Daffodil International University

Department of Computer Science and Engineering (CSE)

Course Outline

Course Code:	CSE 426			
Course Title:	Principles Of Robotics			
Program:	B.Sc. in CSE			
Faculty:	Faculty of Science and Information Technology (FSIT)			
Semester:	Fall	**Year:**	2022	
Credit:	3.0	**Contact Hour:**	3Hrs/Week	
Course Level:	L4 T2	**Prerequisite:**	CSE133	
Course Category:	Core Engineering			
Instructor Name:	Mosharraf Hossain Khan (MHK)			
Designation:	Senior Lecturer			
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Class Hours:	**Section**	**Class Day**	**Class Hours**	**Classroom**
BLC Classroom Link:	https://elearn.daffodilvarsity.edu.bd/course/view.php?id=18204			

1. Course Rationale

This course will provide the basic knowledge about Robot, Types of Robots (manipulator, legged robot, wheeled robot, autonomous underwater vehicles), Use of Robots, Asimov's laws of Robotics, History of Robotics; Key components of Robot, Introduction, working principles and use of sensors (encoder, vision, force, pressure, smoke, accelerometer, gyroscope, odor, bend, touch, laser, tilt, compass, PIR, Infrared etc), working principles and use of different actuators (DC motor, servo motor, stepper motor etc); Spatial transformation and description, forward kinematics, backward kinematics etc. related to the movement of robot. Robot programming with AD conversion and interfacing of different hardware, sensors, actuators etc; Control theory of robotics, Introduction to Robot Operating System (ROS), Obstacle avoidance, object tracking and motion control etc, Advance robotic control and operations.

1.1. Course Objective

The objective of this course is to explain what robots are and what they can do. Knowledgeably discuss the ethical considerations of using robots to help solve societal challenges. Reflect on the future role and development of robotics in human society. Intuitively explain what does sensors and actuators do and how they can be used according to the specifications of the problem and nature of the environments. Design robot based on custom requirements.

1.2 Course Outcomes (CO's)

CO1	Able to identify, define and describe various robot structures, their application and selection of different components (Sensors, actuators, motor driver, controller etc) with their construction and working principles.
CO2	Able to solve the problems on spatial transformation and description, forward kinematics, backward kinematics etc. related to the movement of robot.
CO3	Able to illustrate the Workflow, Functional Control architecture for General and Industrial Robots, Communication terms and process, ROS etc.
CO4	Able to design, describe and analyze different robots based on the problem statement using the necessary hardware and software.
CO5	Able to apply robotics knowledge in design and implementation of various prototype robotic projects.

1.3 Program Outcomes (PO's)

Program Outcomes are reported in **Appendix -I**

1.4 Mapping of Course Outcomes (CO's) to Program Outcomes (PO's)

PO's / CO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	X											
CO2		X										
CO3					X							
CO4			X									

1.5 Mapping of CO-PO with Corresponding Learning Taxonomy

CO No.	CO Statement	Corresponding PO No.	Domain/level of learning taxonomy	Delivery methods and activities	Assessment tools
CO1	Able to identify, define and describe various robot structures, their application and selection of different components (Sensors, actuators, motor driver, controller etc) with their construction and working principles.	PO1	L1, L2	TLA1, TLA2	Midterm/Final (Direct Method)
CO2	Able to solve the problems on spatial transformation and description, forward kinematics, backward kinematics etc. related to the movement of robot.	PO2	L3	TLA1, TLA2	Midterm/Final (Direct Method)

CO3	Able to illustrate the Workflow, Functional Control architecture for General and Industrial Robots, Communication terms and process, ROS etc.	PO5	L1, L2	TLA1, TLA2	Midterm/Final (Direct Method)
CO4	Able to design and analyze different robots based on the problem statement using the necessary hardware and software.	PO3	L4, L6	TLA1, TLA2	Midterm/Final (Direct Method)

1.6 CO Assessment Scheme

Assessment Task	**CO's**				**Mark (Total=100)**
	CO1	**CO2**	**CO3**	**CO4**	
Attendance	--	--	--		7
Class Test (CT)	--	--	--		15
Assignment	--	--	--		5
Presentation	--	--	--		8
Midterm Examination	13	7	--	5	25
Semester Final Examination	10	10	10	10	40
Total Mark	**20**	**20**	**10**	**15**	**100**

2. Strategies and approaches to learning

2.1 Teaching and Learning Activities (TLA)

TLA1	Lectures twice a week using Whiteboard / multimedia of different topics.
TLA2	Active discussion in class regarding efficient solving of the logical and mathematical problems.
TLA3	Group discussion and presentation regarding diverse problems and corresponding lectures.
TLA4	Evaluation of class performances to reach each of the students in a class for every topic.

3. Course Schedule and Structure

3.1 Textbook

1. Introduction to Robotics – Analysis, Systems, Applications by Saeed B.Niku
2. Robot Operating System for Absolute Beginners by Lentin Josheph

3.2 Reference Books

1. Industrial Robotics – Technology, Programming, Applications by Mikell P Groover
2. Robot Building for Beginners by David Cook

3.3 Course Plan/Lesson Plan

Week/Lesson (hour)	Discussion Topic & Book Reference	Student Activities during Online and Onsite and TLA	Assessment and Mapping with CO
Week 1 Lesson 1 (1.5Hrs)	Introduction to OBE Course Outline, Definition of Robot, Asimov's Laws of Robotics, Classification of Robots **(Ref. Text Book and Slides)**	Students should have general ideas about the Introductory Robotics. **TLA1, TLA2**	CO1
Lesson 2 (1.5Hrs)	Types of Robots (manipulator, legged robot, wheeled robot, autonomous underwater vehicles, unmanned aerial vehicles), Use of Robots, Advantages and disadvantages of Robot **(Ref. Text Book and Slides)**	Students should have general ideas about the Different Types of Robot with Advantage and disadvantage. **TLA1, TLA2**	CO1
Week 2 Lesson 3 (1.5Hrs)	A complete Robot structure, Key Components of a Robot **(Ref. Text Book and Slides)**	Students should be able to explain the Components of Robot. **TLA1, TLA2**	CO1
Lesson 4 (1.5Hrs)	Introduction of sensors : classification of sensor, specification of sensor, attributes of sensors, detectable phenomenon, selection of sensors, Type of sensors. **(Ref. Text Book and Slides)**	Students should be able to mention the characteristics of Sensors in Robot. **TLA1, TLA2**	CO1
Week 3 Lesson 5 (1.5Hrs)	Working Principles of Sensors (Sensors based on EM Spectrum, Sensor Based on Sound, Odor Sensor, Proprioceptive Sensors, Problems in sensor choice and placement, Temperature sensor, Accelerometer, Light Sensor, Magnetic Field Sensor, Photogate Sensor, CO_2 Gas Sensor etc.) **(Ref. Text Book and Slides)**	Students should be able to explain working principles of Sensors in Robot. **TLA1, TLA2**	CO1
Lesson 6 (1.5Hrs)	Working Principles of Sensors (Touch Sensor, Tilt Sensor, Encoders sensor, Light Dependant Resistor (LDR) etc) **(Ref. Text Book and Slides)**	Students should be able to explain the working principle of Sensors. **TLA1, TLA2**	CO1
Week 4 Lesson 7 (1.5Hrs)	Working Principles of Sensors (Bend Sensor, Smoke Sensor, Ultrasonic Sensor, Pyro-Electric Infra-Red (PIR) sensor, Gyroscopic Sensor etc). **(Ref. Text Book and Slides)**	Students should be able to explain the working principle of Sensors. **TLA1, TLA2**	CO1
Lesson 8 (1.5Hrs)	Review of the previous classes		
Class Test 1			

Week/Lesson (hour)	Discussion Topic & Book Reference	Student Activities during Online and Onsite and TLA	Assessment and Mapping with CO
Week 5 Lesson 9 (1.5Hrs)	Robot as a System, Functional Unit of Robot, Force Sensors, Distance Sensor, Vision Sensor etc. **(Ref. Text Book and Slides)**	Students should be able to explain the working principle of Sensors. **TLA1, TLA2**	CO1
Lesson 10 (1.5Hrs)	Introduction to Simulator for Prototype Robotic Project (TinkerCad, Proteus etc) Embedded Systems Project vs Robotic Projects. Formation of project groups. **(Ref. Text Book, Slides, Online Recourses)**	Students should be able to learn robotic project simulation. **TLA1, TLA2**	CO4
Week 6 Lesson 11 (1.5Hrs)	Review of Transformation to Kinematics, Vector Operation, 2D Coordinate Vector Transformation, Review of Notation, Homogenous transformation, Describe a frame, 3D Position Vector, Rotation matrix, Coordinate Transformation, Review of Matrix Transpose, Kinematics: Forward Kinematic, Coordinate frames) **(Ref. Text Book and Slides)**	Students should be able to recap 2D and 3D transformation. **TLA1, TLA2**	CO2
Lesson 12 (1.5Hrs)	Spatial Description and Transformation (Rotation around axis, Vector in Space, Examples **(Ref. Text Book and Slides)**	Students should be able to robotic spatial transformation. **TLA1, TLA2**	CO2
Week 7 Lesson 13 (1.5Hrs)	Frame relative to a fixed reference frame, Rigid body, Pure translation, Pure Rotation, Combined Transformation, Inverse of Transformation Matrices) **(Ref. Text Book and Slides)**	Students should be able to robotic spatial transformation. **TLA1, TLA2**	CO2
Lesson 14 (1.5Hrs)	Spatial Description and Transformation (Problem and solution) **(Ref. Text Book and Slides)**	Students should be able to solve problems related to robotic spatial transformation. **TLA1, TLA2**	CO2
Class Test 2			
Week 8 Lesson 15 (1.5Hrs)	Robot Design (General Robot Design Process, Limbed Systems, Humanoid Robot) **(Ref. Text Book and Slides)**	Students should be able to explain the design procedure a prototype robot. **TLA1, TLA2**	CO4
	Assignment		
Lesson 16 (1.5Hrs)	**Review and Problem Solving**		
Exam Weeks (1/2/3)	**Midterm Exam**		

Week/Lesson (hour)	Discussion Topic & Book Reference	Student Activities during Online and Onsite and TLA	Assessment and Mapping with CO
Week 9 Lesson 17 (1.hHrs)	Working with actuators (Robot Join, Actuators, Actuators Control, Types of actuators, Electric Actuators, Components of Motor and working principles, Motor Application, DC Motor, DC-motor Control **(Ref. Text Book and Slides**)	Students should be able to explain the working principle of actuator. **TLA1, TLA2**	CO1
Lesson 18 (1.hHrs)	Stepper Motor operation, Advantage/Disadvantage, Control Sequence **(Ref. Text Book and Slides**)	Students should be able to explain the working principle of actuator. **TLA1, TLA2**	CO1
Week 10 Lesson 19 (1.5Hrs)	Servo Motor, Analog Sensors, Resistive Sensors, Resistive Position Sensor, Bend Sensor Application, A/D Converter **(Ref. Text Book and Slides**)	Students should be able to explain the working principle of analog sensors and AD Converter. **TLA1, TLA2**	CO1
Lesson 20 (1.5Hrs)	Finalization of Project Topics and groups. **(Ref. Text Book, Slides, Online Recourses**)	Students should be able to learn robotic projects. **TLA1, TLA2**	CO4
Week 11 Lesson 21 (1.5Hrs)	Forward Kinematics (Roll, Pitch and Yaw Angles, Denavit-Hartenberg Notations, Link and Joint Parameters, DH parameters) **(Ref. Text Book, Slides)**	Students should be able to explain the Forward Kinematics of Robot. **TLA1, TLA2**	CO2
Lesson 22 (1.5Hrs)	Forward Kinematics (DH techniques, Example and Problem Solving) **(Ref. Text Book, Slides**)	Students should be able to explain the Forward Kinematics of Robot. **TLA1, TLA2**	CO2
Week 12 Lesson 23 (1.5Hrs)	Robot Programming and Control (Introduction, Basic Workflow, Simple behaviour, Complex behaviour, Flowcharts, Robot Research software, Functional Control Architecture, Levels for Reference Model) (**Ref. Text Book and Slides)**	Students should be able to understand the Work flow of Robot Programming. **TLA1, TLA2**	CO3
Lesson 24 (1.5Hrs)	Industrial Robot: Functional Architecture, Interactions: Modules, ROS, ROS Components, Nodes, Topics, Services, Messages, ROS Master, Mobile Robot, ROS Tools **(Ref. Text Book, Slides)**	Students should be able to understand the Work flow of Robot Programming. **TLA1, TLA2**	CO3
Week 13 Lesson 25 (1.5Hrs)	**Review of the previous classes**		
Class Test 3			

Week/Lesson (hour)	Discussion Topic & Book Reference	Student Activities during Online and Onsite and TLA	Assessment and Mapping with CO
Lesson 26 (1.5Hrs)	Introduction ROS (ROS Characteristics, Software Framework, ROS Add Ons, rqt, RVIZ, Gazebo Simulator, ROS- enabled Operating Systems, Philosophy of ROS, ROS Terms) **(Ref. Text Book, Slides)**	Students should be able to explain the ROS characteristics and Philosophy. **TLA1, TLA2**	CO3
Week 14 Lesson 27 (1.5Hrs)	Introduction ROS (Message Communication Steps, ROS Message Diagram, ROS Shell Commands) **(Ref. Text Book, Slides)**	Students should be able to explain the ROS message communication systems. **TLA1, TLA2**	CO3
Lesson 28 (1.5Hrs)	Review of the previous classes and projects discussion		
Week 15 Lesson 29 (1.5Hrs)	**Project PRESENTATION by the students**	**Group Works** Demonstration of projects and Project Reports presentation **TLA3, TLA4**	CO4 CO5
Lesson 30 (1.5Hrs)	**Project PRESENTATION by the students**	**Group Works** Demonstration of projects and Project Reports presentation **TLA3, TLA4**	CO4 CO5
Week 16 Lesson 31 & 32 (3Hrs)	**Review and Problem Solving**		
Exam Weeks (1/2/3/4)	**Final Exam**		

4. Assessment Methods

4.1 Grading System

Numerical Grade	Letter Grade	Grade Point
80-100	A+	4.00
75-79	A	3.75
70-74	A-	3.50
65-69	B+	3.25
60-64	B	3.00
55-59	B-	2.75
50-54	C+	2.50
45-49	C	2.25
40-44	D	2.00
Less than 40	F	0.00

5. Additional Support for Students

- Student Portal: http://studentportal.diu.edu.bd/
- Academic Guidelines https://daffodilvarsity.edu.bd/article/academic-guidelines
- Rules and Regulations of DIU https://daffodilvarsity.edu.bd/article/rules-and-regulation
- Career Development Center: https://cdc.daffodilvarsity.edu.bd/
- For general queries: http://daffodilvarsity.edu.bd/

Appendix -I

Program Outcomes and Assessment

POs	Category	Program Outcomes
PO1	**Engineering Knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**	Identify, formulate, research the literature and analyze complex engineering problems and reach substantiated conclusions using first principles of mathematics, the natural sciences and the engineering sciences.
PO3	**Design/Development of Solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety as well as cultural, societal and environmental concerns.
PO4	**Investigations**	Conduct investigations of complex problems, considering design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
PO5	**Modern tool usage**	Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7	**Environment and sustainability**	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics, responsibilities and the norms of the engineering practice
PO9	**Individual work and teamwork**	Function effectively as an individual and as a member or leader of diverse teams as well as in multidisciplinary settings.
PO10	**Communication**	Communicate effectively about complex engineering activities with the engineering community and with society at large. Be able to comprehend and write effective reports, design documentation, make effective presentations and give and receive clear instructions.
PO11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work as a member or a leader of a team to manage projects in multidisciplinary environments.
PO12	**Life Long Learning**	Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the broadest context of technological change.