Minutes of the 37th Meeting of the Board of Studies Faculty of Engineering Sciences held on 21st January & 7th February 2025 Via VLC

Bahria University Islamabad

Contents

Minutes of the 37th Meeting of Faculty Board of Studies Engineering Sciences held on 21st January 2025 & 7th February 2025 through VLC

Attendance:

BUIC

Dr. Faisal Bashir Hussain	Dean ES	Chair
Dr. Syed Umair Ullah Jamil	HoD(E&ES)	Member
Dr. Khurram Ehsan	HoD (CS)	Member
Dr. Adeel M Syed	HoD (SE)	Member
Dr. Shahzad Khalid	Principal H-11	Member
Dr. Moneeb Gohar	HoD (CS)	Member
Dr. M Hassan Danish	HoD (EE)	Member
Dr. Syed Khawar Hussain Shah	HoD (CE)	Member

BUKC

Dr. Haroon Rasheed	Principal	Member
Dr. Shaista Iftikhar	HoD (E&ES)	Member
Dr. Taha Jilani	HoD (CS)	Member
Dr. Abdul Attayab Khan	HoD (EE)	Member
Dr. Shoaib Mughal	HoD (CE)	Member
Dr. Hina Shakir	HoD (SE)	Member

BULC

Dr. Khawaja Qasim Maqbool	HOD (CS)	Member

Proceedings

Preliminaries

FBoS-ES meeting took place on 21st January 2025, with the quorum complete, the proceedings commenced at 0930 hours, with recitation from the Holy Quran. Since all the agenda items cannot be completed on the same day, the meeting was resumed on 7th February 2025 at 1000 hrs.

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

Item3701: Benchmarking of Undergraduate Degree Program Curricula of FoES with Top International Universities

Sponsor: CS, EE, SE, CE, and E&ES Departments Referral Authority: Respective DBoS

Summary:

1. The objective of benchmarking roadmaps and course contents with top international universities is to ensure global competitiveness, maintain academic excellence, and align curricula with international standards.
2. The benchmarking has been carried out against the curricula of top universities from the QS and THE ranking.
3. HoDs highlighted that most of the courses offered in their departments have curricula in line with top international universities. However, a systematic and in-depth comparison of FoES educational programs with leading international universities has helped to identify new content/topics for addition in existing courses.
4. Also, a few new elective courses are also recommended for addition in degree programs to cater for emerging trends and domains of study.
5. The sponsors presented the benchmarking of degree programs against top universities, including Stanford, University of Oxford, Harvard University, University of California and Imperial College, London etc. The list of international universities used in the benchmarking of the academic program curricula are as follows:

Sr No	Degree Program	International Universities
1	BS Computer Science, BS Information Technology, BS Artificial Intelligence	Stanford University University of Oxford Harvard University University of California Imperial College
2	Bachelor of Computer Engineering	Carnegie-Mellon Ohio State University Ut Austin Wright State University Washington University
3	BS Robotics and Intelligent Systems	Stanford University (Robotics and Embodied Artificial Intelligence) Massachusetts Institute of Technology (Robotics) Harvard University (Robotics) University of California (Robotics and Intelligent Systems) Imperial College (Robotics)
4	BS Software Engineering	National University of Singapore (NUS) Singapore Tsinghua University, Beijing, China University of Washington, Seattle, United States University of Waterloo, Waterloo, Canada The University of Sydney, Sydney, Australia

5	BS Environmental Science	Michigan State University Wageningen University and Research University of Birmingham University of Toronto University of Bristol
6	BS Remote Sensing & GIS	Wuhan University University of Maryland - College Park Massachusetts Institute of Technology University of Colorado Boulder University of Zurich
7	BS Geophysics	Stanford University University of California, Berkeley (UCB) Oxford University Harvard University

6. The summary of the recommendations from the curriculum benchmarking studies are as follows:

Sr No	Degree Program	Number of Courses Reviewed	Number of courses with minor changes	New Electives Recommended	Bench-marking study
1	BSCS, BS AI and BS IT	50	24	11	Appendage 3703
2	BCE	66	12	3	Appendage 3701
3	BS RIS	30	7	4	Appendage 3704
4	BS ES	40	24	2	Appendage 3705
5	BS RS&GIS	24	21	2	Appendage 3705
6	BS Geophysics	26	18	2	Appendage 3705
7	BSE	68	14	5	Appendage 3706

7. List of Courses with Minor Changes:

Sr No	Course Title	Degree Program	Bench-marking study

1	1. Advanced Design and Analysis of Algorithms 2. Artificial Intelligence 3. Big Data Analytics 4. Blockchain Technologies 5. Business Intelligence and Analytic 6. Compiler Construction 7. Computer Communication & Networks 8. Computer Organization and Assembly Language 9. Computer Vision 10. Data Mining 11. Database Management Systems 12. Design and Analysis of Algorithms 13. Digital Logic Design 14. Information and Communication technology 15. Internet of Things 16. Multimedia systems 17. Neural Networks and Fuzzy Logic 18. Programming for Artificial Intelligence 19. Robotics 20. Semantic Computing 21. Software Engineering 22. Speech Processing 23. Theory of Automata 24. Web Systems and Technologies	BSCS, BSIT, BSAI	Appendage 3703
2	1. Computing Fundamentals 2. Computer Programming 3. Digital Logic Design 4. Electronic Devices & Circuits 5. Object Oriented Programming 6. Microprocessors & Interfacing 7. Operating Systems 8. Database Management Systems 9. Discrete Structures 10. Complex Variables & Transforms 11. Differential Equations 12. Communication Skills	BCE	Appendage 3701
3	1. Engineering Drawing and CAD 2. Digital Logic Design 3. Engineering Workshop 4. Engineering Mechanics 5. AI for Games 6. Chatbots 7. Sensors and Actuators	BS RIS	Appendage 3704
4	1. Introduction to Environmental Sciences 2. Chemistry 3. Environmental Statistics 4. Environmental Issues	BS ES	Appendage 3705

	5. Environmental Biology 6. Environmental Chemistry 7. Fundamentals of Ecology 8. Social Theory of Environment 9. Environmental Microbiology 10. Environmental Monitoring 11. Introduction to Climate Change 12. Environmental Toxicology 13. Environmental Biotechnology 14. Environmental and Natural Resource Economics 15. Environmental Engineering 16. Analytical Techniques in Environmental Sciences 17. Environmental Geology 18. Environmental Impact Assessment 19. Energy And Environment 20. Environmental Policies & Laws 21. Occupational Health & Safety 22. Pollution Control Technology 23. Water Resources Management 24. Air & Noise Pollution		
5	1. Physical Geography & Lab 2. Fundamental of Earth Sciences & Lab 3. Introduction to Remote sensing 4. Introduction to Cartography & Lab 5. GPS & Surveying & Lab 6. Human Geography 7. Introduction to Photogrammetry 8. Multidisciplinary Applications of GIS & RS & Lab 9. Database Management System & Lab 10. Active Remote Sensing & Space Law 11. Spatial Decision Support Systems 12. Microwave & Hyper Spectral RS & Lab 13. Integrated Geospatial Technologies & Lab 14. Spatial Data Infrastructure & Visualization 15. Geodesy 16. Satellite Navigation System 17. Spatial Data Analysis 18. GIS for Disaster Management 19. Geospatial Techniques 20. Computer Aided Drafting/Drawing & Lab 21. Legal and Social Issues in Geospatial Sciences	BS RS & GIS	Appendage 3705
6	1. Physical & General Geology 2. Introduction to Geophysics 3. Field Geology & Lab 4. Fundamental of Geography & Geomorphology 5. Structural Geology & Lab 6. Gravity & Magnetic Exploration Techniques	BS Geophysics	Appendage 3705

	7. Geotectonics 8. Earthquake Seismology 9. Rock Physics 10. Petroleum Geology 11. Environmental Geophysics 12. Electrical & Radioactive Exploration Techniques 13. Mining Geophysics 14. Stratigraphy of Pakistan 15. Wireline Logging & Lab 16. Research Methodology 17. Seismic Data Processing 18. Seismic Data Interpretation		
7	1. Digital Design 2. Software Requirement Engineering 3. Human Computer Interaction 4. Software Construction 5. Software Project Management 6. System Programming 7. Game Application Development 8. Mathematical Tools for Software Engineering 9. Cloud Computing 10. Data Mining 11. Data Warehousing 12. Management Information Systems 13. Advanced Database Management Systems 14. Computer Vision	BSE	Appendage 3706

8. The list of recommended new elective courses in different degree programs is as follows:

Sr No	Course Title	Degree Program(s)	Proposed Course Content
1	a. Explainable Artificial Intelligence b. Cloud and DevOps Engineering c. Quantum Computing for Artificial Intelligence d. Ethical Hacking e. Introduction to Cryptography	BSCS	Appendage 3703

	f. Cloud Infrastructure and Scalable Application Deployment g. AI Ethics and Safety h. Vulnerability Assessment & Reverse Engineering	BSIT	
	i. Introduction to Computational Linguistics j. AI Ethics and Safety k. Computer Vision Application in Biomedicine	BSAI	
2	a. Deep Learning and Neural Networks b. Linear Control Systems c. Digital Control Systems	BCE	Appendage 3701
3	a. Networked Robotics b. Cyber-Physical Systems (CPS) in Robotics c. Reinforced Learning d. Intelligent Aerial Robotics e. Robotics, AI and Environmental Sciences f. Robotic Navigation g. Fundamentals of Parallel Robot	BS RIS	Appendage 3704
4	a. Environmental Data Science and Analytics b. Introduction to Environmental Modeling	BS E&ES	Appendage 3705
5	a. Computer Vision to Geospatial Analytics b. Remote Sensing based Geographical monitoring	BS RS&GIS	Appendage 3705
6	a. Applications of Geoscience Software b. Shallow Surface Geophysics	Geophysics	Appendage 3705
7	a. Software Engineering for Web Applications b. Software Process and Project Management c. Introduction to Deep Learning d. Multicore Programming e. Quantum Computing	BSE	Appendage 3706

Decision 3701

9. The courses presented at serial 7 have minor changes and are thus approved from FBoS.
10. After detailed discussion, the following new elective courses are recommended by FBoS for different degree programs. The said courses will be presented in the upcoming ACM for approval.

Sr No	Course Title	Degree Program(s)	Proposed Course Content
1	a. Explainable Artificial Intelligence b. Cloud and DevOps Engineering c. Quantum Computing for Artificial Intelligence d. AI Ethics and Safety	BSCS, BSAI, BSIT	Appendage 3703
2	a. Deep Learning and Neural Networks b. Linear Control Systems c. Digital Control Systems	BCE	Appendage 3701
3	a. Networked Robotics b. Cyber-Physical Systems (CPS) in Robotics c. Reinforced Learning d. Intelligent Aerial Robotics e. Robotics, AI and Environmental Sciences f. Robotic Navigation g. Fundamentals of Parallel Robot	BS RIS	Appendage 3704
4	a. Environmental Data Science and Analytics b. Introduction to Environmental Modeling	BS E&ES	Appendage 3705
5	a. Computer Vision to Geospatial Analytics b. Remote Sensing based Geographical monitoring	BS RS&GIS	Appendage 3705
6	a. Applications of Geoscience Software b. Shallow Surface Geophysics	Geophysics	Appendage 3705
7	a. Introduction to Deep Learning b. Multicore Programming c. AI Ethics and Safety	BSE	Appendage 3706

Item 3702: Inclusion of "Ideology and Constitution of Pakistan" as Social Electives in Undergraduate Programs.
Sponsor: All HODs Referral Authority: FBOS

Summary of the Case

11. As per the Higher Education Commission's directive issued through letter HEC/ACAD/UGEP/2024/6537, dated 19 September 2024, all Higher Education Institutions (HEIs) are required to include two courses, "Ideology and Constitution of Pakistan" and "Pakistan Studies," in their undergraduate programs.

Discussion

12. The sponsors presented the proposed changes to accommodate both HEC's recommended courses in the degree program roadmaps. The recommendations are as follows:
13. BSCS Program:
    a. Semester 4: Include "Ideology and Constitution of Pakistan" and move "Software Engineering" to Semester 5.
    b. Semester 5: Add "Software Engineering" and shift "Theory of Automata" to Semester 6.
14. BSIT and BS AI Programs: Semester 4: Include the course "Ideology and Constitution of Pakistan" for both BSIT and BS AI programs, without any other changes.
15. BSE Program: Semester 4: Offer "Ideology and Constitution of Pakistan" as Social Sciences Elective.
16. BCE Program: Social Sciences Elective: "Ideology and Constitution of Pakistan" to be offered as a Social Sciences Elective.
17. BEE Program: Social Sciences Elective: "Ideology and Constitution of Pakistan" to be offered as a Social Sciences Elective.
18. BS RIS Program:
    a. For the currently enrolled BSRIS batches (Fall 2023, Spring 2024, Fall 2024), offer "PAK 109: Ideology & Constitution of Pakistan" in the 5th semester, and "PAK 103: Pakistan Studies & Global Perspective" in the 4th semester, ensuring the total credit hours remain within the accepted range of 18 credit hours. This adjustment aligns with the latest HEC Undergraduate Policy.
    b. For BSRIS batches from Spring 2025 onward, "PAK 103" will be offered in the 1st semester and "PAK 109" in the 4th semester, ensuring credit hours remain within the permissible limit.
19. E&ES Department Programs: A dedicated 2-credit hour course in the 4th semester is introduced in the BS programs of E&ES department (BSES, BS RS&GIS, BS Geophysics) to address the requirement. Adding this course would increase the total credit hours in the 4th semester from 17 to 19.

Decision 3702

20. The recommendations presented from para 13 to 19 to include courses of "Ideology and Constitution of Pakistan" and "Pakistan Studies" in Bachelor's degree program roadmaps of Faculty of Engineering Sciences are approved from FBoS and will be presented in upcoming ACM.

Item3703: Launch of new program PhD (AI) in the Department of Computer Science H-11

Sponsor: HOD CS BSEAS H-11 Referral Authority: DBOS

Summary of the Case

21. Department of Computer Science H-11 Campus proposed launching a new PhD program in Artificial Intelligence at BUIC (H-11) from Fall 2025 semester subject to issuance of NOC from the HEC.

Discussion

22. The sponsor presented the launch proposal for PhD program in Artificial Intelligence (AI) at BUIC-H11 with a rational that there is an increasing global demand for AI expertise, cutting-edge research, and industry-academia collaboration in multiple domains of AI. AI is transforming multiple sectors, including healthcare, finance, security, and automation which requires specialized knowledge beyond traditional computer science. A dedicated PhD program will attract top researchers, enhances funding opportunities, and will contribute to technological advancements. Bahria University offers BS AI, MS AI, MS DS and the addition of PhD AI will help BU to establish itself as leaders in AI education and research.
23. Some of the few Pakistani HEIs offering PhD AI include National University of Sciences and Technology (NUST), Air University, Sindh Madressatul Islam University (SMIU), University of the Punjab, The Islamia University of Bahawalpur, University of Engineering & Technology (UET) Peshawar. Also, top international universities have now started offering PhD Programs in Artificial Intelligence or Machine Learning including Texas A&M University, George Washington University, Capitol Technology University, University of South Florida, University of Texas at San Antonio (UTSA), University of Technology Sydney (UTS), Carnegie Mellon University.
24. The proposed curriculum aligns with the best international practices and adheres to the postgraduate regulations of Bahria University and HEC standards. The launch proposal for new program (PhD AI) including roadmap of the program is attached as Appendage 3702.
25. Dean ES sought views from HoD Computer Science BUIC E-8, BULC and BUKC, on the launch proposal of PhD AI program. All agreed with the launch proposal and they expressed strong support for the program and showed interest to start the degree program within their departments.

Decision 3703

26. The case for the launch of PhD Artificial Intelligence program at CS Dept BSEAS H-11 is recommended by the FBoS and will be forwarded to ACM for approval.

Item3704: Proposal for Establishing School of Computing

Sponsor: HOD CS BUKC and HoD CS BUIC E-8 Referral Authority: DBOS

Summary of the Case

27. The proposal was presented in the previous FBoS, the decision was to further deliberate the proposal and present it again in the next FBoS.

Discussion

28. The sponsor presented an agenda item regarding the current academic and administrative challenges faced by the BUIC CS E8 and CS BUKC departments, which have student strength of 1900 and 1300, respectively, with a PFM exceeding 70. This situation has created significant administrative strain. To address these issues, the sponsor proposed the establishment of a School of Computing, with a future vision to evolve into a Faculty of Computing.
29. Under this proposal, the current Computer Science department should be divided into two separate departments: the Department of Computer Science and the Department of Artificial Intelligence & IT. The CS department would offer BS CS, MS CS, MS IS, and PhD CS, while the AI and IT department would offer BS AI, BS IT, MS Math, PhD Math, and MS DS. The new departments are proposed to be placed under the proposed *School of Computing* rather than the existing *School of Engineering and Applied Sciences*.
30. Feedback was gathered from all members of the Faculty of Engineering and Sciences (FoES).
    a. HoD CS BSEAS BUIC E-8 and HoD CS BULC supported the idea of establishing the School of Computing and splitting the existing CS Dept at BUIC E-8 and at BULC into two new departments as per the proposal.
    b. The Principal of BUKC suggested maintaining the CS department under the same School (BSEAS BUKC) for the time being, citing limited resources, but recommended splitting the department into two new departments as per the proposal.
    c. HoD CS-H11 supported the proposal for establishing the School of Computing. However, since the CS Dept H-11 is newly established and the BS degree programs have not matured (4 years), they opted to remain under the same structure for BSEAS H-11.
31. Principal BSEAS H-11 supported the splitting of CS Departments into two departments as per the proposal. However, he suggested instead of using a new title of “School of Computing” within the Faculty of Engineering Science. The splitting/new departments should be established under the existing title of “School of Engineering and Applied Science” both at BUIC E-8 and at BULC.

Decision 3704

32. The following is recommended by the FBoS and will be processed further for approval:
    a. Establishment of School of Computing along with two departments of “Computer Science” and “Artificial Intelligence & IT” for BUIC E-8 and BULC.

b. Splitting of Computer Science Department at BSEAS BUKC into two departments of "Computer Science" and "Artificial Intelligence & IT"

Item3705: Admission of Pre-Medical Students in Engineering Programs

Sponsor: HOD EE BSEAS H-11 Referral Authority: FBOS ES

Summary of the Case

33. Pakistan Engineering Council (PEC) has permitted HSSC or equivalent Pre-medical students to take admission in Engineering Programs after successful completion of an 8-week Mathematics deficiency course. The deficiency course will ensure that incoming pre-medical students acquire the essential mathematical skills required to meet the academic standards expected of candidates entering the Engineering programs. Before the completion of this course, students will be granted provisional admission status, allowing them to integrate into the program effectively, after completion of course and entry test requirements. However, as per PEC guidelines, the number of Pre-medical students must not exceed 40% of the allowed intake in any program by PEC.

Discussion

34. The sponsor presented the agenda point and proposed that the Faculty of Engineering should accommodate pre-medical student admission in BEE/BSE/BCE programs by offering 8-week Mathematics foundation course. The content of the Mathematics deficiency course are attached at Appendage 3707.
35. As per PEC guidelines, the number of Pre-medical students will not exceed 40% of the allowed intake in BEE/BSE/BCE by PEC. After successful completion of 8-week Mathematics deficiency course (50% passing marks) the students will receive a course completion certificate, qualifying them for BU Admission Test.
36. The mathematics deficiency course (Basic Mathematics for Engineering) will be a three credit hour course and the credit hour fee will be equivalent to Engineering Programs. The course shall be offered at least once a year. The details of the course offering are as follows:
    a. In order to facilitate Pre-Medical students for admission in Engineering Programs of BU the course will be offered as a certificate course anytime throughout the year (especially during Summer semester) provided that minimum class strength as per BU Academic Rules is ensured.
    b. Pre-Medical students who have not studied Mathematics deficiency course before admission test will also be allowed to appear in admission test of Engineering Programs. However, such students will be granted provisional admission and will be required to complete the 8-week Mathematics Deficiency Course. Upon successful completion of the course, such students will be awarded Regular Admission Status.

Decision 3705

37. The proposal presented at serial 34, 35 and 36 for providing admission to Pre-medical students in Engineering Programs of BU is recommended by the FBoS and will forwarded to ACM for approval.

Item3706: Change of Scope BEE Program – Offering of Power and Electric Vehicle specializations

Sponsor: HOD EE BSEAS H-11 Referral Authority: DBOS EE

Summary of the Case

38. Admissions in the BEE program have been declining in recent years, prompting the Pakistan Engineering Council (PEC) to introduce new measures aimed at enhancing enrollment and ensuring the sustainability of engineering programs across Higher Education Institutions (HEIs). As part of these initiatives, PEC has allowed HEIs to introduce new specialized streams, including Power, Electric Vehicles (EV) and Computer Systems Engineering. These emerging fields are expected to attract a broader range of students, aligning with global technological advancements and the evolving needs of the industry.

Discussion

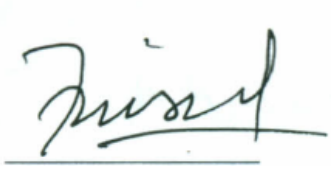
39. The sponsor presented the agenda item, noting that the Electrical Engineering (EE) Department at BSEAS, H-11 Campus, currently offers specializations in Telecommunications and Electronics. The absence of a Power specialization was previously due to a lack of relevant equipment and faculty. The sponsor further highlighted that the laboratories and permanent faculty within the EE Department at the H-11 Campus have been upgraded with the addition of new equipment, particularly in the Power and Telecommunication specializations. With the said addition of equipment, it is feasible to introduce the Power specialization. Additionally, faculty members specializing in Power Systems/Engineering are now available.
40. Also, thorough review of the department's facilities was conducted and some new equipment will be required in next year for the introduction of Electric Vehicle specialization.
41. It was also highlighted that to implement the proposed BEE specializations at BSEAS H-11 — BEE Electric Vehicle, BEE Power Engineering, and BEE Computer Systems—for students enrolled from Fall 2023 onward, a PEC change of scope visit will be required.
42. The Principal of BSEAS, H-11, pointed out that the BEE Computer Systems specialization closely resembles the Bachelor of Computer Engineering (BCE) program. Offering this specialization within the BEE program may negatively impact the BCE program. Additionally, it was noted that establishing the Electric Vehicle specialization would require specific equipment and the development of a dedicated Electric Vehicle lab. However, details regarding the necessary equipment and associated costs were not provided during the discussion.
43. The Chair supported the introduction of the BEE Electric Vehicle and BEE Power Engineering specializations but expressed concerns about offering BEE Computer Systems, given the existence of the BCE program within the Faculty of Engineering Sciences. The department was also advised to prepare a comprehensive proposal outlining the requirements for the Electric Vehicle specialization.

Decision 3706

44. The house recommended the case for starting BEE Power Systems specialization at EE Department BSEAS H-11, whereas, detailed requirements both technical & financial for Electric Vehicle specialization should be prepared for further deliberation.
45. The timeline for the start of the new stream to be decided by BSEAS H-11 keeping in view PEC change of scope requirements.

Closing of the Meeting

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



Prof. Dr Faisal Bashir Hussain
Dean (ES), Chair FBOS
20 March 2024

Appendages:

Appendage 3701

Benchmarking of BCE Program courses

University Symbol	University Name	QS World University Rankings by Subject 2024
CM	Carnegie-Mellon	7
WU	Washington University	76
WSU	Wright State University	98
UA	Ut Austin	66
OSU	Ohio State University	14

Comparison of BCE Degree Program Courses

Bahria University		International Universities					Content Addition
Course Name	Core / Elective	CM	WU	WSU	UA	OSY	
Computing Fundamentals	C	Yes	Yes	Yes	Yes	Yes	-
Computer Programming	C	Yes	Yes	Yes	Yes	Yes	Translating CAD Designs to Real-World `Applications and Budgeting Considerations
Discrete Structures	C	Yes	Yes	Yes	Yes	Yes	-
Workshop Practices	C	No	No	No	No	No	-
Digital Logic Design	C	Yes	Yes	Yes	Yes	Yes	Multi-level memory hierarchies
Circuit Analysis	C	Yes	Yes	Yes	Yes	Yes	-
Electronic Devices & Circuits	C	Yes	Yes	Yes	Yes	Yes	Application of fundamental design principles, and the compromises inherent in the engineering design process.
Object Oriented Programming	C	Yes	Yes	Yes	No	Yes	An introduction to ideal and viscous fluid mechanics, including turbulence, as well as an introduction to nonlinear dynamics, including chaos.
Data Structures & Algorithm	C	Yes	Yes	Yes	Yes	Yes	
Signals & Systems	C	Yes	Yes	Yes	Yes	Yes	
Computer Architecture & Organization	C	Yes	Yes	Yes	Yes	Yes	

Microprocessors & Interfacing	C	Yes	Yes	Yes	Yes	Yes	MEMS Robots.
Operating Systems	C	No	Yes	Yes	Yes	Yes	Game Theory.
Database Management Systems	C	No	Yes	No	Yes	Yes	LLM (as a separate topic).
Software Engineering	C	No	Yes	No	Yes	Yes	
Digital Signal Processing	C	Yes	Yes	Yes	Yes	Yes	
Digital System Design	C	Yes	Yes	Yes	Yes	Yes	
Computer Communication & Networks	C	Yes	No	Yes	Yes	Yes	
Discrete Structures	C	Yes	Yes	Yes	Yes	Yes	Relevant IoT application case studies.
Islamic Studies / Ethics	C	No	No	No	No	No	Basics of machine learning (along with convolutional neural networks), and transformers in the context of image and video data for object classification, detection, and segmentation.
Pakistan Studies & Global Perspective	C	No	No	No	No	No	
Communication Skills	C	No	No	No	No	No	Introduction to Performance Metrics.
Technical Writing	C	Yes	Yes	Yes	Yes	Yes	Overview of the Software Components of the Design.
Applied Calculus & Analytical Geometry	C	Yes	Yes	No	Yes	Yes	
Complex Variables & Transforms	C	Yes	No	No	Yes	Yes	Self-Organising Multi-Agent Systems.
Differential Equations	C	Yes	Yes	Yes	Yes	Yes	Sensing and IoT.
Linear Algebra	C	No	Yes	Yes	Yes	Yes	
Numerical Analysis	C	No	Yes	Yes	Yes	Yes	
Probability & Statistic	C	Yes	No	Yes	Yes	No	
Applied Physics	C	Yes	Yes	Yes	Yes	Yes	
Human-Computer Interaction	E	No	No	No		No	
introduction to Block Chain Technologies	E	No	No	No	No	No	
Neural Networks & Fuzzy Logic	E		Yes	No	Yes	No	
Robotics	E	No	No	No	No	Yes	
Mobile Application Development	E	No	No	No	No	No	
introduction to Virtual Reality	E	No	No	No	No	No	
Software Quality Assurance	E	Yes	Yes	No	Yes	Yes	
Embedded System Design	E	Yes	Yes	Yes	Yes	Yes	
Artificial Intelligence & Machine Learning	E	Yes	No	No	Yes	Yes	

Digital Image processing	E	Yes	Yes	Yes	Yes	Yes	
System & Network Security	E	Yes	Yes	Yes	Yes	Yes	
System Programming	E	No	Yes	Yes	No	Yes	
High Performance Computing	E	No	No	Yes	Yes	Yes	
Algorithms Design and Analysis	E	No	No	Yes	Yes	No	
Hardware Design for DSP & ML	E	Yes	Yes	Yes	Yes	Yes	
Engineering Project Management	E	No	Yes	Yes	Yes	No	
VLSI Design	E	Yes	Yes	Yes	Yes	Yes	
Data Mining & Warehousing	E	No	No	No	Yes	No	
GIS & Remote Sensing	E	No	No	No	Yes	No	
Health Safety & Environment	E	No	No	Yes	Yes	Yes	
Biomedical Engineering	E	No	No	Yes	Yes	Yes	
Business Process Automation	E	No	No	No	No	No	
Control Engineering	E	Yes	Yes	Yes	Yes	Yes	
Software Applications and Mobile Devices	E	No	No	No	Yes	Yes	
Cloud & Distributed Computing	E	No	Yes	Yes	No	No	
Internet of Things	E	Yes	No	Yes	Yes	Yes	
Engineering Management	E	No	No	No	No	Yes	
Principles of Management	E	No	NO	No	No	Yes	
Entrepreneurship	E	Yes	Yes	No	No	Yes	
Engineering Economics	E	Yes	Yes	Yes	No	No	
Sociology for Engineers	E	No	No	No	Yes	Yes	
Engineering Ethics	E	Yes	Yes	Yes	Yes	Yes	
Organizational Behaviour	E	No	No	No	No	No	

***** Similarity Score: By comparing the contents of the course with other university's courses determine the percentage of similarity.

Proposed list of new courses – Elective Courses

International Universities

Key Updated/New Courses	Core / Elective	CM	WU	WSU	UA	OSY	Brief Content / Tools
Deep Learning and Neural Networks	E	Yes	Yes	Yes	Yes	Yes	Many advanced artificial intelligence systems are using both Machine Learning and Symbolic AI to solve sub problems. This course will cover logic programming, expert systems and business rules, fuzzy logic, case-based reasoning, and knowledge graphs. This will also explore more advanced versions of planning and reinforcement learning algorithms.

Deep Learning and Neural Networks	
Course Code:	CEN 489
Credit Hours:	3+1
Prerequisite:	Artificial Intelligence and Machine Learning
Objectives:	Deep learning has resurged with the availability of massive datasets and affordable computing, enabling new applications in computer vision and natural language processing. This course introduces convolutional, recurrent, and other neural network architectures for deep learning. Students design, implement, and train these models to solve real-world problems. The main goal of the course is to equip you with the tools to tackle new AI problems you might encounter in life with the help of Deep Learning and Neural Networks.
Course Learning Outcomes (CLOs):	1. **(C1): Describe** mathematical and geometrical basis of how NN works and learn. 2. **(C2): Discuss** multi-layer feed forward networks for classification and regression machine learning problems. 3. **(C4): Analyze** deep learning/recurrent neural networks and their applications. 4. **(C5) Design** Solutions to real world problems familiar with the use of deep Learning and neural networks.
Course Outline:	• What is a neural network? Biological neural networks and artificial neural networks, their • similarities and differences. History of neural networks and current applications. • Fundamentals of learning and training samples, supervised and unsupervised learning. • Single Layer Perceptrons: architecture, activation function, learning rule, convergence • theorem, limitations. • Multi-layer Perceptrons: hidden units, Back-propagation (generalized delta) learning rule, • applications. • Temporality and recurrent neural networks, learning algorithms and applications.

	• Radial Basis Function Networks: architecture, learning, differences with multi-layer • perceptrons. • The Hopfield model: architecture, learning algorithm, applications to character recognition. • Self-Organizing Maps (SOMs): structure of the Kohonen self-organizing map, learning • algorithm, applications. • Deep Learning and Convolutional Neural Networks, learning algorithm, applications. • Deep Sequence modelling and LSTM networks, learning algorithm, applications. • Deep generative models and Auto-encoders, learning algorithm, applications.
Resources:	Textbook: • Neural Networks and Learning Machines (3rd ed.) Simon O. Haykin Prentice Hall 2008 0131471392. • Deep Learning Aaron Courville, Ian Goodfellow and Yoshua Bengio MIT Press 2015 9780262035613 Reference Book(s): • Deep Learning with Python by Francois Challet https://www.manning.com/books/deep-learning-with-python • Neural Networks and Deep Learning by Michael Nielson http://neuralnetworksanddeeplearning.com Course Descripti

Mapping of CLO to PLOs

CLOs	**MAPPED PLO**	**LEVEL**
1. **(C1): Describe** mathematical and geometrical basis of how NN works and learn.	PLO 1	C1
2. **(C2): Discuss** multi-layer feed forward networks for classification and regression machine learning problems.	PLO 2	C2
3. **(C4): Analyze** deep learning/recurrent neural networks and their applications.	PLO 4	C4
4. **(C5) Design** Solutions to real world problems familiar with the use of deep Learning and neural networks.	PLO 3	C5

Grading Rubric

Assessment Method	**CLO 1**	**CLO 2**	**CLO 3**	**CLO 4**
Final Exam (50)	10	10	10	10
Midterm Exam (20)	10	10	×	×
Assignments (20)	5	5	5	5
Quizzes (10)	5	5	5	5
Total (100)	30	30	20	20

Appendage 3702

Roadmap of PHD AI

LAUNCH OF NEW PROGRAMME - PhD ARTIFICIAL INTELLIGENCE AT CS DEPT BUIC H-11

	A. ACADEMIC DETAILS
1	**Faculty/Department:** Faculty of Engineering and Sciences, Department of Computer Science H11 Campus
2	**Name of the Program:** Doctor of Philosophy in Artificial Intelligence – PhD (AI)
3	**Mission of the Program:** The PhD in Artificial Intelligence program is dedicated to advancing AI research through innovation, critical thinking, and interdisciplinary collaboration. The program will prepare scholars and experts that can develop intelligent systems, address complex real-world challenges, and contribute to the ethical and responsible growth of AI technologies to meet national and international needs.
4	**Objectives of the Program:** a. Conduct advanced AI research to develop innovative solutions for real-world challenges in various sectors, including healthcare, finance, and security. b. Prepare graduates for leadership roles in academia, research, and industry, driving global AI advancements. c. Promote ethical AI development by ensuring fairness, transparency, and accountability in intelligent systems.
5	**Outcomes of the Program:** a. Conduct original research by independently designing and executing AI studies that contribute novel insights and methodologies to the field. b. Develop advanced AI solutions to address complex real-world challenges in areas such as healthcare, finance, robotics, and cybersecurity. c. Manage and analyze large-scale data to drive AI innovations through efficient data processing and model development. d. Uphold ethical AI practices by ensuring fairness, transparency, and accountability in AI-driven decision-making. e. Communicate AI research effectively through publications, presentations, and collaboration with academia, industry, and policymakers.

6	**Rationale for the Program:** Artificial Intelligence (AI) is a rapidly growing field worldwide, transforming industries and societies through intelligent systems that mimic human thinking and decision-making. With time, AI is becoming essential for human life because of its massive applications in diverse fields, such as banking and financial systems, biomedical sciences, disease diagnoses and treatment, heavy industries, air transportation, gaming zones, surveillance and security, disaster management, traffic management and urban planning, agriculture, intelligent systems, and robotics. There is a growing demand for producing scholars that are experts in the Artificial Intelligence domains, techniques, methods, models, tools, and research. Countries across the globe are investing heavily in AI research, with leading universities offering PhD programs to develop experts who can drive innovation. Bahria University aims to address this gap by launching a PhD in AI program that aligns with global trends and national priorities. This program will equip scholars with cutting-edge AI knowledge, covering both theoretical foundations and practical applications. It will foster interdisciplinary research, enabling scholars to develop AI-driven solutions for real-world challenges such as smart cities, intelligent healthcare, business intelligence, and cybersecurity. Additionally, by nurturing high-level AI expertise, the program will support Pakistan's AI ecosystem, enhance industry-academia collaboration, and attract international research opportunities. Establishing a PhD in AI at Bahria University will position the institution as a key contributor to AI advancements, ensuring Pakistan remains competitive in the global AI landscape.
7	**Brief Description of the Program:** The PhD in AI program is designed to equip scholars with the ability to conduct groundbreaking research, formulate novel AI-driven methodologies, and lead interdisciplinary projects that contribute to scientific and economic advancements. The program extends beyond technical expertise by fostering analytical thinking, ethical AI practices, and the ability to translate AI insights into impactful solutions. The curriculum encompasses advanced topics in artificial intelligence, deep learning, reinforcement learning, natural language processing, computer vision, and AI ethics. Through rigorous research and coursework, students will gain expertise in mathematical modeling, statistical inference, machine learning frameworks, and data-driven decision-making. The program follows the best international practices and is structured in accordance with the highest academic and research standards, ensuring that graduates are prepared for leadership roles in academia, industry, and policy-making. This program is structured in accordance with the Postgraduate Academic Regulations of Bahria University and adheres to the standards set by the Higher Education Commission (HEC).

8	**Duration:** 03 Years (6 Semesters)
9	**Venue(s): On Site~~/Off Site/Both On & Off Site~~** *(tick one/strike-through the ones not applicable; if Off Site, give details)* Johar Block, Bahria University, H11 Campus, Islamabad
10	**Program Scheduling Format:** • ~~Morning~~**/<u>Evening</u>/**~~Weekend~~ *(tick one/strike-through the ones not applicable)* • **<u>Bi-Semester</u>**/~~Trimester/Semester+Summer Session/Annual/Bi-Annual~~ *(tick one/strike-through the ones not applicable)*
11	**Proposed Date of Commencement:** Fall 2025
12	**Mode of study** for PhD (AI) is based on class room learning and Research Seminars, Assessments, i.e. Assignment, Quizzes, mid-term and final term will be conducted as per BU PhD policy.
13	**Additional Faculty Member(s) Required:** *(Indicate if there is a requirement for additional faculty members, fulltime/visiting, along with qualifications.)* ***None***
14	**Additional Skilled-Worker(s) Required:** *(Indicate if there is a requirement for additional Skilled Staff, fulltime/part-time, along with their qualifications/skill sets.)* **None**
15	**Additional Classroom(s) required:** *(The requirement is to include the number of classrooms and their capacities.)* Classrooms in Johar block BUIC H-11 Campus are available in the evening, and initially one classroom will be required at the start of the program and maximum 2 rooms will be required when the program matures.
16	**Additional Requirement for Laboratories:** *(The requirement is to include the number of laboratories, their equipment and their capacities.) No*. (MS AI high-end GPU based machines would be used)
17	**Additional Requirement for Books, Subscriptions, Memberships to Online Research Sites/ Repositories: Yes**
18	**Minimum Entry Level:** MS/MPhil or any equivalent degree in relevant subject from HEC recognize University/Institution.
19	**Admission Criteria:** The applicant must meet the following minimum eligibility requirements: 1. 18 Years Education in the relevant discipline with a minimum CGPA of 3.00/4.00 (Semester System) or 60% marks (Annual System). 2. NTS-GAT (Subject) or GRE (Subject) Test passed with minimum 60% marks or BU Admission Test (60% passing marks). 3. Initial Research Proposal/Statement of Purpose is required at the time of PhD admission.
20	**Additional/Different Examination Requirement** *(Indicate if there will be any examination requirement, additional to or different from the BU Academic Rules or Examination Policy in vogue).* No additional/different examination requirements. The examinations will be as per BU Academic Rules and Examination policy

21	**Number of Admissions Expected for First Intake: 8** admissions for first intake
22	**Number of Admissions Planned/Expected for Subsequent Intakes: 8** admissions per intake
23	**Referred by: FBOS**
24	**Complete Plan of Studies, inclusive of complete Roadmap:** *(Attach as Annex 'A')*
25	**Course Outlines, Descriptions, Pre-Requisites & Readings (Compulsory & Recommended)** *(Attach as Annex 'B')*

B. FINANCIAL DETAILS

1 **Source of Funding: Tuition Fee**

- **BU: Fully/Partially: Fully**
- ~~**Public Sector (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)*~~
- ~~**NNGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)*~~
- ~~**INGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)*~~
- ~~**UN/IGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)*~~

2 **Degree Duration:** **3** years
Semester System: Yes (6 Semesters)
Total Number of Credit Hours: 54

3 **Expected fee to be charged based on Cost & Benefits Analysis:** *(show working)*
Per annum fee: or Fee rate per credit hour: Rs. 8,000 /- (5% increase in current Fee rate per credit hour)

Credit Hours	9
Rate Per Credit Hours Tuition Fee	8,000
Tuition Fee Per Semester	72,000
Admission Fee (One Time)	28,000
Caution Money Refundable)	21,000
Degree Fee (One Time)	10,000
Misc. Charges	8,000
Total	1,39,000

4 **Expected Number of students for 1st & 2nd Intakes: 08** & 08

5 **Expected Earning from first three Intakes (B5):** *(Show working)*

	Students			**Fee per student**		**Total Fee**		
Semester	**Fresh**	**Existing**	**Total**	**Fresh***	**Existing****	**Fresh**	**Existing**	**Total**
Fall 2025	8	0	8	139,000	0	1,112,000	0	**1,112,000**

Spring 2026	0	8	8	0	80,000	0	640000	**640,000**
Fall 2026	8	16	24	142,600	83,600	1,140,800	1337600	**2,478,400**
Spring 2027	0	24	24	0	83,600	0	2006400	**2,006,400**
Fall 2027	8	32	40	146,380	87,380	1,171,040	2796160	**3,967,200**
Spring 2028	0	40	40	0	87,380	0	3495200	**3,495,200**

* per credit 8000 with 9 credit hours including admission fee and misc. charges. Also added the 5% increase per credit hour from Fall to Fall semester.
** per credit 8000 with 9 credit hours including misc. charges

6 **Expected Earnings for the Next Five Years (B6):** *(show working)*

		Students			**Fee per student**		**Total Fee**		
Yr	**Semester**	**Fresh**	**Existing**	**Total**	**Fresh***	**Existing ****	**Fresh**	**Existing**	**Total**
1	**Fall 2025**	8	0	8	1,112,000	0	8,896,000	0	**8,896,000**
	Spring 2026	0	8	8	0	80,000	0	640000	**640,000**
2	**Fall 2026**	8	16	24	1,140,800	83,600	9,126,400	1337600	**10,464,000**
	Spring 2027	0	24	24	0	83,600	0	2006400	**2,006,400**
3	**Fall 2027**	8	32	40	1,171,040	87,380	9,368,320	2796160	**12,164,480**
	Spring 2028	0	40	40	0	87,380	0	3495200	**3,495,200**
4	**Fall 2028**	8	32	40	1,202,792	91,349	9,622,336	2923168	**12,545,504**
	Spring 2029	0	40	40	0	91,349	0	3653960	**3,653,960**
5	**Fall 2029**	8	32	40	1,236,132	95,516	9,889,053	3056526.4	**12,945,579**
	Spring 2030	0	40	40	0	95,516	0	3820658	**3,820,658**

Year 1: Rs. 9,536,000/-
Year 2: Rs. 12,470,400/-
Year 3: Rs. 15,659,680/-
Year 4: Rs. 16,199,464/-
Year 5: Rs. 16,766,237/-

Total 5 years' earnings: Rs. 70,631,781/-

7 **Total Estimated Salaries of all Additional Human Resources per annum (B7):** *(Show working)*

	Work load		Per Semester Salary (Rs. 2700 per hour)
Semester	**Course**	**Credit Hours**	**FM**
Fall 2025	3	9	388,800
Spring 2026	6	18	777,600
Fall 2026	9	27	1,166,400
Spring 2027	9	27	1,166,400

Year 1: Rs.1,166,400 **(per annum)**

Year 2: Rs. 2,332,800 **(per annum)**

Total estimated salaries for the first two years: Rs. 3,499,200/-

8 **Cost of <u>Additional</u> Laboratory Equipment/Tools (B8):** *(show working)* **None**

9 **Cost of Additional Classrooms (B9):** *(Include furniture, technical aids etc)* **None**

10 **Cost of Additional Books, Subscription & Memberships to on-line Sites/Repositories (B10):** (*show details) None*

11 **Off-Site rental Expenses and Cost of other Fixtures (B11):** *(Show details)* **None**

12 **Miscellaneous Expenses required for Starting the Program (B12):**

- Advertisement: 100,000 /-
- Printing & Stationery: 60,000/- -
- Admin Cost: None
- Any other: None
- **Total : 160,000/-**

13 **Annual Recurring Expenditures in Subsequent Years (B13):** - Salaries: **2,332,800** - Rentals: None
- Subscriptions/Memberships/Books: **None** Advertisements: 100,000 /-
- Printing & Stationery: 60,000/- Admin Cost: None - Any other:
- **Total: 2,492,800/-**

14 **Total Cost of the Programme (B14):** [Add B(7) to B(12)]

Year 1: Rs. 1,326,400/-

Year 2: Rs. 2,492,800/-

15 **Net Cost of the Programme (B15):** [Subtract B(1) from B(14)]

Year 1: Rs. 1,326,400/-

Year 2: Rs. 2,492,800/-

16 **Net Earnings in First Year (B16:** [Subtract B(15) from B(5)] **Rs. 8,209,600/-**

17	**Projected Annual Gross Earning in Subsequent Years (B 17):** *(show details & working; a 10% towards all expenses in subsequent years.)* Year 2: Rs. 9,961,600/- Year 3: Rs. 13,133,280/-
18	**Projected Annual Net Earning in Subsequent Years:** *[Subtract B(13) from B(17)]* Year 2: Rs. 2,508,800/- Year 3: Rs. 2,526,400/-

Minutes of the 37th FBOS – ES

LAUNCH OF NEW PROGRAMME - PhD ARTIFICIAL INTELLIGENCE AT CS DEPT BUIC H-11

New Academic Road Map of PhD Artificial Intelligence Program

Program Title: Doctor of Philosophy in Artificial Intelligence

Duration: 3 Years

Total Credit Hours: 54

Endorsement References:

A: Recommendations of DBOS dated 21st January, 2025 (recorded in the minutes of DBOS meeting)

B: Recommendations of FBOS dated ---------(recorded in the minutes of FBOS meeting)

C: Recommendations of RAC dated ---------- (recorded in the minutes of RAC meeting)

Summary of Credit Hours

Sr No		Credit Hours
1.	Core Course	3 CH
2.	Electives Courses	15 CH
3.	Thesis	36 CH
	Total	54 CH

Semester-wise Road map

Semester 1

Course Code	Course Title	Credit Hours
	Coursework (Elective-I)	03
	Coursework (Elective-II)	03
ESC 801	Research Methods in PhD Studies	03
	Total Credit Hours	09

Semester 2

Course Code	Course Title	Credit Hours

	Coursework (Elective-III)	03
	Coursework (Elective-IV)	03
	Coursework (Elective-V)	03
	Total Credit Hours	09

Semester 3

Course Code	Course Title	Credit Hours
---	Comprehensive Exam	
THS 899	Thesis	09
	Total Credit Hours	09

Semester 4

Course Code	Course Title	Credit Hours
THS 899	Thesis (Continue)	09

Semester 5

Course Code	Course Title	Credit Hours
THS 899	Thesis (Continue)	09

Semester 6

Course Code	Course Title	Credit Hours
THS 899	Thesis (Continue)	09

University Requirement / Core Course

Sr. No	Course Code	Course Title	Credit Hours	17 UN SDGs alignment (please mention relevant SDG No.
1	ESC 801	Research Methods in PhD Studies	03	4

List of Elective Courses

Course Code	Course Title	Credit Hours	17 UN SDGs alignment (please mention relevant SDG No.
SEN 819	Advance Neural Networks & Fuzzy Logic	3	9
CSC 800	Advanced Al Networking	3	9, 11
CSC 881	Advanced Cloud Computing	3	9, 13
CSC 860	Advanced Complexity Theory and Algorithms	3	9
CSC 841	Advanced Computational Linguistics	3	4, 10
CSC 864	Advanced Computer Vision	3	9, 3
EEN 833	Advanced Computer vision for Robotics	3	9, 11
DSC 800	Advanced Data Analytics	3	9, 17
DSC 802	Advanced Data Visualization	3	4, 9
DSC 807	Advanced Deep Learning	3	9, 3
CSC 801	Advanced Information Retrieval	3	9, 4
CSC 851	Advanced Pattern Recognition	3	9, 3
EET 836	Al for Future Communication Systems	3	9, 11
EEP 805	Artificial Intelligence Techniques in Power Systems Design	3	7, 9
SEN 862	Emerging Trends in Big Data Analytics	3	9, 17
SEN 820	Emerging Trends in Human Computer Interaction	3	10, 4
EEN 832	Fuzzy Logic and Neural Network Based Intelligent control systems	3	9
EEN 834	Human-Robot Interaction	3	8, 9

SEN 809	Internet of Things: Design and Applications	3	11, 9
SEN 864	Knowledge Representation and Reasoning	3	4, 9
CSC 819	Research Trends in Machine Learning	3	9, 17
SEN 861	Semantic Web Modeling and Applications	3	9, 4
AIC 801	Intelligent Video Analytics	3	16
AIC 802	Artificial Intelligence in Sports Analytics	3	3
AIC 811	Ubiquitous Computing and Intelligent Systems	3	11, 9
AIC 803	Design of Intelligent Information Systems	3	9, 8
AIC 812	Brain-Computer Interface	3	3, 10
AIC 821	Intelligent Transportation Systems	3	11, 9, 13
AIC 822	Neurocomputation	3	3, 9
AIC 831	Advanced Reinforcement Learning	3	9, 8
AIC 832	Artificial Intelligence for Cyber Security	3	16, 9

COURSE OUTLINES

Intelligent Video Analytics

Course Objectives/Learning Outcomes:

Video analytics, when applied with machine learning and pattern recognition, give rise to automatic and intelligent application tasks that previously needed human involvement. The Intelligent Video Analytics course will teach the students how to build object detection and tracking models for the analysis of large-scale data from video streams. The students will get an understanding of how to build applications based on computer vision, video intelligence, and/or IoT streaming. Moreover, the students will also perform programming-based practical tasks to get an idea of how to implement different video analytic applications using different frameworks. The key learning outcomes of this course are as follows:

- Understand state-of-the- art framework for video processing and analysis
- Possess advanced knowledge within the area of video analytics, with emphasis on representing, processing, and analyzing video
- Understand specialized insight and good understanding of the research frontier in selected parts of video analytics
- Use relevant and suitable methods when carrying out further research and development activities in video analytics

Course Contents:

Fundamental of Video Processing and Video Analytics Applications, Motion Detection and Estimation from Videos, Online vs. Offline and Trimmed. Vs. Untrimmed Video Processing and Analytics, Benchmarking a Video Analytics System, Deep Learning and Neural Networks for Video Analytics, Object Detection and Tracking for Intelligent Video Analytics, Multiple-Object Tracking from Videos, Human Action Detection and Segmentation from Videos, Smart City Applications based on Video Analytics, Pedestrian Detection from Video Streams, Vehicle Detection and Tracking for Intelligent Transportation, Traffic Congestion and Accident Detection from Videos, Crowd Detection and Counting, Person Reidentification from Multiple Video Cameras, Implementation of Video Analytics Application on Edge Device

Recommended Books:

- Maheshkumar H Kolekar Intelligent Video Surveillance Systems an Algorithmic Approach 1st Edition (2018) ISBN 9781498767118
- Yunqian Ma, Gang Qian, Intelligent Video Surveillance: Systems and Technology, CRC Press (2009)

Artificial Intelligence in Sports Analytics

Course Objectives/Learning Outcomes:

In this course, students will explore machine learning techniques using the python scikit learn (sklearn) toolkit and real-world sports data to understand both machine learning algorithms and how to predict sports outcomes. Building on the previous courses in the specialization, students will apply methods such as support vector machines (SVM), decision trees, random forest, linear and logistic regression, and ensembles of learners to examine data from professional sports (including Audio, videos, and images) as well as wearable devices such as the Apple Watch and inertial measurement units (IMUs). By the end of the course, students will have a broad understanding of how classification and regression techniques can be used to enable sports analytics across athletic activities and events.

Course Outline:

Sports analytics has emerged as a field of research with increasing popularity propelled, in part, by the real-world success illustrated by the best-selling book and motion picture, Money ball. Analysis of team and player performance data has continued to revolutionize the sports industry on the field, court, and ice as well as in living rooms among fantasy sports players and online sports gambling.

Drawing from real data sets in Major League Baseball (MLB), the National Basketball Association (NBA), the National Hockey League (NHL), the English Premier League (EPL-soccer), and the Indian Premier League (IPL-cricket), the students will learn how to construct predictive models to anticipate team and player performance. The students replicate the success of Money ball using real statistical models, use the Linear Probability Model (LPM) to anticipate categorical outcomes variables in sports contests, explore how teams collect and organize an athlete's performance data with wearable technologies, and how to apply machine learning in a sports analytics context. This introduction to the field of sports analytics is designed for sports managers, coaches, physical therapists, as well as sports fans who want to understand the science behind athlete performance and game prediction. New Python programmers and data analysts who are looking for a fun and practical way to apply their Python, statistics, or predictive modeling skills will enjoy exploring courses in this series.

Recommended Books:

- Artificial Intelligence in Sport Performance Analysis 1st edition (2021) Duarte Araújo , Micael S Couceiro Ludovic Seifert Hugo Sarmento,Keith Davids ISBN : 978-0367254360
- AI for Sports 1st Edition (2022) Chris Brady, Karl Tuyls,Shayegan Omidshafiei ISBN: 9781032048291

Ubiquitous Computing and Intelligent Systems

Course Objectives/Learning Outcomes:

Ubiquitous Computing considered the successor to mobile computing and generally involves wireless communication and networking technologies, mobile devices, smart and intelligent sensing systems, embedded systems, wearable devices, Radio Frequency ID (RFID) tags, middleware, internet of things (IoT), and intelligent agents. This course aims to introduce students to the topics of Ubiquitous Computing and Intelligent Systems, providing them with the critical technical knowledge and methodological approaches for designing, developing, deploying, and evaluating intelligent systems. Within the broad set of topics associated with ubiquitous and pervasive computing, this course has a particular focus on applications for Smart Interactions, Ambient Intelligence, Context-Aware Computing, and Human Assisted Living.

At the end of this course, students are expected to be able to:

- Explain the general principles of Ubiquitous Computing and the key technical and social factors driving the change towards post-desktop paradigms
- Model the key Ubiquitous computing properties to demonstrate the architectural design of Ubiquitous Computing systems in the context of real-world scenarios
- Utilize service architecture model of sensor technology and sensor networks to model context-aware and adaptive systems
- Evaluate different interaction designs to meet the real-world requirements from Ubiquitous computing systems
- Justify the design of Autonomous Systems to support self-operation in dynamic and diverse real-life environments
- Understand the role of evaluation at the various design stages and the key evaluation techniques used in ubiquitous computing, context-aware human-centric computing, and intelligent systems

Course Outline:

Introduction to Ubiquitous Computing, Applications of Ubiquitous computing, Smart Devices, Environment, and Interaction, Smart Devices and Services, Tagging, Sensing and Controlling, Context-Aware Systems, IS Architectures (Reactive, Environment Model-based Architecture, Goal-based, Intelligent Interactions and Systems, Semantic Knowledge-based IS (Knowledge representation, Design Issues), Autonomous Systems and Artificial Life, Reflective and Self-aware systems, Autonomous Systems and Artificial Life, Self-management and Autonomic Computing, Complex Systems and Artificial Life

Recommended Books:

- Ubiquitous Computing Fundamentals 1st Edition by John Krumm (2010)
- The Dawning Age of Ubiquitous Computing by Adam Greenfield (2006)
- Ubiquitous Computing: Smart Devices, Environments and Interactions by Stefan Poslad (2009)
- Ubiquitous Computing Fundamentals by John Krumm (2009)

Design of Intelligent Information Systems

Course Objectives/Learning Outcomes:

This course aims to offer a foundation of intelligent system techniques and their applications in various real-world domains, an understanding of how to implement a system with "intelligent" functionality. Students will learn to judge when intelligent functionality and artificial intelligence may be a good solution for a problem and be able to choose suitable AI methods and techniques. Students will also acquire knowledge enabling them to develop necessary skills to design and implement an intelligent system, be able to apply simple core knowledge representation, reasoning and decision-making principles, explain the importance of information processing in real-world applications.

Course Contents:

Intelligent agents, fuzzy control, fuzzy adaptive control, multi-sensor data and information fusion, decision analysis with uncertainty, case-based reasoning, signal analysis and multi-objective optimization, an understanding of modern information modeling frameworks, information sources and related applications, core knowledge representation, reasoning and decision-making principles, information processing in real-world applications, design requirements for intelligent information systems, multi-agent systems.

Recommended Books:

- Advances in Intelligent Systems and Computing (2017) Natalya Shakhovska springer Link ISBN: 978-3-319-45991-2
- Design of Intelligent Applications using Machine Learning and Deep Learning Techniques 1st edition (2022) Ramchandra Sharad Mangrulkar,Antonis Michalas ,Narendra Shekokar, Meera Narvekar,Pallavi Vijay Chavan ISBN :9780367679798
- Business Information Systems: Design an App for That Raymond Frost,Jacqueline Pike,Lauren Kenyo,Sarah Pels,(2011) ISBN 13: 9781453311578 Publisher: Saylor Foundation

Brain-Computer Interface

Course Objectives/Learning Outcomes:

This course will explore the current state of brain sensing and its application to human-computer interaction research. The students will read important research papers on relevant topics, including background on brain function, sensing technology, machine learning methods, and applications of brain-computer interfaces in various domains. Imagine creating a computer that can respond to the brain's neural network by digitalizing the brain's electrical signals into commands that a computer can understand. This brain-computer interface is a field that combines neuroscience with computer programming and is revolutionizing robotics, neurophysiology, and computer science.

- Obtain the background to conduct research in brain-computer interaction and human-computer interaction.
- Understand the literature in the field of brain sensing for human-computer interaction research.
- Understand the various tools used in brain sensing, with a focus on functional near-infrared spectroscopy (fNIRS) research at Drexel
- Understand the steps required to use real-time brain sensing data as input to an interactive system
- Understand the domains and contexts in which brain-computer interfaces may be effective
- Understand the open questions and challenges in brain-computer interaction research today

Course Outline:

Introduction to brain sensing in human-computer interaction, Brain sensing devices (fNIRS, EEG, fMRI, etc.), Signal processing, feature selection, machine learning approaches for classifying brain data, Direct control vs. passive BCI, BCI for disabled, experimental designs for exploring brain sensing for HCI, Brain sensor data as input to interactive systems, as a user interface evaluation method, as neurofeedback, and many application domains (education, driving, video games, human-robot interaction, communication, control, human computation, etc.), and human values, ethics, privacy as it relates to BCI.

Recommended Books:

- Brain-Computer Interfacing: An Introduction 1st Edition Rajesh P. N. Rao (2013) ISBN-13: 978-0521769419,ISBN-10: 0521769418
- Brain-Computer Interfaces: Principles and Practice 1st Edition Jonathan Wolpaw, Elizabeth Winter Wolpaw (2012) ISBN-13: 978-0195388855, ISBN-10: 0195388852

Intelligent Transportation Systems

Course Objectives/Learning Outcomes:

The fundamental concepts of Intelligent Transportation Systems (ITS) to students with interest in engineering, transportation systems, communication systems, vehicle technologies, transportation planning, transportation policy, and urban planning. ITS refers to information and communication technologies, as applied to transportation infrastructure and vehicles, that improve transportation safety, productivity, environment, and travel reliability. With accessibility of mobile devices, ITS applications, such as trip planners, help travelers make informed travel choices. ITS is an international program intended to improve the effectiveness and efficiency of surface transportation systems through advanced technologies in information systems, communications, and sensors. In addition to technology discussions, this course will include topics related to policy, economics, security, as well as urban and rural planning.

Course Contents:

This course will provide students a basic understanding and appreciation of the concepts related to ITS technologies and industry applications of the field. Introduction to Intelligent Transportation Systems (ITS), Advanced Transportation Management Systems (ATMS) ,Advanced Traveler Information Systems (ATIS), Federal ITS Programs, ITS Highway Safety Perspective Environmental Aspects of ITS, Connected Vehicle Technology and Applications, ITS Standards and Architecture, ITS Telecommunications, Travel Information Systems, Interactive Voice Recognition (IVR) Mobile Applications, Economics of ITS – Revenue Generation Models, ITS and Security, ITS Policy Issues, International ITS Programs, Case Studies, and Careers in the ITS Field.

Recommended Books:

- Mashrur A. Chowdhury, Adel W. Sadek Fundamentals of Intelligent Transportation Systems Planning (Artech House Its Library) (20013) ISBN-13: 978-1580531603 ,ISBN-10: 1580531601
- Paolo Pagano Intelligent Transportation Systems from Good Practices to Standards 1st Edition (2016) ISBN 9780367782825
- George Dimitrakopoulos, Lorna Uden, Iraklis Varlamis The Future of Intelligent Transport Systems 1st Edition (2020) ISBN: 9780128182826

Neurocomputation

Course Objectives/Learning Outcomes:

This course introduces theories of neural computation, with an emphasis on the visual system. The goal is to familiarize students with the major theoretical frameworks and models used in neuroscience and psychology, and to provide hands-on experience in using these models. Topics include neural network models, principles of neural coding and information processing, self-organization (learning rules), recurrent networks and attractor dynamics, hierarchical models, and computing with distributed representations.

Course Contents:

It covers foundational quantitative tools of data analysis in neuroscience: correlation, convolution, spectral analysis, principal components analysis, and mathematical concepts including simple differential equations and linear algebra, introduction to Neural Computation, Receptive Fields, Time Series, Spectral Analysis Rate Models and Perceptron, Matrix Operations, Basic Sets, Principal Components Analysis, and Recurrent Networks

Recommended Books:

- Hertz, J. and Krogh, A. and Palmer, R.G. Introduction to the theory of neural computation. 2009
- MacKay, D.J.C. Information Theory, Inference and Learning Algorithms. 2003
- Dayan, P. and Abbott, L.F. Theoretical neuroscience: computational and mathematical modeling of neural systems. 2001
- Sterling, P. and Laughlin, S. *Principles of Neural Design*. 2015

Advanced Reinforcement Learning

Course Objectives/Learning Outcomes:

Reinforcement learning (RL) is an area of machine learning, where an agent or a system of agents learns to archive a goal by interacting with their environment. RL is often seen as the third area of machine learning, in addition to supervised and unsupervised areas, in which learning of an agent occurs because of its own actions and interaction with the environment. In recent years, there has been success in reinforcement learning research in both theoretical and applied fields. This course introduces the applications of RL in a variety of fields such as robotics, pattern recognition, personalized medical treatment, drug discovery, speech recognition, computer vision, and natural language processing. Also, the course primarily focuses on training students to frame reinforcement learning problems and to tackle algorithms from dynamic programming, Monte Carlo and temporal-difference learning. Students will progress towards larger state space environments using function approximation, deep Q-networks and state-of-the-art policy gradient algorithms. We will also go over the recent methods that are based on reinforcement learning, such as imitation learning, meta learning and more complex environment formulations

Course Contents:

Main topics to be covered include the following (see course website for more details): Reinforcement learning framework. Bandit problems and action selection. Dynamic programming. Monte Carlo methods. Temporal difference learning. Planning in RL.Function approximation for generalization. Actor-critic and gradient-based optimisation.Multi-agent reinforcement learning. Environments with partial observability. Training agents and evaluating performance.

Recommended Books:

- Richard S. Sutton and Andrew G. Barto Reinforcement Learning: An Introduction (20015)
- Hao Dong, Zihan Ding, Shanghang Zhang, Deep Reinforcement Learning: Fundamentals, Research and Applications" Springer, 2020
- Richard S. Sutton, Andrew G. Barto , "Reinforcement Learning, second edition: An Introduction", *Publisher:* MIT Press, 2018

Artificial Intelligence for Cyber Security

This course explores the role of AI in cybersecurity, focusing on machine learning models for intrusion detection, anomaly detection, and automated threat response. It begins with an introduction to AI-driven security threats, including adversarial attacks and AI-powered malware detection. Students will study supervised and unsupervised learning techniques for cybersecurity applications, followed by an in-depth analysis of adversarial machine learning, attack strategies, and defense mechanisms. The course covers AI applications in threat intelligence, including deep learning for malware and phishing detection, AI-driven intrusion detection systems, and security challenges in cloud and IoT environments. It also delves into AI-powered digital forensics, automated incident response, and AI governance in cybersecurity. Ethical concerns and regulatory compliance related to AI-driven security solutions will be discussed.

Recommended Books:

- "Artificial Intelligence for Cybersecurity: Techniques, Advances, and Applications" – Mark Stamp (2022)
- "Machine Learning for Cybersecurity Cookbook" – Emmanuel Tsukerman (2019)
- "Cybersecurity Data Science" – Scott Mongeau (2021)

Appendage 3703

Benchmarking of BSCS, BSIT and BSAI Courses

University Name	**QS World University Rankings by Subject 2024**
Stanford University **(SU)**, Stanford	2
University of Oxford **(UOX)**, Oxford	4
Harvard University **(HV)**, Cambridge	7
University of California **(UCB)**, Berkeley	5
Imperial College **(IC)**, London	16

Source : https://www.topuniversities.com/university-subject-rankings/computer-science-information-systems

Bahria University		**International Universities**					**Similarity Score***	**Remarks**
Course Name	**Core / Elective**	**SU**	**UOX**	**HV**	**UCB**	**IC**		**Additional Content Recommended in Course**
Computer Programming	C	Yes	Yes	Yes	Yes	Yes	85	NIL
Object Oriented Programming	C	Yes	Yes	Yes	Yes	Yes	90	NIL
Data Structure & Algorithm	C	Yes	Yes	Yes	Yes	Yes	85	NIL
Operating Systems	C	Yes	Yes	Yes	Yes	Yes	85	NIL
Database Management Systems	C	Yes	Yes	Yes	Yes	Yes	90	Introduction to NoSQL, MongoDB, Vector DB

Bahria University		**International Universities**					**Similarity Score***	**Remarks**
Course Name	**Core / Elective**	**SU**	**UOX**	**HV**	**UCB**	**IC**		**Additional Content Recommended in Course**
Database Administration and Management	C	Yes	Yes	Yes	Yes	Yes	85	NIL
Software Engineering	C	Yes	Yes	Yes	Yes	Yes	85	Introduction to modeling tools for Agile, Scrum, Distributed Application model, like ABCD Agile Model
Computer Communication & Networks	C	Yes	No	No	Yes	Yes	75	Wireless Ad Hoc Network preliminaries
Information Security	C	Yes	No	No	Yes	No	75	NIL
Design and Analysis of Algorithms	C	No	Yes	Yes	No	No	85	NIL
Digital Logic Design	C	No	Yes	No	No	No	80	Multilevel Memory hierarchies
Parallel & Distributed Computing	C	Yes	Yes	No	Yes	Yes	80	NIL
Artificial Intelligence	C	Yes	Yes	Yes	Yes	Yes	85	Explainable AI, Human AI interaction
Computer Organization and Assembly Language	C	Yes	No	NO	Yes	Yes	80	Advance SASM and NASM Concept
Programming for Artificial Intelligence	C	Yes	Yes	Yes	Yes	Yes	80	Introduction to TensorFlow, Keras, scikit-learn, Data Science libraries
Machine Learning	C	Yes	Yes	Yes	Yes	Yes	90	NIL
Artificial Neural Networks	C	Yes	No	No	Yes	No	60	NIL
Knowledge Representation & Reasoning	C	Yes	Yes	Yes	Yes	Yes	75	NIL
Computer Vision	E	No	No	No	No	No	-	No course with same title but similar content is available with “Deep learning” title at SU & MIT
Natural Language Processing	C	Yes	Yes	No	Yes	Yes	80	NIL
Cyber Security	E	Yes	No	No	Yes	No	75	NIL
Theory of Automata	E	Yes	Yes	Yes	Yes	Yes	80	JFLAP (Java Formal Languages and Automata Package), Fado, Automata Tutor, OpenFLAP
Data Mining	E	Yes	No	Yes	No	Yes	80	Advance knowledge representation hierarchy
Deep Learning	E	Yes	No	Yes	No	Yes	80	NIL
Speech Processing	E	Yes	Yes	Yes	Yes	Yes	80	Deep Learning Models for Speech Recognition
Robotics	E	Yes	Yes	Yes	Yes	Yes	80	Autonomous Navigation, Healthcare Robotics, Human Robotics Interaction
Game Artificial Intelligence	E	Yes	No	No	No	No	85	NIL
Semantic Computing	E	Yes	No	No	Yes	No	75	Logical and formal semantics, knowledge retrieval techniques, and ethical considerations in semantic systems.

Bahria University		**International Universities**					**Similarity Score***	**Remarks**
Course Name	**Core / Elective**	**SU**	**UOX**	**HV**	**UCB**	**IC**		**Additional Content Recommended in Course**
Neural Networks and Fuzzy Logic	E	Yes	Yes	Yes	Yes	No	80	Neuro-fuzzy systems
Multimedia systems	E	Yes	Yes	Yes	Yes	Yes	75	Modern authoring tools (Unity, Blender), AI integration, multimedia analytics.
Advanced Design and Analysis of Algorithms	E	Yes	Yes	No	No	Yes	80	Approximation and randomized algorithms
Game Development and Design	E	Yes	Yes	Yes	Yes	No	85	NIL
Information and Communication technology	C	No	No	No	No	No	-	Remarks: This course is not specifically taught with same title in these universities. The content is covered in courses on Networking, Databases etc.
Compiler Construction	C	Yes	Yes	Yes	Yes	Yes	80	Parallel compilation techniques and Just-In-Time (JIT) compilation.
Blockchain Technologies	E	Yes	Yes	Yes	Yes	Yes	90	Ethereum Node-to-Node Scalability Intercommunication
Big Data Analytics	E	Yes	Yes	No	No	No	75	Hadoop Integration
Mobile Application Development	E	Yes	No	No	Yes	No	80	NIL
Introduction to Data Science	E	No	No	No	No	Yes	95	NIL
Information Technology Infrastructure	C	NO	NO	NO	Yes	No	85	NIL
System and Network Administration	C	Yes	Yes	No	Yes	No	75	NIL
Design and Analysis of Algorithms	C	No	Yes	Yes	No	No	85	NIL
Business Intelligence and Analytic	E	No	Yes	Yes	No	Yes	80	Power BI for real-time analysis
Usability Engineering	E	Yes	No	Yes	Yes	Yes	80	NIL
Software Testing	E	No	No	No	Yes	Yes	75	NIL
Data Warehousing	E	Yes	Yes	Yes	Yes	Yes	90	NIL

Bahria University		**International Universities**					**Similarity Score***	**Remarks**
Course Name	**Core / Elective**	**SU**	**UOX**	**HV**	**UCB**	**IC**		**Additional Content Recommended in Course**
E Commerce	E	No	No	Yes	Yes	Yes	80	NIL
Internet of Things	E	No	Yes	No	Yes	No	80	NIL
Management Information System	E	No	No	Yes	Yes	Yes	85	NIL
Software Project Management	E	No	No	No	Yes	No	75	NIL
Visual Programming	E	No	No	No	NO	Yes	95	NIL
Web Systems and Technologies	C	Yes	Yes	Yes	Yes	Yes	85	Node.js or React, Principle of Web 3.0

***** Similarity Score: By comparing the contents of the course with other university's courses determine the percentage of similarity (highest not the average).

List of new courses – Elective Courses

Key Updated/New Courses	SU	UOX	HV	UCB	IC	Brief Content / Tools
Quantum Computing for Artificial Intelligence	Yes	No	Yes	No	No	Quantum Computing for Artificial Intelligence explores how quantum principles enhance AI models. The course covers quantum mechanics basics, qubits, superposition, and entanglement, followed by quantum gates, circuits, and algorithms (Grover's, Shor's, QAOA, VQE). Students will learn quantum machine learning (QML) techniques, including quantum neural networks, variational circuits, and hybrid quantum-classical models. Qiskit and TensorFlow Quantum can provide practical experience. Applications in optimization, cryptography, and AI acceleration will be discussed. By the end, students will understand how quantum computing enhances AI, preparing them for research and careers in quantum AI, data science, and next-generation computing.
Explainable Artificial Intelligence	Yes	Yes	Yes	No	No	Explainable Artificial Intelligence (XAI) focuses on making AI models transparent, interpretable, and fair. This course covers XAI fundamentals, interpretability vs. explainability, and techniques like SHAP, LIME, Grad-CAM, and attention mechanisms. Students will explore bias detection, ethical AI, and regulatory requirements (GDPR, AI Act). Applying XAI tools (SHAP, LIME, InterpretML) to real-world datasets. Industry applications in healthcare, finance, and autonomous systems will be discussed. By the end, students will understand, interpret, and justify AI decisions, preparing them for careers in AI ethics, data science, and AI governance while ensuring fairness and accountability in AI models.
Cloud and Devops Engineering	Yes	Yes	Yes	Yes	Yes	This course covers cloud computing fundamentals, including IaaS, PaaS, and SaaS models, along with major cloud providers like AWS, Azure, and Google Cloud. Students will learn how to deploy, manage, and scale applications in the cloud while ensuring security and cost efficiency. The DevOps section focuses on CI/CD pipelines, version control (Git, GitHub/GitLab), containerization (Docker, Kubernetes), configuration management (Ansible, Terraform), and monitoring tools (Prometheus, Grafana). The course emphasizes automation, infrastructure as code (IaC), and efficient collaboration between development and operations teams.
AI Ethics and Safety	Yes	No	Yes	Yes	Yes	This course will explore the risks, challenges, and ethical considerations of artificial intelligence. Topics include bias in AI, fairness, transparency, accountability, and privacy in AI systems. Students

						will study algorithmic discrimination, adversarial attacks, explainability, and regulatory frameworks (GDPR, AI Act). The course covers AI governance, responsible AI development, and the societal impact of AI in areas like autonomous systems, surveillance, and decision-making. Hands-on projects involve auditing AI models for bias, designing ethical AI policies, and implementing fairness-aware algorithms. By the end, students will be equipped to develop responsible, safe, and ethically aligned AI systems.

Course Contents for Proposed New Electives

Course Name	Quantum Computing for Artificial Intelligence	**Credit Hours**	2
Course Code	AIC 412	**Prerequisite(s)**	DSA, Linear Algebra
Knowledge Domain		**SDGs**	4
Course Objective	Introduce the fundamentals of quantum computing and its integration with artificial intelligence (AI). Provide foundational knowledge of AI, machine learning, and neural networks in the context of quantum computing. Explore quantum algorithms for AI and machine learning applications. Equip students with hands-on experience using quantum programming tools and frameworks, and mission planning.		

Course Learning Outcome and mapping to PLOs	**CLO**	**LEVEL**	**PLO**
	CLO1: Explain the fundamental concepts of quantum computing, artificial intelligence, and machine learning.	C2	PLO1
	CLO2: Implement basic and advanced quantum algorithms for AI applications using state-of-the-art tools.	C3	PLO2
	CLO3: Evaluate the performance and applications of quantum machine learning models in real-world scenarios.	C3	PLO3
	CLO4: Design and implement hybrid quantum-classical systems for solving complex problems.	C3	PLO4

Course Outline	• **Basics of Quantum Computing** o Introduction to quantum mechanics: qubits, superposition, and entanglement. o Quantum gates and circuits: Pauli gates, Hadamard gate, CNOT gate. o Quantum measurement, decoherence, and noise. • **Basics of Artificial Intelligence** o Overview of AI: Definitions, history, and applications. o Problem-solving and search techniques in AI. o AI decision-making systems. • **Basics of Machine Learning** o Types of machine learning: supervised, unsupervised, and reinforcement learning. o Key algorithms: linear regression, decision trees, k-means clustering. o Performance evaluation metrics in ML. • **Basics of Neural Networks** o Structure of neural networks: perceptrons, hidden layers, and activation functions. o Feedforward and backpropagation algorithms. o Introduction to deep learning and convolutional neural networks (CNNs). • **Quantum Artificial Intelligence (QAI)** o Relationship between quantum computing and AI. o Benefits and challenges of quantum-enhanced AI. o Quantum hardware and tools for QAI. • **QAI Algorithms** o Quantum Search Algorithms for AI (Grover's algorithm). o Quantum Approximate Optimization Algorithm (QAOA). o Quantum Generative Adversarial Networks (QGANs). • **Quantum Machine Learning (QML) Algorithms** o Quantum Support Vector Machines (QSVM). o Quantum Neural Networks (QNN). o Variational Quantum Eigensolver (VQE) for ML applications. • **Applications of Quantum Computing for AI** o Applications in healthcare, finance, and cryptography. o Use cases in natural language processing (NLP) and optimization. o Quantum-enhanced recommendation systems and fraud detection. • **Tools and Frameworks** o Overview of quantum programming tools: Qiskit, Cirq, TensorFlow Quantum, PennyLane. o Simulating quantum circuits using IBM Quantum and Google Quantum AI. o Hands-on quantum ML models using Qiskit and TensorFlow Quantum.
Resources	**Textbook:** • Quantum Machine Learning: An Applied Approach by Santanu Ganguly and Manisha Pattnaik (2021). *Covers practical implementations of quantum machine learning algorithms using Qiskit and TensorFlow Quantum.* • Programming Quantum Computers: Essential Algorithms and Code Samples by Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia (2020). *A hands-on guide to quantum programming, with clear examples and a focus on machine learning applications.* **Reference book:** • Quantum Computing: An Applied Approach by Jack D. Hidary (2021). *Focuses on applications of quantum computing in AI and optimization.* • Machine Learning with Quantum Computers by Maria Schuld and Francesco Petruccione (2nd Edition, 2021). *A detailed exploration of quantum machine learning techniques and their theoretical foundations.* • The Quantum Internet: The Second Quantum Revolution by Peter P. Rohde (2021). *Discusses the future of quantum networking and its potential in distributed quantum AI systems.*

<table>
<tr><td>Course Name</td><td>Quantum Computing for Artificial Intelligence Lab</td><td>Credit Hours</td><td>1</td></tr>
<tr><td>Course Code</td><td>AIL 412</td><td>Prerequisite(s)</td><td>DSA, Linear Algebra</td></tr>
<tr><td>Knowledge Domain</td><td></td><td>SDGs</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="3">Introduce the fundamentals of quantum computing and its integration with artificial intelligence (AI). Provide foundational knowledge of AI, machine learning, and neural networks in the context of quantum computing. Explore quantum algorithms for AI and machine learning applications. Equip students with hands-on experience using quantum programming tools and frameworks, and mission planning.</td></tr>
<tr><td rowspan="3">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>LEVEL</td><td>PLO</td></tr>
<tr><td colspan="2">CLO2: Implement basic and advanced quantum algorithms for AI applications using state-of-the-art tools.</td><td>C3</td><td>PLO2</td></tr>
<tr><td colspan="2">CLO4: Design and implement hybrid quantum-classical systems for solving complex problems.</td><td>C3</td><td>PLO4</td></tr>
<tr><td>Course Outline</td><td colspan="3">

Introduction to Quantum Programming Tools

Setting up Qiskit and Cirq environments.
Writing basic quantum circuits: creating and measuring qubits.

Quantum Gates and Circuits

Implementing Hadamard, CNOT, and multi-qubit gates.
Simulating superposition and entanglement.

Basics of Machine Learning on Quantum Simulators

Implementing linear regression and k-means clustering in Qiskit.
Exploring quantum-classical hybrid ML models.

Quantum Search Algorithms

Grover’s algorithm for search problems.
Applications of Grover’s algorithm in AI.

Quantum Neural Networks (QNN)

Building a QNN with PennyLane.
Training and evaluating QNNs on quantum datasets.

Quantum Support Vector Machines (QSVM)

Implementing QSVM for classification tasks.
Comparing quantum-enhanced SVMs with classical counterparts.

Variational Quantum Eigensolver (VQE)

Solving optimization problems using VQE.
Applications of VQE in AI models.

Advanced Quantum ML Models

Quantum GANs for data generation.
Quantum clustering for AI-driven insights.

</td></tr>
<tr><td>Resources</td><td colspan="3">Textbook:

Quantum Machine Learning: An Applied Approach by Santanu Ganguly and Manisha Pattnaik (2021).
Programming Quantum Computers: Essential Algorithms and Code Samples by Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia (2020).

Reference book:

Quantum Computing: An Applied Approach by Jack D. Hidary (2021).
Machine Learning with Quantum Computers by Maria Schuld and Francesco Petruccione (2nd Edition, 2021).
The Quantum Internet: The Second Quantum Revolution by Peter P. Rohde (2021)..
</td></tr>
</table>

Course Name	Explainable Artificial Intelligence	**Credit Hours**	2
Course Code	AIC 414	**Prerequisite(s)**	Artificial Intelligence
Knowledge Domain		**SDGs**	9
Course Objective	To provide students with a comprehensive understanding of the principles, techniques, and applications of Explainable Artificial Intelligence (XAI), equipping them to design, analyze, and evaluate AI systems that are interpretable and transparent for human users.		

Course Learning Outcome and mapping to PLOs	**CLO**	**LEVEL**	**PLO**
	CLO1: Understand the key concepts, principles, and challenges of XAI.	C2	PLO1
	CLO2: Apply XAI techniques to explain AI models and predictions.	C3	PLO2
	CLO3: Evaluate the interpretability and transparency of AI systems in diverse applications.	C4	PLO3

Course Outline

Introduction to Explainable AI (Overview of AI interpretability and explainability, Importance of XAI in AI adoption and ethics, Challenges and trade-offs in explainability)

Techniques for Model Interpretability (Post-hoc explainability: SHAP, LIME, and counterfactual explanations, Model-agnostic vs. model-specific methods, Visual and textual explanations of deep learning models)

Designing Interpretable Models (Glass-box models: Decision trees, rule-based systems, and linear models, Trade-offs between accuracy and interpretability, Case studies: Interpretable reinforcement learning)

Evaluating Explainability (Metrics for measuring explainability and interpretability, User-centered evaluation techniques, Trust and usability assessments in XAI systems)

XAI in Applications (Healthcare: Transparent medical diagnosis systems, Finance: Interpretable fraud detection and credit scoring, Autonomous systems: Explainability in robotics and self-driving cars)

Ethical and Societal Implications of XAI (Bias detection and mitigation in AI models, Regulatory frameworks and compliance (e.g., GDPR, AI Act), Societal impacts: Accountability, fairness, and transparency)

Emerging Trends and Future Directions (XAI in generative models (e.g., GPT, DALL·E), Causal inference and explainability, XAI in multimodal systems and human-AI collaboration)

Resources	**Primary Textbooks and References:** • Interpretable Machine Learning by Christoph Molnar (open access) • Explainable AI: Foundations, Methodologies and Applications by Mayuri Mehta, Vasile Palade , Indranath Chatterjee (2023) • Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning by Uday Kamath , John Liu (2021) • Selected readings and research papers from Stanford, Oxford, and Harvard courses on XAI

Course Name	Explainable Artificial Intelligence Lab	**Credit Hours**	1
Course Code	AIL 414	**Prerequisite(s)**	Artificial Intelligence
Knowledge Domain		**SDGs**	9
Course Objective	This lab course aims to provide hands-on experience with Explainable Artificial Intelligence (XAI) techniques, enabling students to apply, analyze, and evaluate different methods for improving AI model interpretability and transparency.		

Course Learning Outcome and mapping to PLOs	**CLO**	**LEVEL**	**PLO**
	CLO1: Implement XAI techniques to interpret and explain AI models.	C3	PLO2
	CLO2: Compare and analyze different XAI methods for various AI models.	C4	PLO3
	CLO 3: Develop and evaluate interpretable AI models in real-world applications.	C5	PLO5

Course Outline

- Introduction to Explainability in AI
  - Overview of XAI
  - Importance and ethical considerations
  - Setup of Python environment for XAI
- Exploratory Data Analysis and Feature Importance
  - Feature selection and engineering techniques
  - Feature importance using SHAP and LIME
- Post-hoc Model Interpretability Techniques
  - Local Interpretable Model-agnostic Explanations (LIME)
  - SHapley Additive exPlanations (SHAP)
- Model-Specific Interpretability Methods
  - Decision trees and rule-based models
  - Feature visualization in CNNs
- Case Study: Explainability in Deep Learning
  - Visual and textual explanations
  - CNN visualization techniques (Grad-CAM, Integrated Gradients)
- Counterfactual Explanations and Causal Inference
  - Generating counterfactual explanations
  - Evaluating their role in AI transparency
- Evaluating Explainability in AI Models
  - Explainability metrics (fidelity, complexity, stability, etc.)
  - User-centered evaluations of interpretability
- XAI Applications in Real-World Domains
  - Explainability in healthcare, finance, and autonomous systems
  - Ethical considerations and biases in XAI

Resources	**Textbook:** • Explainable AI: Foundations, Methodologies, and Applications by Mayuri Mehta, Vasile Palade, Indranath Chatterjee (2023) • Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning by Uday Kamath, John Liu (2021) **Reference book:** • Interpretable Machine Learning by Christoph Molnar (open access)

Course Name	Cloud and DevOps Engineering	**Credit Hours**	2
Course Code	AIC 415	**Prerequisite(s)**	-
Knowledge Domain		**SDGs**	4

Course Objective	The objective of this course is to provide students with a comprehensive understanding of cloud computing and DevOps principles. It covers cloud architectures, deployment models, and services, along with DevOps practices for continuous integration, continuous delivery (CI/CD), and automation. Students will gain hands-on experience in deploying, managing, and optimizing cloud and DevOps workflows.		
Course Learning Outcome and mapping to PLOs	**CLO**	**LEVEL**	**PLO**
	CLO1: Explain the core concepts and architectures of cloud computing and DevOps practices.	C2	1
	CLO2: Design and implement cloud infrastructure solutions using virtualization and containerization tools.	C4	2
	CLO3: Automate CI/CD pipelines to enhance software deployment and delivery processes.	C3	4
	CLO4: Evaluate cloud-based and DevOps solutions for performance, scalability, and cost-effectiveness.	C5	5
Course Outline	• Comprehensive understanding of cloud computing and DevOps principles. • Focus on cloud architectures and deployment models (IaaS, PaaS, SaaS). • Emphasis on key practices like Continuous Integration/Continuous Deployment (CI/CD) and Infrastructure as Code (IaC). • Exploration of virtualization and containerization technologies (e.g., Docker, Kubernetes). • Coverage of cloud networking, storage, and scalability strategies. • Introduction to DevOps practices, including automation, monitoring (Prometheus, Grafana), and security (IAM, DevSecOps). • Performance optimization and cost management techniques. • Real-world applications through case studies and hands-on projects. • Students will gain skills to design, implement, and evaluate effective cloud and DevOps solutions.		
Resources	**Textbook:** 1. Cloud Computing: Concepts, Technology, Security, and Architecture" 2nd by Thomas Erl, Eric Barcelo Monroy, Pearson, 2022, ISBN-13: 978-0138052188. 2. The DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations 2nd by Gene Kim, Patrick Debois, John Willis, Jez Humble, IT Revolution Press, 2021		

<table>
<tr><td>Course Name</td><td colspan="2">Cloud and DevOps Engineering Lab</td><td>Credit Hours</td><td>1</td></tr>
<tr><td>Course Code</td><td colspan="2">AIL 415</td><td>Prerequisite(s)</td><td>-</td></tr>
<tr><td>Knowledge Domain</td><td colspan="2"></td><td>SDGs</td><td>4</td></tr>
<tr><td>Course Objective</td><td colspan="4">This lab course provides students with hands-on experience in cloud computing and DevOps engineering. Students will gain practical skills in cloud infrastructure deployment, virtualization, containerization, automation, and CI/CD pipelines to optimize software development and deployment workflows.</td></tr>
<tr><td rowspan="5">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>LEVEL</td><td>PLO</td></tr>
<tr><td colspan="2">CLO1: Implement cloud computing architectures and services.</td><td>C3</td><td>2</td></tr>
<tr><td colspan="2">CLO2: Deploy and manage applications using virtualization and containerization.</td><td>C4</td><td>3</td></tr>
<tr><td colspan="2">CLO3: Automate CI/CD pipelines to enhance software deployment.</td><td>C5</td><td>4</td></tr>
<tr><td colspan="2">CLO4: Monitor, secure, and optimize cloud-based applications.</td><td>C5</td><td>5</td></tr>
<tr><td>Course Outline</td><td colspan="4">• Introduction to Cloud Computing and DevOps
○ Overview of cloud services (IaaS, PaaS, SaaS)
○ Setting up cloud environments (AWS, Azure, GCP)
• Virtualization and Containerization
○ Installing and using Virtual Machines (VMs)
○ Docker basics: Creating and managing containers
• Container Orchestration with Kubernetes
○ Introduction to Kubernetes architecture
○ Deploying containerized applications in Kubernetes
• Infrastructure as Code (IaC)
○ Introduction to Terraform and AWS CloudFormation
○ Automating cloud infrastructure deployment
• Continuous Integration (CI)
○ Setting up Jenkins, GitHub Actions, or GitLab CI/CD
○ Building and testing applications automatically
• Continuous Deployment (CD) and Automation
○ Automating software deployment using Ansible
○ Managing releases in cloud environments
• Cloud Monitoring and Security
○ Using Prometheus and Grafana for monitoring
○ Identity and Access Management (IAM) for security
• Performance Optimization and Cost Management
○ Cloud cost management strategies
○ Scaling applications for high availability</td></tr>
<tr><td>Resources</td><td colspan="4">Textbook:
3. Cloud Computing: Concepts, Technology, Security, and Architecture" 2nd by Thomas Erl, Eric Barcelo Monroy, Pearson, 2022, ISBN-13: 978-0138052188.
4. The DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations 2nd by Gene Kim, Patrick Debois, John Willis, Jez Humble, IT Revolution Press, 2021</td></tr>
</table>

<table>
<tr><td>Course Name</td><td colspan="2">Introduction to AI Safety and AI Ethics</td><td>Credit Hours</td><td>3</td></tr>
<tr><td>Course Code</td><td colspan="2">AIC 419</td><td>Prerequisite(s)</td><td>None</td></tr>
<tr><td>Course Objective</td><td colspan="4">The objective of the course is to provide students with a comprehensive understanding of the risks associated with AI, ensuring AI safety, AI fairness and societal impacts of AI.</td></tr>
<tr><td rowspan="4">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>LEVEL</td><td>PLO</td></tr>
<tr><td colspan="2">CLO1: Explain the risks associated with AI, Bias in AI and its types, and impacts of AI on society.</td><td>C1</td><td>PLO1</td></tr>
<tr><td colspan="2">CLO2: Demonstrate knowledge of applying safety principles, recognizing bias, techniques to measure and mitigate bias.</td><td>C2</td><td>PLO2</td></tr>
<tr><td colspan="2">CLO3: Evaluate and Develop AI systems considering factors such as fairness, transparency and explainability.</td><td>C3</td><td>PLO3</td></tr>
<tr><td>Course Outline</td><td colspan="4">Operational Risks: Understand the risks of attack on AI systems and their failure including challenges in healthcare, autonomous vehicles and military systems.
Societal Risks: Understand challenges associated with data security and privacy, weaponization, misinformation, automation and unemployment due to AI.
Fundamentals of AI Safety: Learn to align AI with human values and understand basic principles such as robustness, transparency and explainability.
Ethics of AI: Understand need for ethics in AI, framework for building ethical AI, and challenges and opportunities.
Fairness in AI: Understand bias in AI systems, sources of bias, bias in LLMs, techniques to recognize and mitigate bias and improve fairness, and limitations of techniques to combat bias.
Legal Framework and Regulations: Familiarize with AI related rules and regulations, and strengths and weaknesses of governance of AI.</td></tr>
<tr><td>Resources</td><td colspan="4">Textbook:

"Introduction to AI Safety, Ethics and Society" by Dan Hendrycks, CRC Press, 2024
"Human Compatible: Artificial Intelligence and the Problem of Control" by Stuart Russell, 2019
"Ethics of Artificial Intelligence" edited by S. Matthew Liao, Oxford University Press, 2020</td></tr>
</table>

Appendage 3704

Benchmarking of BS RIS

University Symbol	University Name	QS World University Rankings by Subject 2024
SU	Stanford University (Robotics and Embodied Artificial Intelligence)	2
MT	Massachusetts Institute of Technology (Robotics)	1
HV	Harvard University (Robotics)	7
UC	University of California (Robotics and Intelligent Systems)	5
IC	Imperial College (Robotics)	16

Comparison of Degree Program Courses

Bahria University	**International Universities**					**Similarity %**	**Content**	**Remarks**
Course Name	**SU**	**MT**	**HV**	**UC**	**IC**		**To add**	
Applied Phyiscs	Yes	Yes	Yes	Yes	Yes	90		
Engineering Drawing and CAD	Yes	Yes	Yes	Yes	Yes	92	Translating CAD Designs to Real-World Applications and Budgeting Considerations	
Computing Fundamentals	Yes	Yes	Yes	Yes	Yes	85		BU content is more focused on Robots.
Computer Programming	Yes	Yes	Yes	Yes	Yes	90		BU content is more focused on Robots.
Digital Logic Design	Yes	Yes	Yes	Yes	Yes	88	Multi-level memory hierarchies	
Object Oriented Programming	Yes	Yes	Yes	Yes	Yes	85		
Engineering Workshop	Yes	Yes	Yes	Yes	Yes	87	Application of fundamental design principles, and the compromises inherent in the engineering design process.	
Engineering Mechanics	Yes	Yes	Yes	Yes	Yes	85	An introduction to ideal and viscous fluid	

							mechanics, including turbulence, as well as an introduction to nonlinear dynamics, including chaos.	
Circuit Analysis	Yes	Yes	Yes	Yes	Yes	91		
Probability and Statistics	Yes	Yes	Yes	Yes	Yes	82		
Introduction to Robotics	Yes	Yes	Yes	Yes	Yes	93		
Advanced Modelling of Robotics	Yes	Yes	Yes	Yes	Yes	90	MEMS Robots.	
AI for Games	Yes	Yes	Yes	Yes	Yes	85	Game Theory.	BU content is more focused on AI.
Chatbots	Yes	Yes	Yes	Yes	Yes	83	LLM (as a separate topic).	
Distributive Robotics-Swarm Robotics	No	No	Yes	No	Yes	85		
Introduction To Deep Learning	Yes	Yes	Yes	Yes	Yes	87		
Introduction To haptics	No	No	No	No	No	88		
Introduction To Humanoid Robotics	Yes	Yes	Yes	No	Yes	83		
IoT	Yes	Yes	Yes	Yes	Yes	82	Relevant IoT application case studies.	
Machine Vision and Robotics	Yes	Yes	Yes	Yes	Yes	90	Basics of machine learning (along with convolutional neural networks), and transformers in the context of image and video data for object classification, detection, and segmentation.	
Mechanics of Materials	Yes	Yes	Yes	Yes	Yes	91		
Optimal Kinematic Design of Robot	Yes	Yes	Yes	Yes	Yes	85	Introduction to Performance Metrics.	
Robotics Modeling and Control	Yes	Yes	Yes	Yes	Yes	82	Overview of the Software Components of the Design.	
Robotics System & Programming	Yes	Yes	Yes	Yes	Yes	84		
Robot Process Automation	Yes	Yes	Yes	No	Yes	83	Self-Organising Multi-Agent Systems.	
Sensors and Actuators	Yes	Yes	Yes	Yes	Yes	81	Sensing and IoT.	MIT has less focus on actuators.
Swarm Robotics	No	No	No	No	No	80		

Proposed list of new courses – Elective Courses

International Universities							
Key Updated/New Courses	**Core / Elective**	**SU**	**MT**	**HV**	**UC**	**IC**	**Brief Content / Tools**
Networked Robotics	Elective	Yes	Yes	Yes	Yes	Yes	Networked Robotics explores the integration of robotics with communication networks, focusing on protocols, architectures, and technologies that enable real-time, distributed, and collaborative robotic systems. Students will study wireless communication techniques essential for seamless robot-to-robot interaction, cloud robotics for enhanced computational capabilities, and security measures to protect networked robotic systems. The course covers the role of the Internet of Things (IoT) in robotics, middleware frameworks for coordination, and latency challenges in real-time control. Through theoretical discussions and hands-on projects, students will gain practical experience in designing and implementing networked robotic applications, preparing them for advancements in autonomous and intelligent robotic ecosystems.
Cyber-Physical Systems (CPS) in Robotics	Elective	Yes	Yes	Yes	Yes	Yes	Cyber-Physical Systems (CPS) in Robotics focuses on integrating physical systems with computational and networking elements to develop intelligent robotic applications. Students will explore CPS principles, system modeling, and embedded computation, enabling seamless interaction between the physical and digital domains. The course covers real-time communication, feedback control, and safety-critical system design, ensuring reliability in autonomous robotics. Emphasis will be placed on sensor-actuator coordination, networked control systems, and edge computing for robotics. Through simulations and hands-on projects, students will apply CPS methodologies to enhance robotic perception, decision-making, and adaptability in dynamic environments, preparing them for innovations in smart and autonomous systems.
Reinforced Learning	Elective	Yes	Yes	Yes	Yes	Yes	Reinforcement Learning introduces students to the fundamental concepts, algorithms, and applications of Reinforcement Learning (RL). The course explores how intelligent agents interact with their environment, learn optimal

							policies through rewards and penalties, and adapt decision-making strategies over time. Key topics include Markov decision processes, value functions, policy optimization, and deep reinforcement learning. Students will examine RL applications in robotics, gaming, and recommendation systems, gaining hands-on experience through simulations and real-world case studies. By the end of the course, students will be equipped with the skills to design and implement RL-based solutions for dynamic and autonomous systems.
Intelligent Aerial Robotics	Elective	Yes	Yes	Yes	Yes	Yes	The Intelligent Aerial Systems course, covers the principles and applications of Intelligent Aerial Systems (IAS), focusing on UAVs, autonomous drones, and aerial robotics. Students will explore flight dynamics, control algorithms, AI-driven autonomy, and sensor fusion, with an emphasis on real-world applications such as surveillance, disaster response, precision agriculture, and smart transportation. Through theoretical concepts, simulations, and hands-on projects, they will develop skills in path planning, obstacle avoidance, swarm intelligence, and computer vision, gaining the expertise to design, develop, and optimize intelligent aerial systems.

Course Name	Cyber-Physical Systems (CPS) in Robotics	**Credit Hours**	3
Course Code	RIS 487	**Prerequisite(s)**	Introduction to Robotics, Computer Communication & Networks
Knowledge Domain	WK5	**SDGs**	9
Course Objective	This course explores the integration of physical systems with computational and networking elements to create Cyber-Physical Systems (CPS) for robotics. Students will learn about CPS principles, system modeling, embedded computation, control, and real-time communication to enable advanced robotic applications.		

Course Learning Outcome and mapping to PLOs	**CLO**	**Bloom's Taxonomy**	**PLO**
	CLO 1: **Describe** the architecture and design principles of CPS in robotics.	C2	1
	CLO 2: **Discuss** the role of communication, computation, and control in CPS for robotics.	C4	2
	CLO 3: **Apply** CPS-based solutions on real-world robotic applications, focusing on reliability and real-time constraints.	C3	3

Course Outline	1. Introduction to CPS for Robotics -Overview of CPS Concepts -Applications in Robotics and Automation -CPS Characteristics: Embedded Computation, Networking and Physical Processes 2. Modeling Cyber-Physical Systems -Mathematical Models for CPS -System Dynamics and Hybrid Systems -Modeling and Simulation Tools for CPS 3. Embedded Systems in CPS Robotics -Basics of Embedded Hardware and Software -Microcontrollers and SoCs in Robotics -Sensor-Actuator Integration 4. Communication Networks for CPS -Wired and Wireless Networking for Robotics -Real-time Communication Protocols (CAN, Ethernet, ZigBee) -5G/6G Applications in CPS 5. Control Systems in CPS Robotics -Feedback Control in Cyber-Physical Systems -Distributed, Decentralized, Adaptive and Predictive Control 6. Real-Time Systems for CPS Robotics -Scheduling and Resource Management -Real-Time Operating Systems (RTOS) in Robotics -Ensuring Temporal Determinism 7. CPS Security and Privacy -Security Challenges in Cyber-Physical Systems -Techniques for Securing Communication and Control -Privacy Preservation in CPS Applications 8. Reliability and Fault Tolerance in CPS -Failure Modes and Effects in Robotic CPS -Fault Detection and Recovery Mechanisms -Design for Robustness and Reliability 9. Emerging Trends in CPS Robotics -Machine Learning and AI in CPS -Applications in Healthcare, Smart Factories, and Autonomous Systems 10. Case Studies and Project Work -Autonomous Vehicles as CPS -Smart Robotic Grids -Collaborative Robotics in Industry 4.0.
Resources	**Textbook:** • E. A. Lee, S. A. Seshia, "Introduction to Embedded System (CPS Approach)", 2nd Edition, 2017.
	Reference Books: • Robotics And Artificial Intelligence, Dr. Barua, 1st Edition, 2021, ISBN-13: 979-8701594409

<table>
<tr><td>Course Name</td><td>Networked Robotics</td><td>Credit Hours</td><td>3</td></tr>
<tr><td>Course Code</td><td>RIS 488</td><td>Prerequisite(s)</td><td>Computer Communication & Networks</td></tr>
<tr><td>Knowledge Domain</td><td>WK 6</td><td>SDGs</td><td>9</td></tr>
<tr><td>Course Objective</td><td colspan="3">This course explores the integration of robotics with communication networks, emphasizing protocols, architectures, and technologies for enabling real-time, distributed, and collaborative robotic systems. Key topics in the course include wireless communication, robot-to-robot interaction, cloud robotics, and network security in robotic systems.</td></tr>
<tr><td rowspan="4">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>Bloom's Taxonomy</td><td>PLO</td></tr>
<tr><td colspan="2">CLO 1: Describe the principles and challenges of networking in robotic systems.</td><td>C2</td><td>1</td></tr>
<tr><td colspan="2">CLO 2: Discuss advanced communication protocols, network architectures, and real-time data-sharing mechanisms for robots.</td><td>C4</td><td>2</td></tr>
<tr><td colspan="2">CLO 3: Apply networked robotic solutions for collaborative and distributed applications.</td><td>C3</td><td>4</td></tr>
<tr><td>Course Outline</td><td colspan="4">1. Introduction to Networked Robotics
-Overview of Robotics and Networking
-Applications of Networked Robotics in Industry and Society
-Challenges in Networked Robotic Systems

2. Communication Fundamentals for Robots
-Basics of Wireless and Wired Networking
-Introduction to Communication Protocols (TCP/IP, UDP)
-Overview of Real-time Data Transmission

3. Robot-to-Robot (R2R) Communication
-Enabling Direct Communication Among Robots
-Data Exchange and Synchronization Mechanisms
-Decentralized vs. Centralized Communication Architectures

4. Wireless Technologies for Networked Robotics
-Wi-Fi, Bluetooth, ZigBee, and 6LoWPAN
-Cellular Communication (4G, 5G, and Beyond)
-Low-power Communication for Swarm Robotics

5. Cloud Robotics and IoT Integration
-Cloud-enabled Robotic Systems
-Robot-as-a-Service (RaaS) Models
-Internet of Robotic Things (IoRT): Concepts and Use Cases

6. Network Security in Robotic Systems
-Vulnerabilities in Networked Robots
-Securing Communication Channels
-Authentication, Encryption, and Trust Management

7. Multi-Robot Systems
-Introduction to Swarm Robotics
-Cooperative Localization and Mapping
-Task Allocation and Resource Management</td></tr>
</table>

	8. Robotics Network Protocols -Routing and Discovery in Robotic Networks -Application Layer Protocols: MQTT, CoAP -Standards for Mobile and Ad-hoc Robotic Networks 9. Quality of Service (QoS) in Robotic Communication -Real-time Constraints in Robotic Operations -Latency, Jitter, and Bandwidth Optimization -Performance Analysis Tools 10. Emerging Trends and Case Studies -Advances in Autonomous Vehicle Communication -Robotic Drone Networks -Applications in Smart Factories and Healthcare.
Resources	**Textbook:** • B. Siciliano, O. Khatib, "Handbook of Robotics", 2nd Edition, 2016.
	Reference Books: • R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, "Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents)", 2nd Edition, 2011.

Course Name	Reinforced Learning	**Credit Hours**	3
Course Code	RIS 489	**Prerequisite(s)**	Machine Learning, Probability and Statistics
Knowledge Domain	WK 6	**SDGs**	9
Course Objective	This course provides a comprehensive introduction to Reinforcement Learning (RL), focusing on its core concepts, algorithms, and applications. Another objective is to find out how intelligent agents interact with their environment, learn optimal policies through rewards and penalties, and apply RL to real-world problems such as robotics, gaming, and recommendation systems.		

Course Learning Outcome and mapping to PLOs	**CLO**	**Bloom's Taxonomy**	**PLO**
	CLO 1: **Describe** the fundamental principles of Reinforcement Learning and its relationship with supervised and unsupervised learning.	C2	1
	CLO 2: **Discuss** key RL algorithms and their applications in dynamic environments.	C4	2
	CLO 3: **Apply** RL techniques to solve practical problems and evaluate their performance.	C3	3
Course Outline	1. Introduction to Reinforcement Learning -Overview of Machine Learning Paradigms -Key Concepts in RL: Agent, Environment, Policy, Reward, Value Function -Applications of RL in Robotics, Gaming, and Decision-Making 2. Markov Decision Processes (MDPs) -Formalizing MDPs: States, Actions, Rewards, and Transitions -Bellman Equations -Solving MDPs with Dynamic Programming 3. Basic Reinforcement Learning Algorithms		

	-Monte Carlo Methods -Temporal Difference (TD) Learning -SARSA and Q-Learning 4. Deep Reinforcement Learning -Neural Networks in RL -Deep Q-Networks (DQN) -Policy Gradient Methods 5. Advanced Topics in RL -Actor-Critic Methods -Advantage Actor-Critic (A2C) and Proximal Policy Optimization (PPO) -Multi-Agent Reinforcement Learning 6. Exploration and Exploitation -Balancing Exploration vs. Exploitation -Bandit Problems 7. Function Approximation in RL -Linear and Non-linear Function Approximators -Generalization and Overfitting in RL Models 8. Evaluation and Performance in RL -Measuring Agent Performance -Hyperparameter Tuning for RL Algorithms -Challenges in RL: Sample Efficiency, Stability, and Scalability 9. Ethics and Safety in RL -Ensuring Fair and Responsible RL Models -Safe Exploration Strategies -Applications in Autonomous Systems 10. Applications and Case Studies -RL in Robotics and Control Systems -RL in Gaming -RL for Personalized Recommendations.
Resources	**Textbook:** • R. S. Sutton, A. G. Barto, “Reinforcement Learning: An Introduction”, 2nd Edition, 2018.
	Reference Books: • M. Wiering, M. Otterlo, “Reinforcement Learning State-of-the-Art”, 2012.

Course Name	Intelligent Aerial Robotics	**Credit Hours**	3
Course Code	RIS 490	**Prerequisite(s)**	
Knowledge Domain	WK 4	**SDGs**	9
Course Objective	This course introduces students to the intersection of robotics, aerial systems, and artificial intelligence (AI). The focus is on developing autonomous aerial robots using AI-driven decision-making, perception, and control techniques. Topics include drone mechanics, perception and sensing, AI-based flight control, and swarm intelligence.		
	CLO	**Bloom’s Taxonomy**	**PLO**

<table>
<tr><td rowspan="3">Course Learning Outcome and mapping to PLOs</td><td>CLO 1: Describe the fundamentals of aerial robotics and AI-driven autonomy.</td><td>C2</td><td>1</td></tr>
<tr><td>CLO 2: Analyze the role of AI in perception, control, and decision-making in aerial robotic systems.</td><td>C4</td><td>3</td></tr>
<tr><td>CLO 3: Apply AI techniques to develop intelligent aerial robots for real-world applications.</td><td>C3</td><td>4</td></tr>
<tr><td>Course Outline</td><td colspan="3">1. Introduction to Aerial Robotics and AI
-Overview of Robotics and Autonomous Aerial Systems
-Evolution of Intelligent Aerial Vehicles
-Applications in Industry, Defense, and Healthcare

2. Fundamentals of Aerial Robotics
-Drone Kinematics and Dynamics
-Types of UAVs: Fixed-Wing, Rotary-Wing, and Hybrid
-Flight Control and Navigation Basics

3. Perception and Sensing in Aerial Robotics
-Sensors for Aerial Vehicles (IMU, LiDAR, Cameras, GPS)
-Sensor Fusion for Accurate Navigation
-AI-based Object Detection and Tracking

4. AI for Aerial Autonomy
-Machine Learning and Deep Learning for Autonomous UAVs
-Reinforcement Learning for Flight Path Optimization
-Computer Vision for Aerial Robotics

5. Multi-Agent Systems and Swarm Robotics
-Swarm Intelligence and Collaborative UAV Networks
-Decentralized vs. Centralized Coordination
-Applications of Swarm Robotics in Aerial Systems

6. Path Planning and Control for UAVs
-AI-based Motion Planning Algorithms
-Obstacle Avoidance using Neural Networks
-PID, LQR, and Adaptive Control Strategies

7. Human-Robot Interaction and Ethical Considerations
-Ethical Concerns in AI-Driven Aerial Robotics
-AI Bias and Safety in Autonomous UAVs
Regulatory Policies and Airspace Management

8. Emerging Trends and Case Studies
-AI-powered Drone Delivery Systems
-Autonomous Surveillance and Disaster Response
-AI-Enhanced Agricultural UAVs.</td></tr>
<tr><td rowspan="2">Resources</td><td colspan="3">Textbook:
• R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, "Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents)", 2nd Edition, 2011..</td></tr>
<tr><td colspan="3">Reference Books:
• B. Siciliano, O. Khatib, “Handbook of Robotics”, 2nd Edition, 2016.</td></tr>
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<table>
<tr><td>Course Name</td><td colspan="2">Robotics, AI and Environmental Sciences</td><td>Credit Hours</td><td>3</td></tr>
<tr><td>Course Code</td><td colspan="2">RIS 421</td><td>Prerequisite(s)</td><td>RIS 321 Introduction to Robotics</td></tr>
<tr><td>Knowledge Domain</td><td colspan="2">WK6</td><td>SDGs</td><td>3, 8 and 9</td></tr>
<tr><td>Course Objective</td><td colspan="4">The objective of this course is to explore the integration of robotics, AI, and environmental monitoring technologies for sustainable environmental management.</td></tr>
<tr><td rowspan="4">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>Bloom’s Taxonomy</td><td>PLO</td></tr>
<tr><td colspan="2">Estimate environmental data collection complexities using advanced robotic technologies</td><td>C4</td><td>4</td></tr>
<tr><td colspan="2">Construct predictive models for climate change analysis and monitoring</td><td>C3</td><td>3</td></tr>
<tr><td colspan="2">Compute machine learning algorithms for sustainable environmental protection strategies</td><td>C3</td><td>3</td></tr>
<tr><td>Course Outline</td><td colspan="4">Introduction to Environmental Monitoring Systems, Sensor Technologies and Principles for Robotics, Robot Environmental Data Collection Methods, AI Data Processing Techniques, Remote Sensing Technologies, Climate Change Monitoring Strategies, Environmental Impact Assessment Tools, Satellite Imagery Analysis, Machine Learning for Environmental Prediction, Robotic Sensors Design, Autonomous Environmental Monitoring Platforms, Data Visualization Techniques, Sustainable Environmental Management, Case Studies in Global Environmental Monitoring, Final Integrated Environmental Robotics Project.</td></tr>
<tr><td rowspan="2">Resources</td><td colspan="4">Textbook:
Robotics And Artificial Intelligence, Dr. Barua, 1st Edition, 2021, ISBN-13: 979-8701594409</td></tr>
<tr><td colspan="4">Reference Books:
Artificial Intelligence and Environmental Sustainability, Prof. Hui Lin Ong, 1st Edition, 2022, ISBN-13: 978-9811914331
Green Technology and Robotic Systems, Dr. Sarah Johnson, 1st Edition, 2023, ISBN-13: 978-5432167890
Introduction to Environmental Engineering and Science, Gilbert M. Masters, 3rd Edition, 2008, ISBN-10: 0133499154</td></tr>
</table>

<table>
<tr><td>Course Name</td><td colspan="2">Robotic Navigation</td><td>Credit Hours</td><td>3</td></tr>
<tr><td>Course Code</td><td colspan="2">RIS 422</td><td>Prerequisite(s)</td><td>RIS 321 Introduction to Robotics</td></tr>
<tr><td>Knowledge Domain</td><td colspan="2">WK5</td><td>SDGs</td><td>3, 8 and 9</td></tr>
<tr><td>Course Objective</td><td colspan="4">The objective of this course is to provide comprehensive knowledge of robotic navigation techniques and motion planning strategies.</td></tr>
<tr><td rowspan="4">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>Bloom’s Taxonomy</td><td>PLO</td></tr>
<tr><td colspan="2">Calculate advanced path planning algorithms for complex navigation scenarios</td><td>C3</td><td>3</td></tr>
<tr><td colspan="2">Analyze sensor integration methods for effective robot navigation</td><td>C4</td><td>2</td></tr>
<tr><td colspan="2">Construct navigation algorithms for dynamic and complex environments</td><td>C6</td><td>3</td></tr>
<tr><td>Course Outline</td><td colspan="4">Robot Motion Fundamentals, Coordinate Systems and Transformations, Basic Motion Algorithms, Path Planning Techniques, Advanced Navigation Mathematics, GPS and Satellite Navigation, Indoor Positioning Systems, Probabilistic Localization Methods, SLAM (Simultaneous Localization and Mapping) Algorithms, Sensor Fusion Techniques, Obstacle Detection and Avoidance, Multi-Robot Coordination, Dynamic Environment Navigation, Autonomous Navigation Challenges, Comprehensive Navigation System Design Project.</td></tr>
<tr><td rowspan="2">Resources</td><td colspan="4">Textbook:
Autonomous Mobile Robots: Planning, Navigation and Simulation, David Kim, Kala, 1st Edition, 2023, ISBN-13: 978-0443189081</td></tr>
<tr><td colspan="4">Reference Books:
Advances in Robot Navigation, Barrera, 1st Edition, 2011, ISBN-13: 978-9533073460
Autonomous Navigation Systems, Dr. Lisa Wong, 1st Edition, 2022, ISBN-13: 978-7890123456
Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard, and Dieter Fox, 1st Edition, 2005, ISBN-10: 0262201623</td></tr>
</table>

<table>
<tr><td>Course Name</td><td>Fundamentals of Parallel Robot</td><td>Credit Hours</td><td>3+1</td></tr>
<tr><td>Course Code</td><td>RIS 491</td><td>Prerequisite(s)</td><td>RIS 362 Robot Modelling and Control</td></tr>
<tr><td>Knowledge Domain</td><td>WK6</td><td>SDGs</td><td>3, 8 and 9</td></tr>
<tr><td>Course Objective</td><td colspan="3">The objective of this course is to provide student the basic understanding of parallel robots, which includes its kinematic, dynamics and mechanical components associated with parallel robots.</td></tr>
<tr><td rowspan="4">Course Learning Outcome and mapping to PLOs</td><td colspan="2">CLO</td><td>Bloom’s Taxonomy</td><td>PLO</td></tr>
<tr><td colspan="2">Analyze the kinematics and dynamics of parallel robots.</td><td>C2</td><td>2</td></tr>
<tr><td colspan="2">Apply control strategies to manage the motion and stability of parallel robots.</td><td>C4</td><td>4</td></tr>
<tr><td colspan="2">Identify and understand the key components and systems used in parallel robot, including design and functionality.</td><td>C3</td><td>2</td></tr>
<tr><td>Course Outline</td><td colspan="3">Introduction to parallel robots, basic kinematics of parallel robots, mechanics and dynamics of parallel robots, control strategies, application of parallel robots, overview of cable robots, basic principles of cable robots, mechanical components, actuation and control, kinematics and dynamics of cable robots, application of cable robots.</td></tr>
<tr><td rowspan="2">Resources</td><td colspan="3">Textbook:
Cable-Driven Parallel Robot by Andreas Pott.J. (2018). Springer. ISBN: 978-3-319-76137-4.</td></tr>
<tr><td colspan="3">Reference Books:
Cable-Driven Parallel Robots: Theory and Applications" by Marco Ceccarelli and Victor A. Glazunov).
Robotics: Modelling, Planning and Control by Bruno Siciliano, Lorenzo Sciavicco (2009).</td></tr>
</table>

Benchmarking of BS ES, Geophysics, RS&GIS Program Courses

Comparison of Degree Program Courses - BS Environmental Sciences

University Symbol: University Name QS: World University Rankings by Subject 2024
UB: University of Birmingham: 100
US: University of Toronto: 21
UOB: University of Bristol: 92
WUR: Wageningen University and Research: 02
MSU: Michigan State University: 55

Bahria University		**International Universities**					**Similarity**	**Content**
	Core / Elective	**UB**	**US**	**UOB**	**WUR**	**MSU**	**(%)**	**To Add**
Course Title – 1	**C / E**							
Introduction To Environmental Sciences	Core	Yes	Yes	No	Yes	Yes	90	Ecological Biomes
Chemistry	Core	Yes	No	Yes	Yes	Yes	80	Organic and Inorganic Compounds, Solubility of compounds
Environmental Statistics	Core	Yes	Yes	Yes	Yes	Yes	85	Application of Environmental Statistical Tool
Fundamentals Of Geography & Geomorphology	Core	Yes	Yes	Yes	No	Yes	75	
Environmental Issues	Core	No	Yes	Yes	Yes	Yes	80	Emerging Issues in Environment (Microplastics, Smog, Particulate Matter, E-Waste, Energy Crisis), Sustainable Solutions
Environmental Biology	Core	Yes	No	Yes	Yes		80	Microorganisms
Environmental Chemistry	Core	Yes	Yes	No	Yes	Yes	80	Fundamentals of Aquatic, Atmospheric and Soil Chemistry, Photochemical Reactions, Environmental Impact of Various Industries
Fundamentals of Ecology	Core	Yes	Yes	Yes	Yes	Yes	85	Biomes of the World
Social Theory Of Environment	Core	Yes	Yes	Yes	No	Yes	70	Environmental Ethics
Environmental Microbiology	Core	Yes		Yes	Yes	Yes	85	Microbial Genetics, Microbial Interactions, Role Of Microbes In Environment/Industry, Biological Warfare Agents
Environmental Monitoring	Core	No	Yes	Yes	Yes	Yes	75	Regulatory Purpose for NEQs Compliance, EIA Requirements, NOC for Plant Operations
Applications of Information and Communication Technologies	Core	No	No	Yes	No	No	25	Remarks: Not covered in one course rather in multiple courses
Environmental Management System	Core	Yes	Yes	No	No	Yes	70	

Introduction To Climate Change	Core	Yes	Yes	Yes	Yes	No	90	Information Related to Climate Adaptation Approaches
Environmental Toxicology	Core	Yes	No	Yes	Yes	No	80	Fate of absorbed Toxins and Xenobiotics, Detoxification and Bioactivation
Environmental Biotechnology	Core	No	Yes	Yes	Yes	No	75	Tools of Environmental Biotechnology, Recombinant DNA Technology, Environmental Applications of GMOs, Biosafety
Environmental & Natural Resource Economics	Core	Yes	Yes	Yes	Yes	Yes	80	Circular Economy, Green Financing
Environmental Hazard & Management	Core	Yes	No	Yes	No	Yes	80	
Environmental Engineering	Core	Yes	Yes	No	No	Yes	75	Drinking Water, Wastewater and Stormwater Treatment, Treatment Plants Layout and Design, Sustainability and Engineering Solutions to Environmental Problems
Analytical Techniques in Environmental Sciences	Core	No	Yes	Yes	Yes	Yes	85	Quality Assurance in Environmental Science Laboratory
Environmental Geology	Core	Yes	Yes	Yes	No	No	75	
Solid Waste Management	Core		Yes	Yes	No	Yes	65	Recent Technologies Used For Solid Waste Management, Resources and Financial Evaluation Of Waste Management
Natural Resource Management	Core	Yes	No	Yes	No	Yes	75	Life Cycle Assessment (LCA) of Resources
Natural Disaster Management	Core	Yes	No	Yes	No	No	70	Proactive Approach to Address Disaster Impacts
Environmental Sciences Field Work	Core	No	Yes	No	Yes	Yes	85	
Environmental Impact Assessment	Core	Yes	No	Yes	No	Yes	75	Methods and Techniques for Impact Prediction and Evaluation. Integration during Project Life Cycle, EIA Review and Post Project Analysis
Research Methods in Environmental Sciences	Core	Yes	No	Yes	Yes	Yes	80	
Hydrogeology	Core	Yes	Yes	Yes	No	No	80	
GIS & Remote Sensing	Core	Yes	Yes	Yes	Yes	Yes	80	
Energy And Environment	Core	No	No	Yes	Yes	Yes	70	Geothermal Energy (Shallow and Deep)
Environmental Policies & Laws	Core	Yes	No	No	Yes	Yes	70	Environmental Justice
Occupational Health & Safety	Core	No	Yes	Yes	No	Yes	75	Health and Safety Problems Worldwide, Importance of Management and Training in OHS Engineering & Administrative Controls, Cumulative Trauma Disorder (CTD)

Urban Environmental Management	Elective	Yes	Yes	Yes	No	Yes	70	
Biodiversity & Conservation	Elective	Yes	Yes	No	Yes	No	70	
Soil and Environment	Elective	Yes	No	Yes	Yes	Yes	75	
Health Safety & Environment	Elective	No	Yes	No	No	Yes	70	
Pollution Control Technology	Elective	Yes	Yes	No	Yes	Yes	75	Low-cost water treatment and Sanitation Techniques, Cleaner Production Techniques
Water Resources Management	Elective	Yes	Yes	No	No	No	60	Water Supply and Demand Management Measures, Improving Water Productivity
Public Health and Environment	Elective	Yes	No	Yes	Yes	No	70	
Air & Noise Pollution	Elective	Yes	No	No	Yes	No	65	The Regulatory Control of Air Pollution; Modern Techniques of control

***** Similarity Score: By comparing the title & contents of the course with other university's courses determine the percentage of similarity.

Proposed list of new Electives Courses for BSES program

International Universities							
	Core / Elective	**UB**	**US**	**UOB**	**WUR**	**MSU**	**Brief Content / Tools**
Course Title– 1 Environmental Data Science and Analytics	Elective	Yes	Yes	Yes	Yes	No	This course covers fundamental principles of data science, exploring various data types, storage methods, and preprocessing techniques such as transformation, reduction, and discretization. Students will learn problem-solving strategies in data science, including the application of 3D modeling for spatial analysis, integration of sensor data for real-time monitoring, and web scraping for large-scale data collection. The course also introduces virtual reality applications for data visualization and advanced machine learning techniques, including decision trees and neural networks, for predictive analytics. Emphasis is placed on practical applications in analyzing patterns, trends, and environmental processes to support data-driven decision-making and policy development.
Course Title– 2 Introduction to Environmental Modeling	Elective	No	Yes	No	Yes	Yes	This course provides an overview of modeling techniques used to analyze and predict environmental systems. Topics include mathematical modeling, simulation techniques, and data-driven approaches for studying

							natural and human-influenced processes. Students will explore deterministic and stochastic models, system dynamics, and geospatial modeling. Key applications include climate modeling, pollution dispersion, hydrological modeling, and ecosystem dynamics. Hands-on exercises using computational tools like MATLAB, Python, or R will enhance analytical skills. The course also covers model validation, uncertainty analysis, and policy implications. By the end, students will be able to develop and apply models for environmental assessment and decision-making.

BS REMOTE SENSING & GIS

University Symbol: University Name: World University Rankings by Subject 2024

MIT: Massachusetts Institute of Technology: 01
EZ: ETH Zurich: 07
WU: Wuhan University: 194
UMC: University of Maryland - College Park: 218
UCB: University of Colorado Boulder: 320

Comparison of Degree Program Courses

Bahria University		**International Universities**					**Similarity**	**Content**
Course Title	**Core / Elective**	**WU**	**UMC**	**MIT**	**UCB**	**EZ**	**(%)**	**To add**
Fundamental of GIS & Lab	Core	No	Yes	Yes	Yes	NO	85%	Nil
Physical Geography & Lab	Core	Yes	No	Yes	No	Yes	60%	Streams and Fluvial Landforms, Temperature & Heat Budget
Fundamental of Earth Sciences & Lab	Core	No	Yes	Yes	Yes	NO	70%	Metal Deposits, Industrial Materials, Fossil Fuels, Climate Change, Populations and Resources
Introduction to Remote sensing	Core	Yes	No	Yes	No	Yes	75%	Image Enhancements, Image Classification, Future of Remote Sensing
Introduction to Cartography & Lab	Core	No	Yes	Yes	Yes	NO	70%	Proportional Symbol and Dot Mapping
GPS & Surveying & Lab	Core	No	Yes	No	Yes	NO	65%	Technological developments leading to GNSS, GNSS Constellation as control points
Human Geography	Core	No	Yes	Yes	No	Yes	65%	Social Justice and the City
Introduction to Photogrammetry	Core	No	Yes	Yes	Yes	NO	55%	Stereoscopy and Parallax: Stereoscopic depth perception, Stereoscopes and their use, Parallax, and parallax measurement
Multidisciplinary Applications of GIS & RS & Lab	Core	Yes	No	Yes	No	Yes	65%	Unmanned Aerial Vehicle Application and Processing
Database Management System & Lab	Core	No	Yes	Yes	Yes	NO	60%	Functional Dependencies and Normalization
Active Remote Sensing & Space Law	Core	Yes	No	Yes	No	Yes	65%	National Space Legislations
Spatial Decision Support Systems	Core	Yes	Yes	Yes	Yes	No	50%	Introduction to Multiple Criteria Decision Analysis
Microwave & Hyper Spectral RS & Lab	Core	Yes	Yes	Yes	Yes	No	75%	Unsupervised & Fuzzy Classification
Computing with MATLAB & Lab	Core	Yes	No	Yes	No	Yes	70%	Nil
Integrated Geospatial Technologies & Lab	Core	No	Yes	Yes	Yes	NO	85%	Geospatial Monitoring of Engineering Structures and Geodynamic Processes

Spatial Data Infrastructure & Visualization	Core	Yes	Yes	Yes	Yes	No	75%	Spatial Modeling and Applications
Web GIS	Core	No	Yes	Yes	Yes	No	65%	Nil
Geodesy	Core	Yes	No	Yes	No	Yes	55%	Interferometric Synthetic Aperture Radar (InSAR)
Satellite Navigation System	Core	Yes	No	Yes	No	No	60%	Integrity and integer ambiguity resolution
Spatial Data Analysis	Core	Yes	Yes	Yes	Yes	Yes	70%	Spatial statistics, assumptions and how they are used to characterize spatial patterns and processes.
Geospatial Field Work and Report-I	Core	Yes	No	No	Yes	Yes	75%	Nil
GIS for Disaster Management	Core	No	Yes	Yes	Yes	No	70%	Post-Disaster Damage Assessment and Recovery
Geospatial Techniques	Core	No	Yes	Yes	Yes	No	85%	Future of Geospatial Technologies
Occupational Health & Safety	Core	No	Yes	Yes	Yes	No	60%	Nil
Computer Aided Drafting/Drawing & Lab	Core	No	Yes	Yes	Yes	No	65%	Architectural Drafting
Legal and Social Issues in Geospatial Sciences	Core	Yes	No	No	Yes	Yes	70%	GIS Applications in Landscape Architecture and Environmental Planning
GIS Programming & Python & Lab	Core	No	Yes	No	Yes	No	70%	Nil

Proposed list of new Elective Courses for BS GIS & Remote Sensing

Proposed Course	**Core / Elective**	**WU**	**UMC**	**MIT**	**UCB**	**EZ**	**Brief Content / Tools**
Course Title – 1 Computer Vision to Geospatial Analytics	Elective	Yes	Yes	Yes	Yes	No	This course explores the integration of computer vision techniques with geospatial analytics for remote sensing and GIS applications. It covers image processing fundamentals, feature extraction, object detection, and deep learning approaches for analyzing satellite and aerial imagery. Students will learn to apply image processing techniques using Python, Pillow, and OpenCV for tasks such as land cover classification, change detection, and object recognition. The course also introduces supervised learning techniques for building image classifiers, enhancing geospatial analysis. Practical exercises focus on automation, pattern recognition, and AI-driven insights for environmental monitoring, disaster management, and urban planning, leveraging LiDAR, hyperspectral, and real-time geospatial data.
Course Title – 2 Remote Sensing based Geographical monitoring	Elective	No	Yes	Yes	Yes	Yes	This course focuses on remote sensing techniques for geographical monitoring, with applications in hydrology and glaciology. It covers advanced remote sensing and GIS methods for analyzing water resources, glacier dynamics, and climate change impacts. Key topics include hydrological

							and glaciological terminologies, glacier morphology, mass balance, and meteorology. Students will explore snow and glacier mapping techniques using satellite datasets for monitoring water resources and environmental changes. The course emphasizes real-world applications, including climate change assessment, flood prediction, and water resource management in Pakistan. Hands-on exercises using GIS and remote sensing tools will enhance analytical skills for geospatial decision-making.

BS GEOPHYSICS

University Symbol: University Name: QS World University Rankings by Subject 2024
SU: Stanford University: 9
UOC: University of California, Berkeley (UCB): 5
OU: Oxford University: 3
HU: Harvard University: 2
ICL: Imperial College London: 34
Source: https://www.topuniversities.com/university-subject-rankings/geophysics

Bahria University		**International Universities**					**Similarity**	**Content**
Course Title	**Core / Elective**	**SU**	**UOC**	**OU**	**HU**	**ICL**	**(%)**	**To add**
Physical & General Geology	Core	Yes	Yes	No	Yes	Yes	75%	Energy and mineral resources, including origin, uses, and environmental consequences.
Introduction to Geophysics	Core	Yes	Yes	No	Yes	NO	70%	Operating geophysical equipment and analysing data collected using a wide array of geophysical techniques.
Field Geology & Lab	Core	Yes	Yes	Yes	Yes	NO	80%	Practical Semi-Independent Field And Geological Mapping
Fundamental of Geography & Geomorphology	Core	No	Yes	Yes	Yes	NO	70%	Periglacial processes and landforms
Structural Geology & Lab	Core	No	Yes	Yes	Yes	NO	75%	Kinematic analysis, paleostress and folding, microscale deformation
Mineralogy & Crystallography & Lab	Core	No	Yes	No	Yes	NO	65%	Introduction to Thermodynamics
Geostatistics	Core	No	Yes	Yes	No	Yes	75%	Nil
Gravity & Magnetic Exploration Techniques	Core	Yes	Yes	Yes	Yes	Yes	85%	Gravity And Magnetic Responses To 3D Variation In Density And Magnetization Of Rocks
Sedimentology	Core	Yes	No	Yes	Yes	Yes	85%	Genetic stratigraphy
Geotectonics	Core	Yes	No	Yes	No	Yes	70%	Isotope Dating
Earthquake Seismology	Core	Yes	No	Yes	Yes	No	75%	Anistropy Analysis
Rock Physics	Core	Yes	Yes	Yes	Yes	No	80%	Fluid And Lithology Substitution During Prospect Evaluation
Petroleum Geology	Core	Yes	Yes	Yes	Yes	No	85%	Play Fairway Analysis and Risk Assessment
Stratigraphy of Pakistan	Core	Yes	No	Yes	Yes	No	80%	Nil
Environmental Geophysics	Core	Yes	Yes	No	Yes	No	75%	Radar data acquisition, processing, interpretation and field applications
Computing with Matlab	Core	Yes	Yes	Yes	Yes	No	85%	Nil
Electrical & Radioactive Exploration Techniques	Core	No	Yes	Yes	Yes	No	75%	Transient Electro-Magnetic method

Wireline Logging & Lab	Core	Yes	Yes	Yes	Yes	Yes	90%	Laboratory Petrophysics application, borehole Logging design
Geological & Geophysical Field Work and Report	Core	Yes	No	Yes	No	Yes	65%	Nil
Seismic Data Processing	Core	Yes	Yes	Yes	Yes	Yes	70%	Software based learning and contents needs to be added
GIS & Remote Sensing & Lab	Core	Yes	No	No	Yes	Yes	75%	Nil
Seismic Stratigraphy	Core	Yes	Yes	Yes	Yes	No	80%	Techniques applicable to regional and field scale Analysis in G&G Industry.
Seismic Data Interpretation	Core	Yes	Yes	Yes	Yes	Yes	85%	Nil
Geophysical Software	Core	Yes	Yes	Yes	Yes	Yes	80%	Nil
Mining Geophysics	Core	No	Yes	Yes	Yes	No	70%	Practical experience in collecting, processing and interpreting geophysical data sets and how those data sets can be used for ore deposit exploration and characterization
Seismic Data Acquisition & Planning	Core	No	Yes	Yes	Yes	No	85%	Nil

***** Similarity Score: By comparing the title & contents of the course with other university's courses determine the percentage of similarity.

Proposed list of Elective Courses for BS Geophysics

International Universities							
	Core / Elective	**SU**	**UOC**	**OU**	**HU**	**ICL**	**Brief Content / Tools**
Course Title – 1 Applications of Geoscience Software	Elective	Yes	No	Yes	Yes	No	Overview of software functionalities, Setting up a project, Data import and management, Importing well data, seismic data, and other geological data, Creating and editing geological maps, Quality control techniques for data visualization, Basic concepts of 3D structural modeling, Creating and editing geometrical properties, Configuring geometrical modeling methods, Picking horizons in the time domain, Applying seismic attributes, Converting horizons to depth using well data, Creating simple surfaces and grids, Advanced mapping techniques, Plotting and printing scaled plots, Real-world projects and case studies, Integrated geological and geophysical modeling, Final evaluation and conclusions, Fundamentals of petrophysics, Reservoir simulations and modeling, Property modeling and analysis
Course Title – 2 Shallow Surface Geophysics	Elective	Yes	Yes	Yes	No	Yes	Introduction to engineering geophysics & geology, role of engineering geoscientist in a project, introduction to civil engineering projects, soil analysis and ground models, site investigations, role of geophysics in site investigation, sub-surface investigation, Environmental hazards, seismicity and code designing, laboratory tests, geotechnical parameters, types of foundations,

							tunnels and caverns, tunnel support, underground mining, deterministic and probabilistic approaches in landslide hazard assessment, back analysis of slope failures, linear and nonlinear failure envelopes in slope stability analysis, seismic aspects of slope stability, earthquake-induced catastrophic landslides in liquefiable soils, rainfall-induced shallow landslides on steep slopes, field instrumentation

Appendage 3706

Benchmarking of BSE Program

University Symbol	University Name	QS World University Rankings by Subject 2024
NUS	**National University of Singapore (NUS) Singapore, Singapore** BTech (Software Engineering)	**6**
TU	**Tsinghua University, Beijing, China (Mainland)** Bachelor in Software Engineering	**11**
UWS	**University of Washington, Seattle, United States** Bachelor of Science in Computer Science & Software Engineering	**18**
UW	**University of Waterloo, Waterloo, Canada** Bachelor of Software Engineering	**21**
UOS	**The University of Sydney, Sydney, Australia** BE Hons. Software Engineering	**43**
UNSW	**University of New South Wales (UNSW Sydney)** Bachelor of Engineering (Honors) - BE (Hons) in Software Engineering	**59**
UA	**University of Auckland** Bachelor of Engineering (Honors) - BE (Hons) in Software Engineering	**99**
UO	**University of Ottawa** BASc Software Engineering	**201**

Comparison of Degree Program Courses

Bahria University		International Universities					Similarity	Content
Degree Program Courses	**Core / Elective**	**UNSW**	**OU**	**UA**	**UW**	**US**	**≥80%**	**To add**
Computing Fundamentals	C	N	Y	Y	N	Y	Y	Nil
Applied Calculus & Analytical Geometry	C	Y	Y	Y	Y	Y	Y	Nil
Computer Programming	C	N	Y	Y	Y	Y	Y	Nil
Discrete Mathematics	C	Y	Y	N	Y	Y	Y	Nil
Introduction to Software Engineering	C	Y	Y	Y	Y	Y	Y	Nil
Object Oriented Programming	C	Y	Y	Y	N	Y	Y	Nil
Digital Design	C	N	Y	N	Y	Y	Y	Introducing FPGA-based design and HDL coding
Data Structures & Algorithms	C	Y	Y	Y	Y	Y	Y	Nil
Software Requirement Engineering	C	Y	Y	N	Y	N	Y	Include user experience (UX) principles.
Human Computer Interaction	C	Y	N	Y	N	N	N	Integrate AI-driven UI/UX design techniques.
Operating Systems	C	Y	Y	Y	Y	Y	Y	Nil
Probability & Statistics	C	Y	Y	N	N	Y	Y	Nil
Database Management Systems	C	Y	Y	Y	Y	N	Y	Nil
Software Design & Architecture	C	Y	Y	Y	Y	Y	Y	Nil
Data Communication & Networking	C	Y	Y	Y	N	Y	Y	Nil
Software Construction	C	Y	Y	Y	N	Y	Y	Add AI-based testing and automation.
Web Engineering	C	Y	N	N	N	Y	N	Nil
Software Quality Engineering	C	Y	Y	Y	Y	Y	Y	Nil
Information Security	C	Y	N	Y	N	Y	Y	Nil
Software Project Management	C	Y	Y	Y	Y	Y	Y	Add legacy system modernization techniques
Engineering Ethics	C	Y	N		N	N	N	Nil
Software Re-Engineering	C	N	N	Y	N	N	N	Nil
Business Process Automation	E	N	N	N	N	N	N	Nil
System Programming	E	N	N	N	N	N	N	Integrate AI-powered robotics and automation.
Formal Methods in Software Engineering	E	N	N	Y	N	N	N	Nil
Robotics	E	Y	N	Y	Y	N	Y	Nil

Fault Tolerant Systems	E	N	N	N	N	N	N	Nil
Real Time Systems	E	N	Y	N	N	N	N	Nil
Introduction to Bioinformatics	E	N	N	N	N	N	N	Nil
Design and Analysis of Algorithms	E	Y	Y	N	N	Y	Y	Nil
Computer Architecture & Organization	E	Y	Y	Y	N	N	Y	Nil
Microprocessors & Interfacing	E	N	N		N	N	N	Nil
Basic Electronics	E	N	N	Y	N	Y	N	Nil
Information Theory	E	N	N	N	N	N	N	Nil
Visual Programming	E	N	N	N	N	N	N	Nil
Software Applications for Mobile Devices	E	N	N	N	N	N	N	Nil
Principles of Programming Languages	E	N	N	N	N	N	N	Nil
Game Application Development	E	Y	N	N	N	N	N	Update with emerging languages like Rust and Julia.
Semantic Web	E	N	N	N	N	N	N	Nil
Software Metrics & Estimation	E	N	N	N	N	N	N	Nil
Software Engineering Economics	E	N	N	N	N	N	N	Nil
Mathematical Tools for Software Engineering	E	N	N	N	N	N	N	Expand with cost-benefit analysis for cloud services.
Design Pattern	E	N	N	N	N	N	N	Nil
Agile Development	E	N	N	N	N	Y	N	Nil
Usability Engineering	E	N	N	N	N	Y	N	Nil
Artificial Intelligence	E	N	N	N	N	Y	N	Nil
Introduction to Soft Computing	E	N	N	N	N	N	N	Nil
Natural Language Processing	E	Y	N	N	N	Y	N	Nil
Agent Based Computing	E	N	N	N	N	N	N	Nil
Mobile and Pervasive Computing	E	Y	N	N	N	Y	N	Nil
Cloud Computing	E	N	Y	N	N	Y	N	Include edge computing and IoT integration.
Distributed Computing	E	Y	N	N	N	Y	N	Nil
Data Encryption & Security	E	Y	N	N	N	N	N	Nil
IoT Application Development	E	Y	N	N	N	Y	N	Nil
Data Mining	E	Y	N	N	N	N	N	Expand with deep learning-based data mining techniques.
Data Warehousing	E	N	N	N	N	N	N	Enhance with cloud-based data warehousing solutions.
Introduction to Data Science	E	N	N	N	N	N	N	Nil

Big Data Analytics	E	Y	N	N	N	N	N	Nil
Management Information Systems	E	Y	Y	N	N	Y	N	Include real-time big data processing with Apache Spark.
Advanced Database Management Systems	E	Y	N	N	N	N	N	Introduce sharding and blockchain-based databases.
Knowledge Based Management Systems	E	Y	N	N	N	N	N	Nil
Information System Audit	E	N	N	N	N	N	N	Nil
Distributed Database Systems	E	N	N	N	N	N	N	Nil
Computer Graphics	E	Y	N	Y	N	Y	N	Nil
Digital Animation	E	N	N	N	N	N	N	Nil
Digital Image Processing	E	N	N	Y	N	N	N	Nil
Computer Vision	E	Y	N	N	N	N	N	Enhancing deep learning-based image processing
Multimedia Systems	E	N	N	N	N	Y	N	Nil

Proposed list of new elective courses

1. Software Engineering for Web Applications.
   - Offered in MIT, QS Ranking = 1
2. Software Process and Project Management.
   - Offered in MIT, QS Ranking = 1
3. Introduction to Deep Learning.
   - Offered in Imperial Collage London, QS Ranking = 2
4. Multicore Programming.
   - Offered in MIT, QS Ranking = 1
5. Quantum Computing.
   - Offered in MIT, QS Ranking = 1

Course Title:	**Software Engineering for Web Applications**
Course Code:	
Pre-Requisites:	Web Engineering, Software Requirement Engineering
Credit Hours Theory:	3
Credit Hours Lab (If Applicable):	NIL
Course Objectives:	The objective is to give students some experience in dealing with those challenges that are unique to Internet applications like concurrency, unpredictable load, security risks, opportunity for wide-area distributed computing, and user demands for a multi-modal interface.

Course Learning Outcomes:

CLOs	Description	Mapped PLO	BT Level
CLO 1	Students will be able to identify and address the unique challenges associated with Internet applications, such as concurrency, unpredictable loads, security risks, and wide-area distributed computing.	PLO2 (Problem Analysis)	4

CLO 2	Students will demonstrate the ability to design, implement, and optimize scalable and efficient web applications using software engineering principles and modern web technologies.	PLO3 (Design/Dev of Solutions)	6

Contents (Catalog Description):	This is a course for students who already have some programming and software engineering experience. The objective is to give students some experience in dealing with those challenges that are unique to Internet applications: concurrency, unpredictable load, Security risks, Opportunity for wide-area distributed computing, and user demands for a multi-modal interface. The bottom line: a student who has finished this course should be able to build amazon.com, eBay, or photo.net by him or herself.
Recommended Textbooks:	1. Andersson, E., P. Greenspun, and A. Grumet. Software Engineering for Internet Applications. 2. Greenspun, P. SQL for Web Nerds.
Reference Books:	3. "Designing with Web Standards" by Jeffrey Zeldman - A guide to building standards-compliant websites that work across different browsers and devices 4. "Patterns of Enterprise Application Architecture" by Martin Fowler - This book provides patterns for designing complex enterprise applications. 5. "Clean Code: A Handbook of Agile Software Craftsmanship" by Robert C. Martin - This book focuses on principles and practices for writing clean, maintainable code. 6. "Web Development with Node and Express" by Ethan Brown - Focuses on building web applications using Node.jsand Express. 7. "Design Patterns: Elements of Reusable Object-Oriented Software" by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides - A classic book on design patterns that are essential for software architecture. 8. "Code Complete: A Practical Handbook of Software Construction" by Steve McConnell - A comprehensive guide to software construction with practical advice and best practices
General Instructions for students:	There is 0 tolerance for plagiarism. You must meet all deadlines and there will be penalties for missing the deadlines. No makeup tests/quizzes will be arranged under normal circumstances. 75% attendance is mandatory. Latecomers will be marked as absent. All assignments must be handed in the required format.

Sixteen Week Lesson Plan	Week	Topics Covered
	1	Recap of fundamental software engineering principles Overview of advanced concepts in software engineering Introduction to the unique challenges of Internet applications
	2	Advanced techniques in requirements gathering and analysis Modeling complex user requirements Use of tools for advanced requirement management
	3	Modern web application architectures (Single Page Applications, Progressive Web Apps). Microservices and their benefits. Designing for scalability and maintainability
	4	Techniques for managing concurrent users and requests. Load balancing and auto-scaling. Performance tuning and optimization.
	5	In-depth study of frontend frameworks (React, Angular, Vue). State management and performance optimization. Advanced topics in responsive design and accessibility.
	6	Server-side programming best practices. Optimizing backend performance. Building robust and scalable RESTful APIs. Implementing GraphQL
	7	Advanced web application security principles. Secure coding practices. Protecting against common vulnerabilities (OWASP Top Ten).
	8	Security testing and ethical hacking.
	9	**Midterm EXAMINATIONS**
	10	Fundamentals of distributed computing.
	11	Designing and managing distributed systems. Cloud services and platforms (AWS, Azure, Google Cloud). Data consistency and replication strategies.
	12	Integrating voice, text, and touch interfaces.
	13	Designing user experience for multi-modal applications. Usability testing for multi-modal interfaces. Accessibility considerations.
	14	Advanced data modeling techniques.
	15	Performance optimization for large-scale databases. Handling distributed databases. NoSQL and NewSQL databases.
	16	Advanced testing methodologies. Automated and manual testing strategies. Performance and stress testing. Ensuring reliability and quality in complex applications
	17	Review Week
	18	**FINAL EXAMINATIONS**

Multicore Programming	
Course Title:	Multicore Programming
Course Code:	
Pr-Requisites:	Data Structures & Algorithms
Credit Hours Theory:	3
Credit Hours Lab:	0
Course Objectives:	This course introduces the students to the programming for multicore systems for high performance software solutions.
Contents (Catalog Description):	This course introduces students to the world of software development for multicore systems to exploit the concurrency for improved system performance. Important topics included are introduction to multicore and multiprocessor architectures, principles related to mutual exclusion, concurrent objects and shared memory, threads and its various types, parallel data structures, Distributed memory programming (MPI & OpenMPI) and programming GPUs.
Recommended Text Books:	Gerassimos Barlas, "Multicore and GPU Programming: An Integrated Approach", 2nd Ed, Morgan Kaufan Publisher, 2023.
Reference Books:	Maurice Herlihy, Nir Shavit, Victor Luchangco, Michael Spear, "The Art of Multiprocessor Programming", Morgan Kaufan Publisher
General Instructions for students:	There is 0 tolerance for plagiarism. Attendance is mandatory. You must meet all deadlines and there will be penalties for missing the deadlines. Students are required

	to take all the tests/quizzes. No makeup tests/quizzes will be arranged under normal circumstances. 75% attendance is mandatory. Latecomers will be marked as absent. All assignments must be handed in in the required format and late submissions will not be entertained.

	Course: Software Process and Project Management		
Course Objectives:	This course aims to give students an understanding of the principles, processes, and practices associated with managing software-intensive projects. This course is designed to equip and prepare the students to work in the software industry on software development projects such that they have an insight into specific knowledge of the application domain, project management domain, and software engineering practices at the same time		
CLOs	**Description**	**Mapped PLO**	**BT Level**
CLO 1	Explain key principles of project management, knowledge areas, lifecycles, work breakdown structures, and process groups	PLO11	C2
CLO 2	Apply project management techniques for IT projects to initiate, plan, execute and close software projects	PLO11	C3
CLO 3	Evaluate IT projects using monitor and control project management techniques for successful completion of IT projects while working individually or in teams.	PLO9	C6
Course Outline	Software Process Maturity Software maturity Framework, Principles of Software Process Change, Software Process Assessment, The Initial Process, The Repeatable Process, The Defined Process, The Managed Process, The Optimizing Process. Process Reference Models Capability Maturity Model (CMM), CMMI, PCMM, PSP, TSP). Workflows and Checkpoints of process Software process workflows, Iteration workflows, Major milestones, minor milestones, periodic status assessments. Process Planning Work breakdown structures, Planning guidelines, cost and schedule estimating process, iteration planning process, Pragmatic planning. Project Organizations Line-of-business organizations, project organizations, evolution of organizations, process automation. Project Control and process instrumentation The seven-core metrics, management indicators, quality indicators, life-cycle expectations, Pragmatic software metrics, metrics automation. Introduction to project management, Introduction to software crisis for motivation, Basic software project management concepts, Software Lifecycle processes and models, Waterfall model, Spiral model, Incremental delivery model, Agile Methods and basics of SCRUM. Knowledge areas and process groups, Knowledge areas, Process groups, Project scope management, Project initiation and project planning, Project charter development, Project management plan and project plan, Project planning basics,, Difference between planning, estimating and scheduling, Work breakdown structure development, Project Proposal / Bid documents, Project Schedule development, Scheduling activities, CPM and PERT, Budgeting activities, Software Estimation, Core concepts regarding software cost and effort estimation, Software Size estimation through Function points, Object points, use-case points, and algorithmic methods, Software Project monitoring and control, Project Control, Earned value analysis, Project Risk Management, Schedule development: Fast tracking vs. Crashing, Budget development and control, HR and Contract Management, Software Quality Assurance and reviews, Software configuration management, Change Management, SCM activities and planning, Software Project Selection management, Project selection methods, Project closure, Software Project Management using SCRUM, SCRUM processes and practices, PRINCE2 processes and practices, Process improvement with standards, Comparison of PRINCE2 and PMIt-Generation software Economics, Modern Process Transitions.		

Recommended Books	Introduction to Software Project Management by Adolfo Vilafiorita, CRC Press available at http://portal.belesparadisecollege.edu.et:8080/library/bitstream/123456789/2658/1/137%20%281%29.pdfA guide to Information Technology Project Management by Jack T. Marchewka, Wiley Press, available at https://ugcollege.ge/storage/books/ June2021/rDuZFLMTq8TPMzG8ebzi.pdf The SCRUM Framework, International Scrum Institute, available at https://www.scrum-institute.org/contents/The_Scrum_Framework_by_International_Scrum_Institute.pdf

Introduction to Deep Learning			
Course Objective	This course aims to familiarize students with the concepts of Deep Learning and Neural Network and the processing going on within each layer Make students confident that they can solve machine learning problems, through the use of deep features		
CLOs	Description	Mapped PLO	BT Level
CLO 1	Outline key principles of data driven problem solving paradigm	PLO11	C1
CLO 2	Apply basic theory and applications of Deep Learning	PLO11	C3
Outline / Content	Overview – Brain – Neuron - Hubel & Wiesel, 1959 What is Learning? What is Machine Learning Historical Context Shallow Feature Learning What is Classification? Shallow vs. Hierarchical vs. Deep Features (ML vs. DL) What is Regression – Line fitting? The Neuron – Biologically Perceptron Linear Perceptron as Neuron Logistic Regression The Fast-Food Problem (Hinton / Buduma) Gradient Descent - Intuition The Delta Rules and Learning Rules Handout: MSE with Sigmoid, cross entropy + sig, MSE + Softmax, cross entropy + softmax Gradient Descent with Sigmoid Neurons More Derivative Examples (Ng) Computation Graph Derivatives with a Computation Graph Multi-layer Perceptron Gradient Descent The Back Propagation Algorithm Stochastic and Minibatch Gradient Descent Test Set, Validation Set, Overfitting Regularization Hyper parameter tuning Data Augmentation Vanishing/Exploding Gradients Weight/Initialization Methods, Activation Functions Softmax Optimization Algos Gradient Descent with momentum Learning rate adaptation (AdaGrad, RMSProp, Adam) ConvoluKon-1D ConvoluKon-2D Convolution-Filters (Edge detection) Forward and Backward Propagation using Convolution operation Transforming Multilayer Perceptron to Convolutional Neural Network Texture Classification Example + Filter Banks (Dr. Mohsen) A toy ConvNet: X's and O's Eg. (Brandon Rohrer)/ Full Arch Description on ConvNet Feature Maps Pooling, FC, Batch Normalization etc Closing the loop on MNIST with ConvNet Accelerating training with batch normalization Multi-Class Learning - Building a ConvNet for CIFAR-10 Transfer Learning Classical CNN: Case Studies AlexNet, VGG, GoogleNet, ResNet, ResNet, IncepKon, U-Net Relationship between ConvFilters and Receptive Field Embedding and Representation Learning, Learning Lower-Dimensional Representations Principal Component Analysis Motivating the Auto-encoder Architecture Denoising to Force Robust Representations Sparsity in Autoencoders Stacked Autoencoders CLO-01 Image Segmentation, Instance Segmentation Image Retrieval using Unsupervised/Semi-supervised Learning		

Basic Mathematics for Engineering

Course Title:	Basic Mathematics for Engineering	
Course Code:		
Pre-Requisites:	None	
Credit Hours Theory:	3	
Course Objectives:	The basic objective of the course is to build a strong foundation of the essential mathematical concepts required for engineering studies. This course is designed as an entry level mathematics course for students who have not studied mathematics in their intermediate or HSSC. The course will develop problem-solving skills in different domains of mathematics to ensure a smooth transition to university-level engineering programs.	
Course Learning Outcomes:		

CLOs	Description
CLO 1	Describe knowledge of fundamental concepts of mathematics
CLO 2	Express an understanding of concepts of analytical geometry in mathematics.

Contents (Catalog Description):		
Recommended Textbooks:	1. College Algebra & Trigonometry by Richard W. Beveridge	
Reference Books:	1. Mathematics Made Easier Series (MMES) For High Schools and Colleges by Comfort Amoako-Attah and Xorlali Samuel Mattson 2. Mathematics: A Complete Course with CXC Questions by Raymond Toolsie	

Eight Week Lesson Plan	**Week**	**Topics Covered**
	1	Numbers, order of operations, Sets (Union, Intersection, Complements, Subtraction and Power sets)
	2	Plotting graphs of liner and quadratic equations using graph paper, MS Excel and online tools
	3	Solving simultaneous Equations using substitution, elimination and graphical methods
	4	Gradients, Equation of straight line, distance formula and Mid-point formula
	5	Properties of circles and triangles, Functions with Domain and Range
	6	Mensuration (area of Square, Triable, Rectangle, Trapezium, Circle)
	7	Mensuration (Volume of Cube, Cuboid, Prism, cone, cylinder and pyramid.
	8	Sine and cosine rule to find lengths and angles of oblique triangles Sequences of numbers
	9	EXAMINATIONS

Assessment Plan:

CLOs	**Quizzes**	**Assignments**	**Midterm exam**	**Final exam**	**Overall %**
CLO1	*		*	*	50%
CLO2		*	*	*	50%

Marking Scheme:

Assessment Method	**Marks**
Quizzes	10
Assignments/projects	20
Midterm	20
Final exam	50

Grading Scheme:

Grade	% Marks	Grade Point	Grade	% Marks	Grade Point	Grade	% Marks	Grade Point	Grade	% Marks	Grade Point
A	85 – 100	4.0	B	71 – 74	3.0	C	60 – 63	2.0	D	50-52	1.0
A-	80 – 84	3.67	B-	68 – 70	2.67	C-	57 – 59	1.87	F	Below 50	0
B+	75 – 79	3.33	C+	64 – 67	2.33	D+	53 – 56	1.33	W	Withdraw	