**COURSE DESCRIPTION FORM**

**INSTITUTION**  FAST School of Computing, National University of Computer and Emerging Sciences, Islamabad

BS-AI: **FALL 2023**

**PROGRAM(S) TO BE EVALUATED**

**Course Description**

| **Course Code** | AI-3001s | | | |
| --- | --- | --- | --- | --- |
| **Course Title** | **Knowledge Representation & Reasoning** | | | |
| **Credit Hours** | 3 | | | |
| **Course Instructor** | Dr. Amna Basharat, Amna binte Kamran | | | |
| **Prerequisites by Course(s) and Topics** |  | | | |
| **Grading Policy** | Absolute grading | | | |
| **Policy about missed assessment items in the course** | Retake of missed assessment items (other than midterm/ final exam) will not be held.  For a missed midterm/ final exam, an exam retake/ pretake application along with necessary evidence are required to be submitted to the department secretary. The examination assessment and retake committee decides the exam retake/ pretake cases. | | | |
| **Course Plagiarism Policy** | Plagiarism in project or midterm/ final exam may result in F grade in the course.  Plagiarism in an assignment/quiz will result in zero marks in the whole assignments/quiz category, with up to 15% score penalty in the entire course grade. | | | |
| **Assessment Instruments with Weights** (homework, quizzes, midterms, final, programming assignments, lab work, etc.) | *100% Theory*  Assessment items of Theory Part   | **Assessment Item** | **Number** | **Weight (%)** | | --- | --- | --- | | Assignments | 3 | 5 | | Lab Activities/ Home Works | 5 | 10 | | Quiz | 5 | 5 | | Class Participation | 5 | 5 | | Case Study/Tool Talk | 5 | 5 | | Midterm Exam | 2 | 15 | | Project | 1 | 15 | | Final Exam | 1 | 40 | | | | |
| **Course Coordinator** | Dr. Amna Basharat | | | |
| **URL (if any)** |  | | | |
| **Current Catalog Description** | Knowledge representation is one of the fundamental areas of Artificial Intelligence. It is the study of how knowledge about the world can be represented and manipulated in an automated way to enable agents to make intelligent decisions. This course will provide an overview of existing knowledge representation frameworks developed within AI including but not limited to propositional and first-order logic, ontologies, planning, reasoning and decision making under uncertainty. The assignments component of the course would provide hands-on experience of software like Prolog, Protégé, probabilistic reasoning APIs and tools to support complex decision making. It is expected that after completing this course, students will understand (a) the foundations of Knowledge Representation & Reasoning and (b) which tools and techniques are appropriate for which tasks. | | | |
| **Textbook** (or **Laboratory Manual** for Laboratory Courses) | 1. Stuard Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd Ed.) (2015) 2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 2nd Ed, 2017 3. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning, 2004 | | | |
| **Reference Material** |  | | | |
| **Course Goals** | | **A. Course Learning Outcomes (CLOs)** | | --- | | After completion of the course, the students shall be able to:   1. Understand the fundamentals of knowledge representation and reasoning in deterministic situations 2. Understand the challenges in representing knowledge and reasoning under uncertainty 3. Analyze different situations and apply appropriate knowledge representation frameworks 4. Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems 5. Conduct independent research on topics and latest trends in knowledge graphs, semantic web and linked data. 6. Design and develop a complete knowledge driven project, while working in a team, using the skills and knowledge gained through the course; and be able to present their work to peers. | | **B. Program Learning Outcomes (PLOs)** | | | **PLO 1** | Computing and Artificial Intelligence Knowledge | Apply knowledge of mathematics, natural sciences, computing fundamentals, and a computing specialization to solve complex computing problems using artificial intelligence techniques. | | --- | --- | --- | | **PLO 2** | Problem Analysis | Identify, formulate, research literature, and analyze complex computational problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, computing, and artificial intelligence. | | **PLO 3** | Design/Develop Solutions | Design solutions for complex computing problems and design systems, components, and processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. | | **PLO 4** | Investigation & Experimentation | Conduct investigation of complex computing problems using research based knowledge and research based methods | | **PLO 5** | Modern Tool Usage | Create, select, and apply appropriate techniques, resources and modern computing and artificial intelligence tools, including prediction and modelling for complex computing problems. | | **PLO 6** | Society Responsibility | Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to context of complex computing problems. | | **PLO 7** | Environment and Sustainability | Understand and evaluate sustainability and impact of professional computing and artificial intelligence work in solving complex computing problems. | | **PLO 8** | Ethics | Apply ethical principles and commit to professional ethics and responsibilities and norms of computing and artificial intelligence practice. | | **PLO 9** | Individual and Team Work | Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings. | | **PLO 10** | Communication | Communicate effectively on complex computing and AI activities with the computing and artificial intelligence community and with society at large. | | **PLO 11** | Project Management and Finance | Demonstrate knowledge and understanding of management principles and economic decision making and apply these to one's own work as a member or a team. | | **PLO 12** | Life Long Learning | Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes. |  | **C. Mapping of CLOs to PLOs**  (CLO: Course Learning Outcome, PLOs: Program Learning Outcomes) | | | | | | | | | | | | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | | **PLOs** | | | | | | | | | | | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | | **CLOs** | 1 | x |  |  |  |  |  |  |  |  |  |  |  | | 2 | x |  |  |  | x |  |  |  |  |  |  |  | | 3 | x | x | x | x | x |  |  |  |  |  |  |  | | 4 | x | x | x | x | x |  |  |  |  |  |  |  | | 5 | x |  |  |  |  |  |  |  | x | x |  | x | | 6 | x | x | x | x | x |  |  |  | x | x |  | x | | | | | |
| **Topics Covered in the Course, with Number of Lectures on Each Topic** (assume 15-week instruction and one-hour lectures) | | Topics to be covered: | | | | | --- | --- | --- | --- | | **List of Topics** | **No. of Weeks** | **Contact Hours** | **CLO(s)** | | **Introduction to KRR, Knowledge Graphs, Linked Data and the Web of Data;** The Story of the Web so far (Web 1.0 vs 2.0 vs 3.0); Understanding Data on the Web ; Towards a Universal Data Representation; Understanding the foundation of Semantic Web Technology, Knowledge, vs Information vs. Data. | **2** | **6** | **1,4** | | Semantic Networks, **Knowledge Graphs using Semantic Web Technologies such as RDF,** How to Represent Simple Facts with RDF, RDF and Turtle Serialization, RDF Data structures, RDF Reification, Model Building with RDFS, Logical Inference with RDF(S), RDF - RDF and the Web | **2** | **6** | **1,2,3,4** | | **Querying RDF Based Knowledge Graphs:** How to Query RDF(S) – SPARQL, SPARQL is more than a Query Language, Complex Queries with SPARQL, More Complex SPARQL Queries, SPARQL Sub-queries and Property Paths | **2** | **6** | **1,2,3,4** | | Ontologies and Ontology Languages, OWL (Web Ontology Langugage) | **2** | **6** | **2,3** | | Propositional Logic, First-order Logic, Horn Clauses, Description Logic, Reasoning using Description Logic, Forward and Backward Chaining in Inference Engines | **2** | **6** | **1,2,3,4** | | Logical Agents, Planning, Rule-based Knowledge Representation | **1** | **3** | **2,3** | | Reasoning Under Uncertainty, Bayesian Networks Representation, Inference in Bayesian Networks | **1** | **3** | **1,4** | | Fuzzy Logic, Inference using Fuzzy Rules, | **1** | **3** | **1,4** | | Markov Models, Commonsense Reasoning, Explainable AI. | **1** | **3** | **1,4** | | **Knowledge Representation Case Studies, Project Presentations** | **1** | **3** | **1,2,3,4** | | **Total** | **15** | **45** |  | | | | |
| **Laboratory Projects/Experiments Done in the Course** | **Tools/Technologies: RDF, SPARQL, Protégé, GraphDB, OWLViz, Virtuoso amongst others** | | | |
| **Programming Assignments Done in the Course** | Yes | | | |
| **Class Time Spent** (in hours) | **Theory** | **Problem Analysis** | **Solution Design** | **Social and Ethical Issues** |
| 28 | 10 | 5 | 2 |
| **Oral and Written Communications** | Every student is required to submit at least \_\_5\_\_\_ written reports of typically \_3-5\_\_\_\_ pages and to make \_\_2\_\_\_ oral presentations of typically \_\_\_\_10\_\_\_ minutes’ duration. | | | |