Minutes of the 33rd Meeting of the Board of Studies

Faculty of Engineering and Sciences

held on 14th March 2024 at BUIC H-11

Bahria University Islamabad

Contents

Minutes of the 33rd Meeting of Faculty Board of Studies Engineering Sciences held on 14th March 2024 at BUIC H-11 Campus

Attendance:

BUIC		
Snr. Prof. Dr. Faisal Bashir Hussain	Dean ES	Chair
Snr. Prof. Dr. Shahzad Khalid	Principal BSEAS H-11	Member
Prof. Dr. Arif ur Rehman	HoD (CS) BUIC E-8	Member
Prof. Dr. Moneeb Gohar	HoD (CS) BUIC H-11	Member
Snr. Assoc. Prof. Dr. Said Akbar Khan	HoD(E&ES)	Member
Assoc. Prof. Dr. Junaid Imtiaz	HoD (EE)	Member
Assoc. Prof. Dr. Adeel M Syed	HoD (SE)	Member
BUKC		
Snr. Assoc. Prof. Dr. Sohaib Ahmad	Associate Dean	Member
Snr. Assoc. Prof. Dr. Hina Shakir	HoD (SE)	Member
Assoc. Prof. Dr. Mukesh Kumar Maheshwari	HoD (EE)	Member
Assoc. Prof. Dr. Syed Safdar Ali	HoD (CS)	Member
Assoc. Prof. Dr. Salma Hamza	HoD (E&ES)	Member
Snr. Asst. Prof. Dr. Shoaib Mughal	HoD (CE)	Member
BULC		
Snr. Asst. Prof. Dr. Khawaja Qasim Maqbool	HOD (CS)	Member

Proceedings

Preliminaries

FBoS-ES meeting took place on 14th March 2024, with the quorum complete, the proceedings commenced at 0930 hours, with recitation of the Holy Quran.

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

Item3301: Review of seats allocation for BEE Program from the PEC

Sponsor: HOD EE BUKC, HoD EE BUIC Referral Authority: DBOS

Summary of the Case

In 45th ACM during a discussion on the item 4503 "Launch of BS(CS) and BS(AI) Programs at BSEAS (H-11 Campus)" the advisor academics of HEC commented that since intake in BEE program has a declining trend across all HEIs and suggested to strategize the intake approvals as per the market capacity. As a separate activity, Dean ES was to pursue the review of seats allocation for BEE programs from the PEC. In this regard, EE Departments at BUIC & BUKC deliberated on the necessity of reducing seat allocations and pursuing it with PEC in their DBoS meetings.

Discussion

PEC has allowed admission intake of 160 and 120 per annum to EE Departments of BUIC & BUKC, respectively. HoD EE BUKC gave the following arguments that were strongly supported by his counterpart HoDD EE BUIC.

a. As the world becomes increasingly reliant on technology and innovation, the demand for electrical engineering expertise is expected to remain strong. Specific demand levels may fluctuate regionally and over time based on industry trends and economic factors. The said fluctuations are transient in nature and would subside in due course of time.
b. Lower intakes in the said program does not necessitate any correspondence with PEC to decrease the allocation.
c. PEC has very stringent criteria for change of scope and it might take considerable time to regain current seat allocation if they are decreased.
d. The faculty in EE Departments is in accordance with the held student strength rather than approved student strength and as per PEC requirements.

In addition to HoD's of EE Dept, other members also supported that there is no need to explicitly request PEC for reduction in allocated seats of BEE program.

Decision 3301

Status quo to be maintained. Point dropped.

Item3302: Review of pre-requisites of non-credited courses in BS(SE) Roadmap - Tajweed, Understanding Quran, and Seerah

Sponsor: HOD SE BUKC Referral Authority: DBOS

Summary of the Case

In 45th ACM, non-credited courses of Tajweed, Understanding Quran and Seerah were added in the BSE roadmap as a compulsory degree award prerequisite starting from the Fall 2023 semester. These are eight courses designed for Muslim students, each spanning one semester, with prerequisites linked consecutively up to the 8th semester. Each student requires 75% attendance and a minimum of 50% marks for successful completion. Notably, failure in any of these courses may necessitate an additional semester to clear the backlog.

Discussion

The house had a detailed discussion on the consequences of offering said non-credited courses with too many pre-requisite requirements. As students who fail a course cannot take the next course in the series and it may result in exceeding the time duration of degree program beyond four years. Also, credit transfer students from other universities will find it difficult to complete these courses within the normal degree duration of four years. The house agreed that offering of non-credit courses of Tajweed, Understanding Quran and Seerah should be simplified without many pre-requisites. Since these courses have been introduced in the last ACM and have started with effect from Fall 2023, therefore the changes are relatively new and should be deliberated further before suggesting any changes in all the roadmaps of Engineering Sciences.

Decision 3302

The roadmaps of non-engineering programs approved in the 45th ACM should be studied and possible way forward to be presented in next FBoS for all undergraduate roadmaps by Principals BSEAS BUIC E-8, BUIC H-11, and BUKC.

Item3303: Voluntary Based TA System

Sponsor: HOD SE BUKC Referral Authority: DBoS

Summary of the Case

A large amount of documentation and paperwork is associated with each course and faculty member have carry out LMS uploads, Scanning, OBE sheet preparation, checking of assignments and quizzes, etc. Due to the existing workload, many FMs are not able to focus on other aspects including updating course contents, labs, research, conducting seminars, etc. On the other hand, the current TA system is not effective anymore as it's difficult to find graduates who would be willing to come for an amount of Rs. 20k while having a CGPA >= 3.0. Therefore, voluntary based TA system should be introduced in which letter of appreciation should be given to the Tas.

Discussion

It was agreed that checking of quizzes and assignments should not be carried out by the TAs to ensure fairness and accuracy in grading. However, they can play a role in documentation-based tasks. TAs on honorarium/salary should be inducted as per BU's defined procedure. Departments do involve students in different tasks e.g., during organization of different events, and can be given letter of appreciation based on their contributions.

Decision 3303

The status quo to be maintained. Point dropped.

Item3304: Corrections of Course Codes/Credit hours in the BCE Roadmap

Sponsor: HOD CE BUIC Referral Authority: DBOS

Summary of the Case

- The course code of Robotics as presented in the 45th ACM is CEN-458 with 2+1 credit hours. However, the course code as per the latest course code handbook is CEN-459 for 2+1 credit hours for Robotics course. CEN 458 is in fact the course code of 3+1 credit hours Robotics course which is not part of BCE roadmap.

- As per the current roadmap of BCE approved in 45th ACM, the course code of Circuit Analysis is specified as CEN 121 with 3+1 credit hours. However, the course code of Circuit Analysis with 3+1 credit hours in the updated Common Course Code Book is GSC 115.
- In the current roadmap of BCE as approved in 45th ACM, the credit hours of course Compiler Construction is specified as 3 whereas the credit hours of Compiler Construction should be specified as 2+1 to highlight the presence of Lab component in the course.

Discussion
Relevant changes in course codes of Robotics and Circuit Analysis course along with correction in the credit hours of Compiler Construction should be made in the BCE roadmap approved in the 45th ACM.

Decision 3304
Following changes are approved in the BCE roadmap approved in the 45th ACM.

i. Change of course code from CEN 458 to CEN 459 for Robotics course.
ii. Change of course code from CEN 121 to GSC 115 for Circuit Analysis course.
iii. Credit hours of CSC 323 Compiler Construction course to be corrected from 3 to 2+1.

Item3305: Correction of course codes of two courses: Communication Skills and Technical Writing

Sponsor: HOD CE BUKC Referral Authority: FBOS ES

Summary of the Case
The current roadmap of BCE as of 45th ACM does not contain updated course codes of courses: Communication Skills, Technical Writing. The correct course codes of said courses as per 43rd ACM are ENG 134 Communication Skills and ENG 321 Technical Writing.

Discussion
The course codes should be corrected from HSS 118 to ENG 134 and HSS 321 to ENG 321.

Decision 3305
The following changes in course code are approved in the BCE roadmap as of 45th ACM.

a. ENG 134 Communication Skills instead of HSS 118.
b. ENG 321 Technical Writing instead of HSS 321.

Item3306: Shifting of Computer Architecture & Organization from 5th to 4th semester in BCE program

Sponsor: HOD CE BUKC Referral Authority: DBOS

Summary of the Case
The course Microprocessor & Interfacing is being offered in the 4th semester and, courses of Operating Systems and Computer Architecture & Organization are being offered in the 5th semester in the current roadmap of BCE, as per 45th ACM. Computer architecture & organization serve as a rudiment to the Microprocessor course, and it should be offered before the 5th semester.

Discussion

HoD CE BUKC suggested that Microprocessor & Interfacing (4th semester) should be swapped with the Computer Architecture & Organization course (5th semester). HoD CE BUIC did not agree with the proposed changes and argued that said changes were intentionally made in the last roadmap. There is no dependency of Microprocessor & Interfacing course on the Computer Architecture course. After thorough deliberation both HoDs agreed to maintain the course offering as per existing roadmap of 45th ACM.

Decision 3306
Status quo to be maintained. Point dropped.

Item3307: Modification in the list of electives for the BCE program

Sponsor: HOD CE BUKC Referral Authority: DBOS

Summary of the Case
The CE department at Bahria University offers many courses as electives for the BCE program. There is still room for improvement and some more courses should be included in the list according to new research trends and industrial demand such as Wireless and Mobile Networks and Software Project Management.

Discussion
The house had a detailed discussion on not making any changes to the roadmap after one semester. The suggested courses are not critical, and their alternatives (e.g., Engineering Project Management) already exist in the roadmap.

Decision 3307
Status quo to be maintained. Point dropped.

Item3308: Clarity in PEO of BSIT

Sponsor: HOD CS BUKC Referral Authority: DBOS

Summary of the Case
During the Mock Audit of CS department BUKC, it has been suggested that the Graduate Attribute regarding "Lifelong Learning" should be mapped with the PEOs of BS (IT) on the highest priority. The approved PEOs in 43rd ACM are as follows:
PEO 1: Apply principle and practices of information technology and computing knowledge to solve challenging problems in relevant profession.
PEO 2: Demonstrate the ability to use modern tools learnt during degree Program to design and develop effective solutions.
PEO 3: Exhibit managerial capabilities with ethical and moral values.

The mentioned "lifelong learning" was mapped with PEO 2 in 43rd ACM.

Discussion
HoD CS BUIC commented that the ability to use modern tools is lifelong learning and is already covered under PEO 2 of the BSIT program which were approved in 43rd ACM. PEOs reflect the educational outcomes of the program and should be modified with strong rational along with feedback from

industry or indirect assessment (graduate survey etc). Modifying changes to PEO at this point is not suitable.

Decision 3308
Status quo to be maintained. Point dropped.

Item3309: Revision of BS(AI) PEOs

Sponsor: HOD CS BUKC Referral Authority: DBoS

Summary of the Case
In CS and IT programs, 3 PEOs are designed and approved. However, in AI program four PEOs used. In order to maintain the uniformity in all computing programs and to efficiently manage the OBE documentation, it has been suggested that the BSAI PEO-4 should be merged with PEO-2.

PEO-1: Utilize knowledge to solve real-world problems by applying theory, principles, and methods of computing in general and artificial intelligence in particular.
PEO-2: Demonstrate social and ethical responsibility in professional life.
PEO-3: Manifest lifelong learning for sustained professional and personal progression.
PEO-4: Practice effective communication and teamwork skills.

Discussion
The house had detailed discussion on the forms and surveys associated with BS level programs in the OBE framework. It was agreed that the questionnaire can be changed instead of PEOs. No batch of BS AI have graduated, so far and PEOs should only be changed after evaluation/recommendation of indirect assessment methods. Also, it was argued that both PEO 2 and PEO 4 are different in nature.

Decision 3309
Status quo to be maintained. Point dropped.

Item3310: Establishment of School of Computing

Sponsor: HOD CS BUKC Referral Authority: DBoS

Summary of the Case
During the interaction of Honorable Rector with faculty members of CS Dept BUKC on 19th October 2023, establishment of School of Computing point was highlighted. It was directed that the draft proposal may be processed through concerned Dean for consideration at BUHO. It was further suggested that this agenda should be discussed in FBoS and final recommendations should be sent to BUHO through concerned Dean.

Discussion
HoD CS BUKC presented a working paper on the establishment of School of Computing. Concentrating on the fact that Computing programs are on the rise both Nationally and Internationally. The name BSEAS has no reflection of Computing discipline. NCEAC has many computing streams which can be launched under the proposed School of Computing. In addition, it was argued that CS Departments in BUIC & BUKC are very big and a single HOD is looking after many programs, faculty and students.

The chair asked FBoS members to comment on the pros and cons of the proposed School of Computing. The Principals BSEAS BUKC and BUIC H-11 were of the view that Engineering programs especially EE program is facing challenges of low student intakes. With the establishment of School of the Engineering programs will suffer further loss of applicants. HoDs of EE Departments also had reservations on the establishment of School of Computing because they also thought that it would impact number of applicants of Engineering programs. It was suggested to split CS Department into two or three departments rather than establishing of new School of Computing.

The chair commented that with the introduction and success of BS RIS program EE Departments at BUIC and BUKC are admitting significantly good number of students. Hence, they should not be worried about the loss of student intake in their departments with the launch of the School of Computing. HoD EE BUIC admitted that BS RIS has been a success but most of the students in this program are the residual of CS Dept applicants. It was suggested by the HoD EE BUIC to further monitor the applicants and success of BS RIS in Fall 2024 after which final decision on the establishment of School of Computing should be taken. The suggestion was also endorsed by other FBoS members.

Decision 3310
Point to remain on agenda. HoD CS BUKC is requested to include the financial effects in the working paper for the establishment of the School of Computing.

Item3311: Proposal for new program - BS Software Engineering

Sponsor: HOD CS BULC Referral Authority: DBoS

Summary of the Case
The Department of Computer Sciences was established in 2014 at Bahria University Lahore Campus (BULC) under the directions of Bahria University Head Office (BUHO), Islamabad. The department commenced with two undergraduate programs including Bachelor of Science in Computer Science (BSCS) and Bachelor of Science in Information Technology (BSIT). The department of computer science should produce graduates, particularly in the field of software engineering, who can design and develop quality software solutions. Moreover, they should be able to work effectively within a challenging environment as successful professionals. The department has a good collaboration with the local software industry. Since Software Engineering is an emerging discipline and is a highly concerned area specifically with respect to the production of cost effective and quality software solutions. Keeping in view the importance of the field of software engineering, the Department of Computer Sciences has decided to launch an undergraduate degree program i.e., Bachelor of Science in Software Engineering (BSSE) in addition to BSCS and BSIT programs.

Discussion
BS Software Engineering is a popular program and is successfully running in BUIC H-11 and BUKC under the accreditation of PEC. The program can be a good addition for CS Dept BULC but detailed working is required before presenting it for approval in FBoS. The following issues should be addressed in the program proposal:

a. During the mock academic audit, it was observed that CS Dept requires 15 classrooms for its current degree programs of BSCS and BSIT whereas it has 12 classrooms. In this situation, how the department would ensure classroom requirements for the new program.
b. At least two new Computing Labs would be required for the new program but the current proposal does not address the issue

c. SE Depts at BUKC and BUIC H-11 both are offering BSE program accredited with PEC, how would the new program at CS Dept BULC be accredited: PEC or NCEAC. PEC requires FMs with PEC number, does the department have sufficient FMs or new FMs should be inducted.
d. BULC has recently launched AD CS program in Fall 2023 and Bachelor of Business & IT in Spring 2024, both programs have failed to attract students. It would be better to stabilize recently launched programs rather than offering new programs.
e. Currently applicants in BSCS program are also offered BSIT program due to low number of applicants in BSIT, with the addition of another BS level program how the department would manage the intake requirements of BSIT program.

Decision 3311
The department should present the new program launch proposal of BS SE on the BU's prescribed format while addressing the concerns of FBoS. Point dropped.

Item3312: New Assessment Methods for Students

Sponsor: HOD EE H-11 Referral Authority: DBoS

Summary of the Case
As part of our commitment to fostering academic excellence and ensuring the holistic development of our students, the Bachelor of Electrical Engineering program and newly launched program BS(RIS) at BSEAS, H-11 Campus, employs a comprehensive assessment framework tailored to the diverse needs of our student body. This agenda point presents the assessment methods for various categories of courses within the program, ranging from foundational/basic courses to specialized technical electives. By utilizing a variety of assessment strategies. We aim to provide students with opportunities to demonstrate their knowledge, skills, and competencies in alignment with the program's learning objectives. These assessment methods are carefully designed to facilitate meaningful learning experiences, promote critical thinking, and prepare students for success in their academic and professional endeavors. Through this framework, we strive to uphold the highest standards of academic rigor and ensure the equitable evaluation of student performance across all courses. These assessment methods are designed to ensure comprehensive evaluation of students' understanding and performance across various types of courses within the BEE program and other newly launched programs.

The Important aspect of bringing this agenda point is to emphasis that newly launched program BS(RIS) are bought to have ease of financial effect on BEE (while also not compromising on quality). Students having different assessments methods than the conventional methods might help them keep focus (E.g. as compared to BS(ETM) which came as BSCS back in 2009 and vanished as same assessment method existed for all students). Exam policy was presented last semester and also with all roadmaps now aligned as per HEC, hence an equal equation can help in defining assessment methods for various category courses (Core/Electives Etc.)

Discussion
HoD EE BUIC presented the agenda arguing new methods such as viva-based exam, project based final exam, etc should be adopted for practical course especially in the BS RIS program. However, no formal working paper regarding proposed new methods of assessment or the suggested courses in which it would be applied was presented. It discussed that the proposed new assessment methods are very open ended and it would be difficult to maintain fairness. Also, it was argued that CMS portal is not designed for the record keeping of such activities and evaluations. In addition, PEC should also be consulted regarding new and innovative ways of assessment prior to pitching the proposal.

Decision 3312
Status quo to be maintained. Point dropped.

Item3313: Revision in Methodology for Improvement of Underperforming Students

Sponsor: HOD SE H-11 Referral Authority: FBOS ES

Summary of the Case
Policy regarding making improvement in the performance of underperforming students was approved in 44th Special ACM. The policy is being implemented from Fall 2023 semester. However, following administrative problems have been faced by the department:

a. The programs with no cluster head, keeping track of the student progress has become difficult as the overall picture of the students is only visible to ASA and HoD for which they have to collect the data manually. In 45th ACM, development of IT based solution was asked, however, it is still not functional.
b. Student mentoring/conduct of classes for all students attaining 60% or less after the midterm exams is also not a feasible solution as the student strength in the classes is also high in most of the engineering programs (up to 50) and conduct of extra classes by the concerned/assigned teachers beyond regular teaching hours is an additional workload. Moreover, in the case of VFMs conduct of these extra hours of teaching requires additional honorarium payment for which no provision has been provided in the approved policy.
c. Existing CQI process of the approved OBE framework also has similar process of underachieving students who are unable to meet satisfactory progress in Program Learning Outcomes (PLOs) in the form of conduct of workshops and additional comprehensive assignments.

The current system involves ASAs, Cluster Heads, and Faculty members, thus increasing the paperwork and slowing down the process.

Discussion
The chair informed the house that Deans Committee has been pursuing the IT implementation of the underperforming students. DIT has been tasked to implement the said framework to facilitate the implementation. The BU's framework for improving the quality of underperforming students has been devised after thorough deliberations and has been recently launched (Fall 2023). Sufficient time should be given to the framework for implementation before any changes or improvements are suggested. Furthermore, if any changes/modifications are necessary they should be precisely presented w.r.t existing framework and completely revising the methodology is not suitable.

Decision 3313
Status quo to be maintained. Point dropped.

Item3314: New Program Launch Proposal - MS Artificial Intelligence

Sponsor: HOD CS BUIC H-11 Referral Authority: DBoS

Summary of the Case
Artificial Intelligence (AI) represents a significant stride in scientific and technological advancement, offering substantial social benefits. It has the potential to enhance living conditions, improve healthcare, facilitate justice, boost the economy, enhance public safety, and more. Similarly, in Pakistan, there is a demand for skilled AI professionals who can leverage their expertise to develop

intelligent systems. These systems find application in various sectors such as healthcare, agriculture, security, education, defense, and numerous other areas, thereby contributing to the transformative growth of the economy. Master of Science in Artificial Intelligence, MS (AI), will address the intersection of three areas driving AI science: technologies, analytics and business needs. MS (AI) is being proposed as per the requirements of Postgraduate Academic Regulations of Bahria University and HEC.
The detailed working paper for the launch of the new program is attached at Annex-A.

Discussion
The sponsor of the agenda told the house that MS AI program will be offered in the evening and would not have significant financial effects. It was questioned that CS Dept BUIC E-8 is offering MS DS (Data Science) program. The same program should be offered at CS Dept at H-11. As response it was argued that MS AI is a more attractive nomenclature and in line with the BS AI program already offered in H-11 Campus. The roadmap of the MS AI program is slightly different than the MS DS program with the introduction of a new core course and a few new elective courses.
The house recommended a few changes in the course codes, course contents and highlighted that relevancy of the associated FMs should be processed through Relevance Assessment Committee.

Decision 3314
The new program of MS AI for launch at CS Department H-11 Campus is approved. Case to be forwarded to ACM for formal approval before obtaining NOC from HEC.

Item3315: Focus on Emerging Tools and Technologies – IT Graduates

Sponsor: HOD CS BUIC H-11 Referral Authority: Dean ES

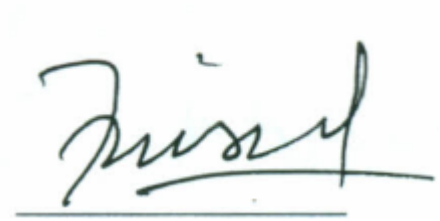
Summary of the Case
In 2023, a massive IT graduate placement initiative was taken to place graduates from Pakistan to Japan. BU signed an MoU with Fauji Foundation Overseas Employment Services (FF OES) to extend this opportunity to its IT graduates. Out of 200 applicants only 05 graduates survived the interview and shortlisting process. After a thorough review, the client communicated the following shortcomings IT graduates. “Insufficient experience with the required tools, frameworks, databases, version control, web protocols, libraries, testing tools and cloud frameworks. For example: Django/Angular/Ionic, MongoDB/MariaDB/Firebase/Oracle11g, Git, Docker/Kafka/Apache Flink, Websockets, microservices, CI/CD, and AWS/Azure etc.”

Discussion
The chair highlighted that important developmental frameworks and technologies must be covered in all IT programs in courses/seminars/guest sessions/ hands-on sessions. It was informed by relevant HoDs that modern tools and technologies are covered during the degree program but with the plethora of emergence technologies, it is not possible to cover all technologies in degree duration. Rather students are given strong foundation to learn and adapt to any new technology or language. The chair advised relevant HoDs to review the received comments during their CAC meetings. In case, any necessary skill is not covered in the curriculum, special guest lectures/sessions should be arranged for the students.

Decision 3315
Discussion on the agenda item should be carried out in the CAC and DBoS of CS and SE departments. Point dropped.

Closing of the Meeting

With no further agenda points, the Chair brought the meeting to a close, thanking the participants for their wholehearted participation.



Prof. Dr Faisal Bashir Hussain
Dean ES
30st March 2024

Annex-A

New Programme Proposal Form MS Artificial Intelligence

A. ACADEMIC DETAILS	
1	**Faculty/Department:** Faculty of Engineering and Sciences, Department of Computer Science H11 Campus
2	**Name of the Programme:** MS Artificial Intelligence – MS (AI)
3	**Mission of the Programme:** The mission of the MS (AI) program is to cultivate AI scientists equipped with the capacity to apply their theoretical understanding and analytical prowess in devising innovative and efficient solutions for both practical challenges and research endeavours.
4	**Objectives of the Programme:** The objective of the Master of Science in Artificial Intelligence (AI) degree program is to foster proficiency among students in the diverse subjects, tools, techniques, methodologies, and models pertinent to the AI field. Highlighting key areas such as machine learning, deep learning, mathematics, and signal/image/video processing, the program is structured to align with contemporary trends and global market needs. Strategically crafted to meet the evolving demands of both local and international markets, this program is geared towards producing adept researchers. It seeks to cater to the current and future requisites for AI expertise across a spectrum of sectors including government, industries, businesses, applied sciences, research, health, and security.
5	**Outcomes of the Programme:** The program aims to furnish students with the requisite skills for both professional and research roles in the domain of Artificial Intelligence. Upon completing the degree, students will possess proficiency in producing/overseeing AI solution for decision-making processes, as well as utilizing, analyzing, and appraising technologies and methodologies within an organizational framework. Graduates will be adept at: • Gathering and managing data to devise solutions for AI tasks. • Choosing, implementing, and assessing models to tackle AI challenges. • Interpreting findings from AI scientific analyses. • Effectively conveying AI science-related information in diverse formats to suitable audiences. • Embracing and upholding ethical standards in data usage across all facets of their professional endeavours.

6	**Rationale for the Programme:** AI holds a central position in moulding strategic decision-making and stimulating innovation within diverse professional sectors including engineering, finance, and healthcare. The growing demand for AI scientists capable of adeptly harnessing potent tools and sophisticated statistical modelling techniques to unearth insights into business challenges, operations, and frameworks is unmistakable. The Master of Science in AI (MS(AI)) program is tailored to tackle the intersection of three pivotal realms propelling AI science: technologies, analytics, and business imperatives.
7	**Brief Description of the Programme:** Artificial Intelligence (AI) marks a pivotal leap in scientific and technological progress, promising substantial benefits for society. It holds the promise to elevate living standards, advance healthcare, streamline justice, stimulate economic growth, improve public safety, and much more. In Pakistan, there's a noticeable demand for proficient AI professionals capable of utilizing their skills to create intelligent systems. These systems are applicable across a variety of sectors including healthcare, agriculture, security, education, defence, and many others, thus playing a crucial role in the country's economic transformation. AI's scope extends beyond its technological and mathematical components, requiring a combination of technical skills and soft skills. This enables AI scientists to turn data into meaningful insights. The MS(AI) program is designed to thoroughly cover the essential elements of AI. It includes training in mathematical and statistical techniques, artificial intelligence, machine learning, data mining, data engineering, and data visualization. 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:** 2 years
9	**Venue(s): On Site**~~/Off Site/Both On & Off Site~~ *(tick one/strike-through the ones not applicable;if Off Site, give details)* Johar Block, Bahria University, H11 Campus, Islamabad
10	**Programme Scheduling Format:** • ~~Morning~~**/Evening/**~~Weekend~~ *(tick one/strike-through the ones not applicable)* • **Bi-Semester**/~~Trimester/Semester+Summer Session/Annual/Bi-Annual~~ *(tick one/strike-throughthe ones not applicable)*
11	**Proposed Date of Commencement:** Fall 2024
12	**Mode of study** for MS (AI) is based on classroom teaching. Assignments, quizzes, presentations, mid-term, and final term exams will be used to evaluate the students in each semester. Also, students will be encouraged to undertake 6 credit hours of MS thesis.
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 berequired at the start of the program and maximum 3 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.)* **Yes**. (02 x high-end GPU based machines would be required)
17	**Additional Requirement for Books, Subscriptions, Memberships to Online Research Sites/ Repositories: Yes**
18	**Minimum Entry Level:** 4 years Bachelor degree in AI/CS/IT/EE/CE/SE/Robotics/Mechatronics or equivalent

19	**Admission Criteria:** HEC recognized 4 years Bachelor degree in AI/CS/IT/EE/CE/SE/Robotics/Mechatronics or equivalent with CGPA 2.5/4.0 (Semester System) or 50% marks (Annual System). NTS-GAT (General)/ GRE/University entry test passed with 50% marks. The following courses are recommended to be completed before entering the MS Artificial Intelligence (AI) program. a. Programming Fundamentals OR Computer Programming b. Data Structures & Algorithms OR Design & Analysis of Algorithms c. Database Systems
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:** 10 admissions for first intake
22	**Number of Admissions Planned/Expected for Subsequent Intakes:** 10 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:** 2 years **Semester System:** Yes (4 Semesters) **Total Number of Credit Hours:** 30
3	**Expected fee to be charged based on Cost & Benefits Analysis:** *(show working)* Per annum fee: or Fee rate per credit hour: Rs. 7350 /- (5% increase in current Fee rate per credit hour)
4	**Expected Number of students for 1st & 2nd Intakes:** 10 & 10
5	**Expected Earning from first two Intakes (B5):** *(Show working)*

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh***	**Existing****	**Fresh**	**Existing**	**Total**
Fall 2024	10	0	10	120,650	0	1,206,500	0	**1,206,500**
Spring 2025	10	10	20	120,650	73,650	1,206,500	736,500	**1,943,000**
Fall 2025	10	20	30	123,953	73,650	1,239,530	1,473,000	**2,712,530**
Spring 2026	10	30	40	123,953	73,650	1,239,530	2,209,500	**3,449,030**

* per credit 7350 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 7350 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 2024**	10	0	10	120,650	0	1,206,500	0	**1,206,500**
	Spring 2025	10	10	20	120,650	73,650	1,206,500	736,500	**1,943,000**

	2	**Fall 2025**	10	20	30	123,953	73,650	1,239,530	1,473,000	**2,712,530**
		Spring 2026	10	30	40	123,953	73,650	1,239,530	2,209,500	**3,449,030**
	3	**Fall 2026**	10	30	40	127,427	76,953	1,274,270	2,308,590	**3,582,860**
		Spring 2027	10	30	40	127,427	76,953	1,274,270	2,308,590	**3,582,860**
	4	**Fall 2027**	10	30	40	131,072	76,953	1,310,720	2,308,590	**3,619,310**
		Spring 2028	10	30	40	131,072	80,427	1,310,720	2,412,810	**3,723,530**
	5	**Fall 2028**	10	30	40	134,897	80,427	1,348,970	2,412,810	**3,761,780**
		Spring 2029	10	30	40	134,897	80,427	1,348,970	2,412,810	**3,761,780**

Year 1: Rs. 3,149,500/-
Year 2: Rs. 6,161,560/-
Year 3: Rs. 7,165,720/-
Year 4: Rs. 7,342,840/-
Year 5: Rs. 7,523,560/-

Total 5 years' earnings: Rs. 31,343,180/-

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

	Work load		Per Semester Salary (Rs. 2500 per hour)
Semester	**Course**	**Credit Hours**	**FM**
Fall 2024	3	9	360,000
Spring 2025	6	18	720,000
Fall 2025	9	27	1,080,000
Spring 2026	10	30	1,200,000

Year 1: Rs.1,080,000 **(per annum)**
Year 2: Rs. 2,280,000 **(per annum)**

Total estimated salaries for the first two years: Rs. 3,360,000/-

8 **Cost of <u>Additional</u> Laboratory Equipment/Tools (B8):** *(show working)*
Year 2: 1GPU=Rs. 3,000,000

Total estimated cost of the GPUs: Rs. 3,000,000/-

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)* **Rs. 100,000/-**

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: **23,50,000/-**
- Rentals: None
- Subscriptions/Memberships/Books: **100,000/-**
- Advertisements:
- Printing & Stationery: None
- Admin Cost: None
- Any other:
- **Total: 2,450,000**

	Total Cost of the Programme (B14): [Add B(7) to B(12)] Year 1: Rs. 1,340,000 Year 2: Rs. 5,280,000
15	**Net Cost of the Programme (B15):** [Subtract B(1) from B(14)] Year 1: Rs. 1,340,000 Year 2: Rs. 5,280,000
16	**Net Earnings in First Year (B16:** [Subtract B(15) from B(5)] **Rs. 1,809,500/-**
17	**Projected Annual Gross Earning in Subsequent Years (B 17):** *(show details & working; add 10% towards all expenses in subsequent years.)* Year 2: Rs. 6,161,560/- Year 3: Rs. 7,165,720/-
18	**Projected Annual Net Earning in Subsequent Years:** *[Subtract B(13) from B(17)]* Year 2: Rs. 711,560/- Year 3: Rs. 46,65,720/-

MS(AI) - COMPLETE PLAN OF STUDY

Semester 1

Course Code	Course Title	Credit Hours	SDGs alignment
CSC 711	Advanced Artificial Intelligence	03	3,4,7,9
DSC 708	Statistical and Mathematical Methods for Data Analysis	03	4,8,16
ESC 701	Research Methodology	03	4
	Total	09	

Semester 2

CSC 719	Machine Learning	03	3,4,7,9
AIC 703	Advanced Knowledge Representation and Reasoning	03	4,11,16
	Elective-I	03	
	Total	09	

Semester 3

DSC 707	Deep Learning	03	3,4,7,9
	Elective-II	03	
THS 799/Elec-Code	Thesis-I / Elective-III	03	4,8,9
	Total	09	

Semester 4

THS 799/Elec-Code	Thesis-II / Elective-IV	03	4,8,9
	Total	03	
	TOTAL CREDIT HOURS	**30**	

Electives

Sr. No	Course Code	Course Title	Credit Hours	UN SDGs alignment
1	CSC 721	Decision Support Systems	3	4,5,10
2	CSC 715	Intelligent Agents	3	4,9,11
3	CSC 741	Advanced Natural Language Processing	3	3,4,11
4	CEN 745	Advanced Digital Image Processing	3	3,4,11
5	CSC 751	Pattern Recognition	3	3,4,9
6	CSC 722	Advanced Information Theory	3	4,8
7	SEN 764	Ontology Engineering	3	3,4,11
8	THS 799	Thesis	6	4,8,9
9	CSC 723	Game Theory	3	4,9
10	AIC 704	Optimization Techniques	3	4,9,16
11	AIC 705	Artificial Intelligence in Embedded systems	3	3,4,9,11
12	AIC 706	AI for Healthcare Applications	3	3,4,9
13	AIC 707	Ethics of Artificial Intelligence	3	4,9,16

COURSE OUTLINES

Course Title: **Advanced Artificial Intelligence**
Course Code: CSC 711
Pre-Requisite: None

Objectives:
The objective of this course is to provide students with a comprehensive understanding of the theories, techniques, and applications of artificial intelligence (AI). The course aims to equip students with the knowledge and skills necessary to develop intelligent systems capable of performing tasks that traditionally require human intelligence. The students will explore concepts such as machine learning, knowledge representation, reasoning, planning, and natural language processing. They will also be introduced to advanced topics including deep learning, reinforcement learning, computer vision, and robotics, gaining insight into cutting-edge AI research and methodologies.

Contents:
AI history, goals, introduction to intelligent agents, problem-solving, search algorithms, exploration of AI applications across various domains, such as healthcare, finance, education, gaming, and autonomous vehicles, Ethics and Societal Implications, Knowledge Graphs, Expert Systems, Case Based Reasoning, Fuzzy Logic, Hierarchical Planning, Reinforcement Learning, Large Language Models, Artificial Neural Networks, State Space Search, Constraint-Based Reasoning, Combinatorial Optimization, Metaheuristics.

Textbooks:
- "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig, published by Pearson, 4th edition, 2020.
- "Artificial Intelligence: Structures and Strategies for Complex Problem Solving" by George F. Luger and William A. Stubblefield, published by Addison Wesley, 7th edition, 2019.

Reference Books

- "Artificial Intelligence: A Guide to Intelligent Systems", by Michael Negnevitsky published by Pearson, 2011
- "Artificial Intelligence: A Guide to Intelligent Automation", by Nigel Duffy published by Springer, 2023
- "Artificial Intelligence: Foundations of Computational Agents", by David L. Poole and Alan K. Mackworth, published by Cambridge University Press, 2017

Course Title: **Statistical and Mathematical Methods for Data Analysis**
Course Code: DSC 708
Pre-Requisite: None

Objectives:
The objective of this course is to provide students with a rigorous and in-depth understanding of the mathematical and statistical techniques essential for proficient data analysis. The course aims to equip students with skills in probability theory, statistical inference, and mathematical modeling, enabling them to handle complex datasets with confidence and precision. Students will understand concepts of linear algebra for dimensionality reduction and optimization, probability distributions

for modeling uncertainty, and hypothesis testing for making data-driven decisions. By the end of the course, students will be proficient in applying sophisticated mathematical and statistical techniques to extract actionable insights from data.

Contents:

Probability Theory: Probability distributions, conditional probability, Bayes' theorem, random variables, and expectations, Statistical Inference: Estimation (point estimation, interval estimation), hypothesis testing, confidence intervals, and p-values. Regression Analysis: Simple linear regression, multiple linear regression, logistic regression, Multivariate Analysis, Time Series Analysis, Machine Learning Foundations: Classification, regression, Clustering, Linear Algebra for Data Analysis: Matrix operations, eigenvalues, eigenvectors, singular value decomposition (SVD), and its applications in dimensionality reduction, Bayesian Methods: Bayesian inference, Markov Chain Monte Carlo (MCMC) methods, hierarchical modeling, and Bayesian model selection.

Textbooks:

- Mathematical Methods in Data Science 1st Edition by Jingli Ren , Haiyan Wang, Elsevier, 2023.
- Statistics and Mathematics for Data Science and Data Analytics by Nikolai Schuler, 2023.

Reference Books

- Digital and Discrete Geometry: Theory and Algorithms, Book by Li. M. Chen. ISBN 978-3-319-12098-0,2014, Springer
- Convexity and Discrete Geometry Including Graph Theory, Book by Karim Adiprasito, Imre Barany,Costin Vilcu, ISSN 2194-1009, Springer, 2016
- Mathematical Problems in Data Science: Theoretical and Practical Methods, Book by Bo Jiang, Li Chen,and Zhixun Su, December 15, 2015, Springer

Course Title: Research Methodology

Course Code: ESC-701
Pre-Requisite: None

Objectives:

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

Contents:

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

Textbooks:

- Introducing Research Methodology Thinking Your Way Through Your Research Project Third edition by Uwe Flick, 2020 .
- Research Methodology: A Step-by-Step Guide for Beginners 5th Edition by Ranjit Kumar, 2019.

Reference Books:

- Research Methodologies – A step by step guide for beginners, Ranjit Kumar, 2005.
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell, 2008.
- How to Research, L. Blaxter, C. Hughes, M. Tight, 4th Edition, 2010.
- Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Publisher: SAGE,3rd Edition, 2010
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Course Title: **Machine Learning**
Course Code: CSC-719
Pre-Requisite: None

Objectives:
The objective of this course is to provide students with a comprehensive understanding of the principles, algorithms, and applications of machine learning techniques. The course aims to equip students with the knowledge and skills necessary to develop and apply machine learning models to solve a wide range of real-world problems. Through a blend of mathematical derivations, proofs, and algorithmic implementations, students will gain insight into the underlying principles governing the behavior and performance of classification models. At the end of this course, students will be able to apply various types of machine learning algorithms and will be able to evaluate, validate, and optimize machine learning models.

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

Textbooks:
- Introduction to Machine Learning, fourth edition (Adaptive Computation and Machine Learning series) by Ethem Alpaydin, 2020.
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurélien Géron , 2022

Reference Books:

- Machine Learning: Fundamental Algorithms for Supervised and Unsupervised Learning With Real-World Applications by Joshua Chapmann (Author, Publisher), 2nd Edition, 2017.
- Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and CaseStudies by John D. Kelleher, Brian Mac Namee, Aoife D'Arcy, MIT Press, 1st Edition, 2017.
- Machine Learning with R - Second Edition by Brett Lantz, Packt Publishing, Second Edition, 2015.
- Machine Learning with Python: Understanding Machine Learning with Python in the World of DataScience by Robert Wilson (Author, Publisher), 1st Edition, 2016.

Course Title: **Advanced Knowledge Representation and Reasoning**
Course Code: AIC 703

Pre-Requisite: None

Objectives:

The course aims to equip students with a comprehensive understanding of advanced techniques and methodologies for representing, organizing, and reasoning with knowledge in intelligent systems. Students will gain proficiency in designing and implementing complex knowledge representation models capable of capturing rich and nuanced semantics. Students will understand the computational properties of these logics, and study algorithms for solving the relevant reasoning problems and discuss logics that depart from first order logic, such as non-monotonic logics. By the end of the course, students are expected to possess the skills necessary to design, develop, and evaluate advanced knowledge-based systems.

Contents:

Introduction to knowledge-based technologies and knowledge representation, propositional logic, representing knowledge in first order predicate logic – predicates, variables, quantifiers, connectives, functions and constants, Limitations of propositional and first order predicate logic, Higher-order logics and other formalisms, Description logic as knowledge representation languages, reasoning in Description Logics, Lightweight description logics, Non-monotonic logic, Stable Model semantics, Answer Set Programming, Fuzzy set theory and fuzzy logic systems, fuzzy inference systems and fuzzy control.

Textbooks:

- Knowledge Representation and Reasoning A Complete Guide - 2020 Edition Paperback – April 21, 2021
- Knowledge Representation Learning and Knowledge-Guided NLP by Xu Han, Weize Chen, Zhiyuan Liu, Yankai Lin & Maosong Sun , 2023

Reference Books:

- Understanding Meaning and Knowledge Representation By Eva M. Mestre-Mestre Carlos Periñán-Pascual, 2016.
- Logic for Computer Scientists. Uwe Schoning. Modern Birkäuser Classics, Reprint of the 1989 edition.
- Handbook of Knowledge Representation. Frank van Harmelen, Vladimir Lifschitz and Bruce Porter (Eds) Foundations of Artificial Intelligence, 2008.
- Foundation of Semantic Web Technologies. Chapman & Hall/CRC Textbooks in Computing. Pascal Hitzler, Markus Kroetsch, and Sebastian Rudolph, 2009.

Course Title: **Deep Learning**

Course Code: DSC-707

Pre-Requisite: Machine Learning

Objectives:

The course aims to provide students with a comprehensive understanding of advanced neural network architectures and their applications. Firstly, the course seeks to impart foundational knowledge of deep learning principles, including feedforward and recurrent neural networks, convolutional neural networks, and generative adversarial networks. Students will gain proficiency in training deep learning models using techniques such as backpropagation, gradient descent optimization, and regularization methods. Additionally, the course aims to explore cutting-edge research developments in deep learning, including advancements in areas such as self-supervised learning, attention mechanisms, and transformer architectures.

Contents:

The course content includes foundational concepts such as artificial neural networks, backpropagation algorithm, and gradient descent optimization, leading into more advanced topics like convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short-term memory networks (LSTMs), and generative adversarial networks (GANs). Deep learning techniques such as transfer learning, reinforcement learning, and unsupervised learning methods like autoencoders and variational autoencoders (VAEs). Emerging trends and research directions in deep learning, such as attention mechanisms, transformer architectures, and self-supervised learning. Practical components of the course involve hands-on experience with deep learning frameworks such as TensorFlow or PyTorch, enabling students to implement and experiment with state-of-the-art deep learning algorithms.

Textbook:

- Deep Learning for Beginners: A beginner's guide to getting up and running with deep learning from scratch using Python by Dr Pablo Rivas, 2020.
- Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence (Addison-Wesley Data & Analytics Series) by Jon Krohn , Grant Beyleveld , et al., 2019.

Reference Books:

- Deep Learning with Python, Francois Chollet, O'Reilly Media, 2017
- Deep Learning (Adaptive Computation and Machine Learning series), Ian Goodfellow, Yoshua Bengio, Aaron Courville, The MIT Press, 2016.

Course Title: **Decision Support Systems**
Course Code: CSC 721
Pre-Requisite: None

Objectives:

This course will enable a student to understand managerial decisions, to participate in the decision-making process, and to be able to develop models and systems to support the decision making. This course focuses on the use and application of information systems to support the decision-making process. Objectives of the course include understanding different types of systems, data models, interactive processes, knowledge-based approaches and integration with database systems. Theoretical concepts would be applied to real-world applications.

Contents:

Decision support systems, Decision Making, Systems, Modelling and Support, business intelligence, Data Management, Modelling and Analysis, Decision Support System Development, Fundamentals of Expert Systems and Intelligent Systems, Collaborative Computing Technologies, Knowledge Management.

Text*b*ooks:

- Decision Support Systems A Complete Guide - 2020 Edition Paperback by Gerardus Blokdyk , 2021
- Intelligent Decision Support Systems—A Journey to Smarter Healthcare, Smaranda Belciug , Florin Gorunescu, 2020.

Reference Books:

- Machine Learning with Python: Understanding Machine Learning with Python in the World of DataScience by Robert Wilson (Author, Publisher), 1st Edition, 2016.
- Decision Support Systems and Intelligent Systems, Efraim Turban and Jay E. Aronson, Prentice HallPub, 7th Edition, M 2004.
- Decision Support Systems and Business Intelligence Systems. Dursun Delen, Efraim Turban, Ramesh Sharda, Pearson Pub, 2013.
-

Course Title: **Intelligent Agents**
Course Code: CSC 715
Pre-Requisite: None

Objectives:

The primary objective of this course is to provide students with a comprehensive understanding of the principles, algorithms, and methodologies underlying the design and development of intelligent systems. Emphasis of the course will be on understanding the concepts of thinking, planning and learning associated with intelligent agents and using them to model and build relevant agent-based systems. Students will these concepts so that they can apply them to solve complex real-world problems across diverse domains including natural language processing, computer vision, robotics, and data analytics.

Contents:

Agent, Environment, Interaction, Solving Problem by Search Algorithms, Informed Search, Constraint Satisfaction Problem, Logical Agents, Theorem Proving Algorithms (propositional logic, predicate logic), Partial Order Planning, Graph Plan, BDI Agents, Decision trees, Neural Networks, Reinforcement learning, Q-learning, Temporal Difference Learning, Monte Carlo Methods.

Textbooks:

- "Hands-On Intelligent Agents with OpenAI Gym", by Palanisamy P, 2018.
- "Artificial Intelligence: A Modern Approach", by Russell, S. J. and Norvig, P., 4th edition, Prentice Hall, 2020.

Reference Books:

- Logic Based Artificial Intelligence, Jack Minker, Springer, 2000
- Reasoning about Rational Agents, Michael J. Wooldridge, MIT Press, 2003
- Artificial Intelligence, A modern Approach, Stuart Russel and Peter Norvig, Prentice Hall, 3rdEdition, 2009.
- Knowledge Representation, reasoning, and the design of Intelligent Agents, Yulia Kahl, MichaelGelfond, Cambridge University Press, 2014

Course Title: **Advanced Natural Language Processing**
Course Code: CSC 741
Pre-Requisite: None

Objectives:

This course is intended to introduce the students to the advanced concepts and ideas in natural language processing (NLP). Students will be acquainted with the algorithms available for the processing

of linguistic information, as well as the underlying computational properties of natural languages. By the end of this course the student should be able to carry out independent work with modern techniques for processing of texts.

Contents:

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

Textbooks:

- Advanced Natural Language Processing with TensorFlow 2 By Ashish Bansal, Tony Mullen, 2021
- Deep Learning for Natural Language Processing, 2nd Edition by Jon Krohn, 2020.
- Natural Language Processing: A Textbook with Python Implementation 1st ed. by Raymond S. T. Lee , 2024 Edition.

Reference Books:

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

Course Title: Advanced Digital Image Processing
Course Code: CEN 745
Pre-Requisite: None

Objectives:

This course will provide mathematical foundations and practical techniques for digital manipulation of images, image acquisition, pre-processing, and segmentation. The course will expose the students to the basic theory and algorithms widely used in digital image processing. After the completion of this course the students will be able to understand the concepts behind the processing of digital imagesas well as various techniques of filtering/processing images in spatial as well as in frequency domain.

Contents:

Overview of Digital Image Processing, Computer Vision and Pattern Recognition, Fundamental element of visual Perception, Image Sensing and Acquisition Image Sampling and Quantization. Pixel operations, linear & Nonlinear operations, Image Enhancement in spatial Domain: Background, Grey level Transformations, Filtering in spatial domain. Image Enhancing in Frequency Domain: Frequency domain,Fourier Transform, Filtering in frequency domain, Color Image Processing, Fundamentals of

Image Compression, Lossless and lossy compression, Image Compression standards, Image Segmentation: Detection of Discontinuities, Edge and Boundary detection, Thresholding, Region Based segmentation, Morphological image processing, Representation schemes: Boundary and region descriptors.

Textbooks:

- Advanced Digital Image Processing and Its Applications in Big Data ByAnkur Dumka, Alaknanda Ashok, Parag Verma, Poonam Verma, 2020.
- G. Shengrong et al., "Advanced Image and Video Processing Using MATLAB," Springer International Publishing, 2018.

Reference Books:

- Machine Learning with Python: Understanding Machine Learning with Python in the World of DataScience by Robert Wilson (Author, Publisher), 1st Edition, 2016.
- Digital Image Processing, R. C. Gonzalez and R. E. Woods, Addison Wesley, 3rd Edn., 2007.
- Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab, ChrisSolomon and Toby Breckon, 2011.
-

Course Title: **Advanced Neural Networks and Fuzzy Logic**
Course Code: CSC 749
Pre-Requisite: Artificial Intelligence

Objectives:

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

Contents:

Artificial Intelligence Artificial Neural Network overview, Supervised Learning: Single-Layer Networks , Perceptrons , Adalines Supervised Learning: Multi-Layer Networks, Multi-Layer Perceptrons (MLPs) , Backpropagation , Conjugate Gradient method , Levenberg-Marquardt (LM) method , Madalines , Radial-Basis Networks , Cascade-Correlation Networks , Polynomial Networks ,Recurrent Networks (Time series , Backpropagation through time , Finite Impulse Response (FIR) MLP), Temporal Differences method (TD). Unsupervised Learning, Simple Competitive Networks: Winner-take-all | Hamming network , Learning Vector Quantization (LVQ), Counter propagation Networks (CPN) , Adaptive Resonance Theory (ART) , Kohonen Self-Organizing Maps (SOMs) , Principal Component Analysis networks (PCA), Associative Models, Linear Associative Memory (LAM) , Hopfield Networks , Brain-State-in-a-Box , BSB) , Boltzmann Machines and Simulated Annealing , Bi-Directional Associative Memory (BAM), Optimization Problems, Neural Network Approaches, Evolutionary Programming , Fuzzy logic and its connection to NNs.

Text Books:

- A Learner's Guide to Fuzzy Logic Systems, Second Edition by K Sundareswaran, 2019.
- Fuzzy Logic A Practical Approach by Jacob Lopez, 2022.
- Trask, Andrew. Grokking deep learning. Manning Publications Co., 2019.

- Morales, M. "Grokking Deep Reinforcement Learning." 2019.

Reference Books:

- Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall, 2nd Edition, 1999.
- Artificial neural networks: an introduction, by Kevin L. Priddy, Paul E. Keller, SPIE Press, 2005.
- Neural networks: methodology and applications, by G. Dreyfus, Springer, 2005
- Evolving Fuzzy Systems - Methodologies, Advanced Concepts and Applications, By Edwin Lughofer, Springer, 2011.

Course Title:	**Pattern Recognition**
Course Code:	CSC 751
Pre-Requisite:	None

Objectives:

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

Contents:

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

Text Books:

- Fundamentals of Pattern Recognition and Machine Learning 1st ed. 2020 Edition by Ulisses Braga-Neto.
- Essentials of Pattern Recognition by Jianxin Wu, Cambridge Press, 2020

Reference Books:

- Pattern recognition and Machine Learning, Christopher M. Bishop, Springer, 2007.
- Introduction to Machine Learning, Ethem Alpaydin, MIT Press, 2004.
- The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani and Jerome Friedman,Springer, 2009.
- Pattern Recognition and Classification: An Introduction, by Geoff Dougherty, S. Theodoridis & K.Koutroumbas, Academic Press, 2012.

Course Title:	**Advanced Information Theory**
Course Code:	CSC 722
Pre-Requisite:	None

Objectives:

This course presents the advance concepts of Information Theory, that stays at the basis of modern digital communications, data compression, lossy source coding and multiuser networks. Details of to what computer scientists mean by "information", including topics in data compression (such as zip files and mp3), error correcting codes, information entropy, cryptography, and randomness.

Contents:

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

Text Books:

- Theory of Information and its Value by Ruslan L. Stratonovich, Springer, 2020.
- Information Theory: A Tutorial Introduction (2nd Edition) by by James V Stone , 2022.

Reference Books

- Stochastic Models, Information Theory, and Lie Groups: Analytic Methods and Modern Applications, Gregory S., Chirikjian, Birkhauser Pub, 2011
- Information theory: coding theorems for discrete memoryless systems, Csiszar and J. Korner,Cambridge University Press, 2nd edition, 2011.
- Information Theory: A Tutorial Introduction, James V Stone, Sebtel Press, 2015
- Entropy and Information Theory, Robert M. Gray, Springer, 2011

Course Title:	**Ontology Engineering**
Course Code:	SEN 764
Pre-Requisite:	None

Objectives:

This course provides students with a theoretical and practical understanding of modern solutions for the Semantic Web. It introduces students to the W3C standard Web Ontology Language, OWL, its underlying Description Logics, establishing patterns to avoid the pitfalls in using OWL. The course provides an opportunity to become familiar with a widely used environment for developing APIs for applying OWL ontologies, and making use of reasoning services accessible via both.

Contents:

Introduction to ontology and its significance in knowledge representation and semantic web technologies. Study of formal ontology languages such as OWL (Web Ontology Language) and RDF (Resource Description Framework), learning how to design and develop ontologies using these languages. Advanced topics include ontology alignment and integration techniques to facilitate interoperability among heterogeneous systems. Explore ontology evaluation methodologies and quality assurance techniques to ensure the accuracy, consistency, and completeness of ontological models. Additionally, students may study ontology-based reasoning and inference mechanisms, enabling them to harness ontologies for automated reasoning tasks.

Text Books:

- An Introduction to Ontology Engineering by C Maria Keet, 2018
- Ontology Engineering, by Elisa Kendall & Deborah L McGuiness, 2019.

Reference Books:

- Semantic Web for the Working Ontologist, D. Allemang and J. Hendler, Morgan Kaufmann Pub,2008
- Ontology Management: Semantic Web, Semantic Web Services, and Business Applications, MartinHepp, Pieter de Leenheer, Aldo de Moor, York Sure, Springer, 2008.
- Ontology Engineering in a Networked World, by Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez, Enrico Motta – 2012
- Building Ontologies with Basic Formal Ontology, Robert Arp, Barry Smith, Andrew D. Spear, MIT Press, 2015

Course Title:	**Game Theory**
Course Code:	CSC 723
Pre-Requisite:	None

Objectives:

The objective of this course is to provide a foundation of game theory to help students apply game theory to problem solving in a rigorous way. At the end of this course, the students can expect to be able to model real world situations using game theory, analyze the situations using game theoretic concepts, and design correct and robust solutions (mechanisms, algorithms, protocols) that would work for rational and intelligent agents.

Contents:

Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium, Mixed Strategy Nash Equilibrium, Von Neumann - Morgenstern Utility Theory, Rationalizable Strategies, Sperner's Lemma, Fixed Point Theorems, and Existence of Nash Equilibrium, Computation of Nash Equilibrium, Complexity of Computing Nash Equilibrium, Introduction to Mechanism Design, Social Choice Functions and Mechanisms, Incentive Compatibility and Revelation Theorem, Properties of Social Choice Functions, GibbardSatterthwaite Theorem and Arrow Impossibility Theorem, Quasilinear Mechanisms, Vickrey-Clarke-Groves Mechanisms, Bayesian Incentive Compatible Mechanisms, Revenue Equivalence Theorem, Optimal Auctions and Myerson Auction

Text Books:

- Course In Game Theory, A Kindle Edition by Thomas S Ferguson, 2020.
- Game Theory An Introduction with Step-by-Step Examples by Ana Espinola-Arredondo , Felix Muñoz-Garcia, 2023.

Reference Books:

- Michael Maschler, Eilon Solan, and Shmuel Zamir, Game Theory, Cambridge University Press, 2013
- Avinash K. Dixit y Barry J. Nalebuff, The Art of Strategy: A Game Theorist's Guide to Success in Business and Life, Norton, 2008

Course Title:	**Optimization Techniques**
Course Code:	AIC 704
Pre-Requisite:	None

Objectives:

The objective of this course is to equip students with a comprehensive understanding of the principles, algorithms, and methodologies essential for solving complex optimization problems prevalent in AI and related domains. Through this course, students aim to develop proficiency in both theoretical concepts and practical applications of optimization techniques. They will understand various optimization algorithms such as linear programming, nonlinear optimization, integer programming, evolutionary algorithms, and metaheuristic methods like genetic algorithms and simulated annealing. Additionally, students learn about optimization problems commonly encountered in AI, such as parameter tuning in machine learning models, resource allocation in robotics, scheduling in autonomous systems, and route optimization in logistics.

Contents:

Mathematical concepts and formulation of multivariable optimization, Classical methods of unconstrained optimization, Zero, first and second-order direct search techniques and algorithms for unconstrained optimization, Linear programming, Constraints - equality and inequality, optimality criteria, Numerical techniques for constrained optimization, Neural Networks as an optimization problem.

Text Books:

- Optimization Techniques | e Paperback by A.K. Malik (Author), S.K. Yadav, S.R. Yadav, 2020.
- Fundamentals of Optimization Techniques with Algorithms by Sukanta Nayak, 2020

Reference Books:

- Beck, Introduction to Nonlinear Optimization Theory, Algorithms, and Applications with MATLAB, SIAM, 2014.
- R. K. Arora, Optimization: Algorithms and Applications, Chapman and Hall/CRC, 2015. 4. L.E. Scales, Introduction to Non-Linear Optimization, Springer-Verlag, 1985.
- E.K.P. Chong, S.H. Zak, An Introduction to Optimization, 4th Edition, John Wiley and Sons, Inc., 2013.
- S. S. Rao, Engineering Optimization: Theory and Practice, 4thEdition, John Wiley & Sons, 2009.

Course Title:	**Artificial Intelligence in Embedded Systems**
Course Code:	AIC 705
Pre-Requisite:	None

Objectives:

This course will present recent advances towards the goal of enabling efficient implementation of deep machine learning models on embedded systems. Specifically, it will provide an overview of the theoretical foundations and motivations behind various deep learning models, software modeling and optimization techniques for these models, hardware platforms and architectures to support efficient execution of machine learning models, and hardware-software co-design approaches for machine learning.

Contents:

Machine Learning and Embedded Computing, Deep Neural Networks (DNNs and CNNS), Hardware Acceleration for ML, HW/SW codesign, Software Optimization for ML, TinyML, Reinforcement Learning, optimized AI algorithms for resource-constrained environments, addressing challenges of limited processing power, memory, and energy consumption, evaluation of AI algorithms on embedded platforms such as microcontrollers or System-on-Chip (SoC) devices, Anomaly detection and security, Emerging directions and applications in ML.

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Text Book:

- Embedded Artificial Intelligence Devices, Embedded Systems, and Industrial Applications by Ovidiu Vermesan, Mario Diaz Nava, Björn Debaillie, 2023.
- "TinyML: Machine Learning with Tensorflow Lite on Arduino and Ultra-Low Power Microcontrollers", Pete Warden and Daniel Situnayake, 2020

Reference Books:

- Shibu, K.V., Introduction to Embedded Systems, 1st Ed., TMH, 2009
- Frank Vahid & Tony Givargis, Embedded System Design, 2nd Edition, John Wiley.

Course Title:	**AI for Healthcare Applications**
Course Code:	AIC 706
Pre-Requisite:	None

Objective: The objective of course is to equip students with the ability to analyze the challenges and ethical considerations associated with the integration of AI in healthcare, apply advanced AI methodologies such as machine learning and deep learning to medical image analysis and predictive analytics for disease diagnosis and prognosis, utilize NLP techniques for clinical note analysis and decision support, and evaluate the application of AI-enabled robotics in surgical assistance and rehabilitation.

Contents: Introduction to AI in Healthcare (Overview of healthcare challenges and the role of AI, Ethical considerations and regulatory frameworks), Medical Image Analysis using AI (Fundamentals of medical imaging modalities, Image preprocessing techniques, Deep learning models for image segmentation and classification, Case studies: Radiology, pathology, and medical imaging diagnostics), Predictive Analytics in Healthcare (Predictive modeling for disease diagnosis and prognosis, Risk stratification and patient outcome prediction, Time-series analysis for patient monitoring, Case studies: Predictive analytics in chronic disease management), Natural Language Processing (NLP) for Healthcare (Introduction to NLP techniques, Text mining and information extraction from clinical notes, Clinical decision support systems, Case studies: Electronic Health Record (EHR) analysis and clinical documentation improvement), AI-enabled Healthcare Robotics (Robotic-assisted surgery and rehabilitation, AI-driven medical robotics for diagnostics and treatment, Human-robot interaction and safety considerations, Case studies: Surgical robots, telemedicine, and assistive devices).

Textbooks:

- "Healthcare Analytics: From Data to Knowledge to Healthcare Improvement" by Chandan K. Reddy, Charu C. Aggarwal, and Hui Liu, published by CRC Press (2018)
- "Artificial Intelligence in Healthcare: AI, Machine Learning, and Deep and Intelligent Medicine Simplified for Everyone" by Dr Parag Suresh Mahajan, published by MedMantra (2022)

Reference Books:

- "Artificial Intelligence in Medicine: Applications, Challenges, and Future Directions" edited by Lei Xing and Kang Zhang, published by Springer (2017)
- "Artificial Intelligence in Medical Imaging: Opportunities, Applications, and Risks" edited by Erik R. Ranschaert, Georg Langs, and Andreas M. Wimmer, published by Springer (2019)
- "Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again" by Eric Topol, published by Basic Books (2019)

Course Title:	**Ethics of Artificial Intelligence**
Course Code:	AIC 707
Pre-Requisite:	None

Objective: The objectives of this course are multi-faceted and critical in preparing future AI practitioners to navigate the ethical complexities inherent in the field. Firstly, the course aims to instill a deep understanding of the ethical implications of AI technologies, covering topics such as bias, fairness, transparency, accountability, and privacy. Secondly, the course seeks to cultivate ethical decision-making abilities by examining ethical frameworks and principles relevant to AI development and deployment. Ultimately, the goal is to empower students with the knowledge, skills, and ethical awareness necessary to contribute to the advancement of AI technologies in a socially responsible manner, ensuring that AI serves the greater good while minimizing harm to individuals and communities.

Contents: Foundational ethical theories and frameworks relevant to AI, including utilitarianism, deontology, and virtue ethics. Topics include algorithmic bias and fairness, transparency and interpretability, privacy and data protection, accountability and responsibility, and the societal impacts of AI. Case studies and discussions to examine real-world ethical dilemmas in AI applications across various domains such as healthcare, criminal justice, autonomous vehicles, and social media. Emerging ethical challenges posed by advanced AI technologies, including autonomous weapons, deepfakes, and algorithmic decision-making systems.

Text Books:

- AI Ethics By Mark Coeckelbergh, MIT Press, 2020.
- Ethical Issues of AI by Bernd Carsten Stahl, Springer. 2021.

Reference Books:

- The Oxford Handbook of Ethics of AI by Markus D. Dubber, Frank Pasquale, Sunit Das, 2020
- Ethics of Artificial Intelligence by S. Matthew Liao, 2020