a subset of AI. This field is incredibly pervasive, with applications spanning from business intelligence to security, from analyzing biochemical interactions to structural monitoring of aging bridges, etc. It uses interdisciplinary techniques such as statistics, linear algebra, optimization, and computer science to create automated systems that can sift through large volumes of data at high speed to make predictions or decisions without human intervention. This course will familiarize students with a broad cross-section of models and algorithms for machine learning. Students will also implement algorithms using python machine learning libraries. Students should be familiar with basic mathematics concepts such as linear algebra, calculus, and statistics to get maximum benefit of this course.

Course Objectives

1. To provide the knowledge of supervised and unsupervised machine learning paradigm that how it can help to do the tasks that humans can do out of instinct.
2. To provide understanding of machine learning process cycle from data acquisition to model training, and performance evaluation.
3. To enable student to implement different machine learning algorithms for classification and regression problems.

Course Learning Outcomes

1. Understand and describe a wide variety of learning algorithms
2. Apply the machine learning algorithms to a case study data/real-world problem
3. Evaluate and optimize the trained models to tune up the performance

Course Contents:

1. Introduction: what is ML; Problems, Applications
2. Categories (Supervised Learning, Un-supervised Learning, Reinforcement Learning)
3. An introduction to Prominent Supervised learning (Classification and Regression Algorithms)
4. Introduction to Python (Language, Tools and IDE's Tour, Scikit learn ML Libraries)
5. ML Process cycle (Data Acquisition, Model Training Process, Trained Model Evaluation)
6. Data Acquisition (Categorical & numerical data, Data Pre-processing and Preparation, Data Wrangling)
7. Algorithms (concept, mathematical model, implementation using python)
    a. Linear regression

b. Naïve Bayes Algorithm
c. Decision Trees (ID3)
d. Random Forest
e. Support vector machines
f. K-near neighbors
g. K-mean clustering
h. Logistic Regression
i. Neural Network
j. Reinforcement learning (Agent, reward, feedback policy, different RL Models)

8. Model Training process (Train test split, hyper parameter, tuning, cross validation, best fit model selection)
9. Training & Testing conventions (K-fold cross validation, Overfitting, Underfitting)
10. Model Performance Evaluation
    a. Bias, Variance trade-off
    b. Loss Functions
    c. Optimization, Gradient Descent
    d. Regularization (L1 and L2)
    a. Reporting predictive performance by Evaluation metrics (Accuracy, Precision, Recall, F1, ROC and AUC)
11. Tuning model complexity, Model Design Issues
12. Trained Model Deployment

Recommended Text Books/Reference Books (latest edition)

2. Géron, A. (2022). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow*. " O'Reilly Media, Inc.
3. Burkov, A. (2019). *The hundred-page machine learning book* (Vol. 1, p. 32). Quebec City, QC, Canada: Andriy Burkov.
4. Sebastian Raschka (2017). *Python Machine Learning* (2nd ed.). ISBN: 978-1-78712-593

Web Resources/Other Course Materials

2. http://cs229.stanford.edu/
3. Wang, W., & Siau, K. (2019). Artificial intelligence, machine learning, automation, robotics, future of work and future of humanity: A review and research agenda. Journal of Database Management (JDM), 30(1), 61-79.
4. https://machinelearningmastery.com/a-tour-of-machine-learning-algorithms/

Course Title: _Business Processing Re-engineering
Course Code: ___ ITC 425_____
Credit Hours: ____3_____
Pre-requisite (if any): _None___

Course Description

This course focuses on the application of industry 'best practice' strategies, tools and techniques in business process management to re-engineer organizations' business processes. Students will learn about key business process management concepts, and how to apply a proven five (5) phase methodology to re-engineer business processes in 'real world' organizational situations. Upon successful completion of this course, students would be equipped to carry out business process reengineering (BPR) initiatives within their own organizations, to produce better performing business processes.

BS Artificial Intelligence

CURRICULUM DOCUMENT

DEPARTMENT OF COMPUTER SCIENCE, BAHRIA UNIVERSITY

Vision and Mission

Vision and Mission of Bahria University

Vision: To become a knowledge and creativity driven international university that contributes towards development of society.

Mission: To ensure academic excellence through deliverance of quality education and applied research in a collegiate environment having strong linkages with industry and international community to meet the societal challenges.

Vision of the Computer Science Department

To become a center of excellence in Computer Science education, research, and globalized technologies

Mission of the BS Artificial Intelligence program

To prepare graduates who can analyze, design, and develop effective AI solutions and contribute effectively towards society.

Program Educational Objectives (PEOs)

PEO-1: Utilize knowledge to solve real-world problems by applying theory, principles, and methods of computing in general and artificial intelligence in particular.

PEO-2: Demonstrate social and ethical responsibility in professional life.

PEO-3: Manifest lifelong learning for sustained professional and personal progression.

PEO-4: Practice effective communication and teamwork skills.

Program Learning Outcomes (PLOs)

PLO1 **Academic Education:** To prepare graduates as computing professionals.

PLO2 **Knowledge for Solving Computing Problems:** Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements.

PLO3 **Problem Analysis:** Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.

PLO4 Design/ Development of Solutions: Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO5 **Modern Tool Usage:** Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.

PLO6 **Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PLO7 **Communication:** Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions.

PLO8 **Computing Professionalism and Society:** Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.

PLO9 **Ethics:** Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.

PLO10 **Life-long Learning:** Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

Mapping of PLOs to PEOs

No.	Program Learning Outcomes (PLOs)	PEOs			
		PEO-1	PEO-2	PEO-3	PEO-4
1	Academic Education	✓		✓	
2	Knowledge for solving Computing Problems	✓		✓	
3	Problem Analysis	✓			
4	Design/ Development of Solutions	✓	✓		
5	Modern Tool Usage	✓		✓	
6	Individual and Teamwork				✓
7	Communication				✓
8	Computing Professionalism and Society		✓	✓	
9	Ethics		✓		
10	Lifelong Learning	✓		✓	

Program Eligibility Criteria

Minimum 50% marks in Intermediate (HSSC) Examination (Pre-Medical/Pre-Engg.) or equivalent qualification with Mathematics certified by IBCC.

Deficiency: For Pre-Medical students, the following two deficiency courses of mathematics will be taught during the first year.

- Fundamentals of Mathematics I GSC 103 (3 Credit Hours)
- Fundamentals of Mathematics II GSC 104 (3 Credit Hours)

Curriculum for BS in Artificial Intelligence

The generic structure for computing degree program is mapped with the BS(AI) program in the following table.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	49	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**133**	**44**

BS (Artificial Intelligence) Road Map

Program Roadmap

SEMESTER 1						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	GSC 114	Applied Physics	2	0	2	**16**
None	GSL 114	Applied Physics Lab	0	1	1	
None	CSC 114	Introduction to Information & Communication Technology	2	0	2	
None	CSL 114	Introduction to Information & Communication Technology Lab	0	1	1	
None	ENG 101	Functional English	3	0	3	
None	CSC 113	Computer Programming	3	0	3	
None	CSL 113	Computer Programming Lab	0	1	1	
None	GSC 221	Discrete Mathematics	3	0	3	

SEMESTER 2						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	GSC 121	Linear Algebra	3	0	3	**17**
CSC 113	CSC 210	Object Oriented Programming	3	0	3	

CSC 113	CSL 210	Object Oriented Programming Lab	0	1	1	
None	CSC 220	Database Management Systems	3	0	3	
None	CSL 220	Database Management Systems Lab	0	1	1	
None	GSC 110	Applied Calculus and Analytical Geometry	3	0	3	
None	CEN 122	Digital Design	2	0	2	
None	CEL 122	Digital Design Lab	0	1	1	

SEMESTER 3						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
GSC 110	GSC 211	Multivariable Calculus	3	0	3	**17**
None	CEN 223	Computer Communication and Networks	3	0	3	
None	CEL 223	Computer Communication and Networks Lab	0	1	1	
CSC 113	CSC 221	Data Structures and Algorithms	3	0	3	
CSC 113	CSL 221	Data Structures and Algorithms Lab	0	1	1	
None	AIC 202	Programming for Artificial Intelligence	2	0	2	
None	AIL 202	Programming for Artificial Intelligence Lab	0	1	1	
None	GSC 122	Probability and Statistics	3	0	3	

SEMESTER 4						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
CSC 221	CSC 320	Operating Systems	3	0	3	**16**
CSC 221	CSL 320	Operating Systems Lab	0	1	1	
AIC 201	AIC 203	Knowledge Representation & Reasoning	3	0	3	
None	AIC 301	Machine Learning	2	0	2	
None	AIL 301	Machine Learning Lab	0	1	1	
AIC 202	AIC 201	Artificial Intelligence	3	0	3	
AIC 202	AIL 201	Artificial Intelligence Lab	0	1	1	
None	ENG 134	Communication Skills	2	0	2	

SEMESTER 5						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
CEN 122	CEN 323	Computer Organization & Assembly Language	2	0	2	**17**
CEN 122	CEL 323	Computer Organization & Assembly Language Lab	0	1	1	
AIC 301	AIC 401	Deep learning	2	0	2	
AIC 301	AIL 401	Deep learning Lab	0	1	1	
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3	
None	PAK 101	Pakistan Studies	2	0	2	
		Elective 1	2	1	3	
		Elective 2	3/2	0/1	3	

SEMESTER 6						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	SEN 220	Software Engineering	3	0	3	**17**
None	AIC 304	Computer Vision	2	0	2	
None	AIL 304	Computer Vision Lab	0	1	1	
None	ISL 101	Islamic Studies/ Ethics	2	0	2	
		Social Science Elective(General Education)	3	0	3	
		Elective 3	2	1	3	
		Elective 4	2	1	3	

SEMESTER 7						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	FYP 400	Final Year Project I	0	3	3	**17**
CSC 320	AIC 302	Parallel & Distributed Computing	2	0	2	
CSC 320	AIL 302	Parallel & Distributed Computing Lab	0	1	1	
None	ENG 320	Technical Writing & Presentation Skills	3	0	3	
None	CSC 307	Professional Practices and Ethics	2	0	2	
		Supporting Elective (Social Sciences)	3	0	3	
		Elective 5	2	1	3	

SEMESTER 8						
Pre-Req	**Course Code**	**Course Title**	**Theory**	**Lab**	**CR**	**CR/Sem**
None	FYP 400	Final Year Project II	0	3	3	**16**
CEN 223	CSC 407	Information Security	3	0	3	
None	HSS 217	Introduction to Sociology	2	0	2	
None	HSS 423	Entrepreneurship	2	0	2	
		Elective 6	3/2	0/1	3	
		Elective 7	3/2	0/1	3	
					Total:	**133**

List of Courses

Computing Core Courses (49 credit hours)

Pre-requisite	Course Code	Course Title	Lec	Lab	CR
None	CSC 113	Computer Programming	3	0	3
None	CSL 113	Computer Programming Lab	0	1	1
CSC 113	CSC 210	Object Oriented Programming	3	0	3
CSC 113	CSL 210	Object Oriented Programming Lab	0	1	1

None	CSC 220	Database Management Systems	3	0	3
None	CSL 220	Database Management Systems Lab	0	1	1
None	CEN 122	Digital Design	2	0	2
	CEL 122	Digital Design Lab	0	1	1
None	CEN 223	Computer Communication and Networks	3	0	3
None	CEL 223	Computer Communication and Networks Lab	0	1	1
CSC 113	CSC 221	Data Structures and Algorithms	3	0	3
CSC 113	CSL 221	Data Structures and Algorithms Lab	0	1	1
CSC 221	CSC 320	Operating Systems	3	0	3
CSC 221	CSL 320	Operating Systems Lab	0	1	1
CEN 122	CEN 323	Computer Organization & Assembly Language	2	0	2
CEN 122	CEL 323	Computer Organization & Assembly Language Lab	0	1	1
AIC 202	AIC 201	Artificial Intelligence	3	0	3
AIC 202	AIL 201	Artificial Intelligence Lab	0	1	1
CSC 221	CSC 321	Design and Analysis of Algorithms	3	0	3
None	SEN 220	Software Engineering	3	0	3
None	FYP 400	FYP I	0	3	3
None	FYP 400	FYP II	0	3	3
CEN 223	CSC 407	Information Security	3	0	3

Artificial Intelligence Core Courses (18 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	AIC 202	Programming for Artificial Intelligence	2	0	2
None	AIL 202	Programming for Artificial Intelligence Lab	0	1	1
None	AIC 301	Machine Learning	2	0	2
None	AIL 301	Machine Learning Lab	0	1	1
AIC 201	AIC 203	Knowledge Representation & Reasoning	3	0	3
AIC 301	AIC 401	Deep Learning	2	0	2
AIC 301	AIL 401	Deep Learning Lab	0	1	1
None	AIC 304	Computer Vision	2	0	2
None	AIL 304	Computer Vision Lab	0	1	1
CSC 320	AIC 302	Parallel & Distributed Computing	2	0	2
CSC 320	AIL 302	Parallel & Distributed Computing Lab	0	1	1

List of Courses

Artificial Intelligence Electives (21 Credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
GSC 122	AIC 305	Advance Statistics	3	0	3
None	CSC 315	Theory of Automata	3	0	3

None	CSC 452	Data Mining	3	0	3
None	AIC 306	Speech Processing	3	0	3
None	AIC 402	Reinforcement Learning	3	0	3
None	AIC 403	Fuzzy Systems	2	1	3
None	AIC 307	Evolutionary Computing	3	0	3
None	AIC 308	Agent-Based Modeling	3	0	3
None	CEN 459	Robotics	2	1	3
None	ITC 412	Introduction to Cyber Security	2	1	3
None	AIC 442	Natural Language Processing	2	1	3
None	AIC 410	Virtual and Augmented Reality	2	1	3
None	AIC 411	HCI & Computer Graphics	2	1	3
None	AIC 310	Swarm Intelligence	2	1	3
None	CSC 400	Quantum Computing	2	1	3
None	AIC 377	Game Artificial Intelligence	2	1	3

Mathematics & Supporting Courses (12 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	GSC 121	Linear Algebra	3	0	3
GSC 110	GSC 211	Multivariable Calculus	3	0	3
None	GSC 122	Probability and Statistics	3	0	3
	ENG 320	Technical Writing and Presentation Skills	3	0	3

Elective Supporting Courses (3 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	MKT 110	Principles of Marketing	3	0	3
None	FIN 201	Fundamentals of Finance	3	0	3
None	MGT 111	Principles of Management	3	0	3
None	MGT 242	Organizational Theory and Behavior	3	0	3

General Education Courses (30 credit hours)

Prerequisite	Course Code	Course Title	Lec	Lab	CR
None	GSC 114	Applied Physics	2	0	2
None	GSL 114	Applied Physics Lab	0	1	1
None	CSC 114	Introduction to Information & Communication Technology	2	0	2
None	CSL 114	Introduction to Information & Communication Technology Lab	0	1	1
None	ENG 101	Functional English	3	0	3
None	GSC 221	Discrete Mathematics	3	0	3
None	GSC 110	Applied Calculus and Analytical Geometry	3	0	3
None	ENG 134	Communication Skills	2	0	2

None	PAK 101	Pakistan Studies	2	0	2
None	ISL 101	Islamic Studies/ Ethics	2	0	2
None	CSC 307	Professional Practices and Ethics	2	0	2
	HSS 423	Entrepreneurship	2	0	2
None	ENG 320	Introduction to Sociology	2	0	2
Social Sciences Electives					
None	HSS 107	Introduction to Psychology	3	0	3
None	HSS 115	Introduction to Media studies	3	0	3
None	BES 103	Critical Thinking	3	0	3

Course Name: Quantum Computing
Credit Hours: 3 (2+1)
Contact Hours: 2+3
Pre-requisites: None
Course Code: AIC 400
Content: Introduction to the principles and practice of quantum computing, with an emphasis on the perspective of computer scientists, Introduction to quantum mechanics, Basic principles of quantum mechanics: superposition, entanglement, and measurement, Quantum gates and circuits: Quantum gates and circuits: the Hadamard gate, Pauli gates, and CNOT gate, Basic quantum circuits such as the circuit for Grover's search algorithm, platforms for developing and exploring quantum computing algorithms, Quantum computing Libraries: Qiskit for mapping computer science datasets in to quantum realm.

Course Name: Virtual and Augmented Reality
Credit Hours: 3 (2+1)
Contact Hours: 2+3
Pre-requisites: None
Course Code: AIC 410
Content: Introduction to Virtual Reality and Augmented Reality, Design for AR/VR, History of AR/VR, Basics of Computer Vision and Multimodal Interaction, Business of AR/VR, Basics of Human Perception, Depth Perception and Projection, AR/VR Displays, Graphics Pipeline, Lighting, Shading, and Effects, Scene Graphs and Acceleration, 2D & 3D Tracking, Interaction, Principles and Problems, Algorithms for AR and VR, Human Robot Interaction using AR/VR systems, Eye and Displays (2D), Head Up and Head Mounted Systems in Automotive and Aviation Domains, Virtual Reality System development in Unity

Course Name: Game Artificial Intelligence
Credit Hours: 3 (2+1)
Contact Hours: 2+3
Pre-requisites: None
Course Code: AIC 377
Content: Introduction to Game AI, Basic concepts and methods of artificial intelligence and their applications in computer games, Artificial stupidity, intelligent mistakes, models of game AI, data structures, representations, complexity, and constraints, Agent Movement Steering Behaviors, Coordinated Movement, character movement, pathfinding, decision making (behavior trees), Tactical & Strategic AI, Scripting language for game AI, navigation, planning, and learning in the game, AI for human-like characters, Decision Making: State Machines in gaming, Rule-based systems, Decision trees, Optimizing the behavior of NPCs, Procedural Content Generation, GANs, Pattern recognition and agents in the game, Learning algorithms, training agents with find-grained control, Playing games with deep RL, General video game AI (GVGAI), GameAI platforms

Course Name: Swarm Intelligence
Credit Hours: 3 (2+1)
Contact Hours: 2+3
Pre-requisites: None
Course Code: AIC 310
Content: Agent-based modeling: Bottom-up modeling method, individual agents, System theory and complex systems, multi-agent systems, Behavioral swarm intelligence: Modeling flocking behavior, Boids model, flocking behavior applications, such as agents queuing and homing, Computational swarm intelligence (CSI): Optimization theory and multi-objective optimization, Particle swarm optimization (PSO), Ant colony optimization (ACO), Bees colony algorithm (BCO), Bats algorithm, Selected applications: Different selected applications where the students can apply the swarm intelligence algorithms to solve real problems, such as: Multi-robot path planning, Task scheduling.

Background: Sophus Lie's theory was virtually the only systematic method for solving nonlinear ordinary differential equations. It was rarely used for practical problems because of the massive number of calculations involved. But with the advent of computer algebra programs, it became possible to apply Lie theory to concrete problems. Taking this approach, Algorithmic Lie Theory for Solving Ordinary Differential Equations serves as a valuable introduction for solving differential equations using Lie's theory and related results.

Recommendations: Applications covered in the course include calculation of symmetry groups of differential equations, integration of ordinary differential equations, including special techniques for Euler-Lagrange equations or Hamiltonian systems, differential invariants and construction of equations with prescribed symmetry groups, group-invariant solutions of partial differential equations, dimensional analysis, and the connections between conservation laws and symmetry groups. The exposition is reasonably self-contained, and supplemented by numerous examples of direct physical importance, chosen from classical mechanics, fluid mechanics, elasticity and other applied areas.

Lie Group Methods for Differential Equations

Course Code: Math-738
Credit Hours: 3+0
Pre-Requisite: NIL
Course content:
Basic concepts of groups of transformation, parameter Lie group of transformation, infinitesimal transformation, infinitesimal generators, Lie's first fundamental theorem, invariance, canonical coordinates, prolongations, multi-parameter Lie group of transformations, Lie algebra, solvable Lie algebra, Lie's second and third fundamental theorems, invariance of ordinary differential equations under Lie group of transformation and multi-parameter Lie group of transformations, mappings of solutions to other solutions from invariance of an ordinary differential equations and partial differential equations, determining equations for infinitesimal transformation of an n-th order ordinary differential equations and a system of partial differential equations, determination of n-th order ordinary differential equations in variant under a given group, reduction of order by canonical coordinates and differential invariants, invariant solutions of ordinary differential equations and partial differential equations.

Recommended Books:
1. Fritz Schwartz, Algorithmic Lie Theory for Solving Ordinary Differential Equations, Chapman and Hall, (2019)
2. Peter J. Olver, Applications of Lie Groups to Differential Equations, Springer Science & Business Media, 2012
3. Nail H. Ibragimov, A Practical Course in Differential Equations and Mathematical Modelling. World Scientific, (2010).
4. Meleshko, S.V., Methods for Constructing Exact Solutions of Partial Differential Equations, Springer, 2005