KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year 1st Term Examination, 2019

ME 4083

(Robotics)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

1(a) Define the term 'Robot'. What can robots do? Briefly explain the history of major events in the development of industrial robots. 12

1(b) Compare Robot with human labor and explain the importance of robot in this case. 08

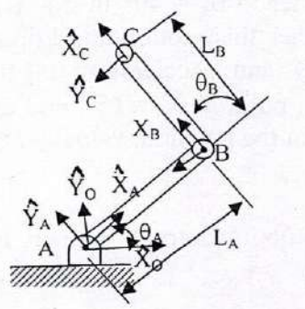
1(c) Write short notes on : 06
(i) Manipulator (ii) Mobile Robot

1(d) As a Robotics engineer, you are planning to start a Robot company. Which kind of robots you will focus to bring in market? Justify your decision by explaning the evolution of robots and the trend of global market outlook of robots for last two decades. 09

2(a) Derive the rotation matrix for the mapping involving rotate frames which is rotated along the z-axis. 07

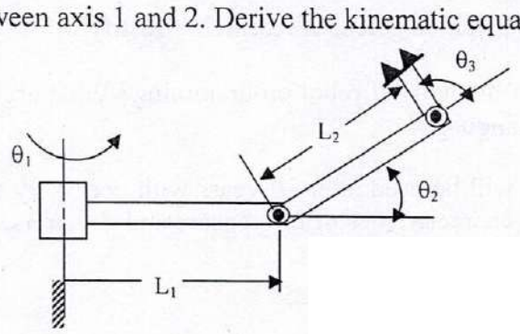
2(b) Suppose, frame {A} is the universal coordinate system. Frame {B} is rotated relative to frame {A} about $\hat{X}$ by 60°, translated 30 unit in $\hat{Y}_A$, and translated 15 unit in $\hat{Z}_A$. Draw both frames and find A_P, where $B_P = [0\ \ 7\ \ 9]^T$. 08

2(c) A two-link manipulator with rotational joints is shown in figure. Derive the velocity equation of the tip of the arm as a function of joint rates. Give the answer in two forms – in terms of frame {C} and also in terms of frame {A}. Find the Jacobians in both cases and mention the points of singularity. 20

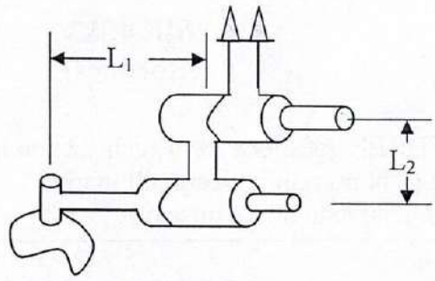


3(a) What is forward kinematics and inverse kinematics? 07

3(b) The arm with three degree of freedom shown in figure. All three joints are revolute and the joint 1's axis is not parallel to the other two. There is a twist of 90 degrees in magnitude between axis 1 and 2. Derive the kinematic equations for ${}^{B}_{W}T$. 15



3(c) For the following robotic manipulator which shows a three-link, 3R manipulator for which joint axis 1 and 2 intersect and axis 2 and 3 are parallel. Find out its Denavit – Hartenberg parameters. 13



4(a) Write a short note on "Jacobians". 05

4(b) Derive the velocity propagation equation from link {i} to link {i + 1} with necessary sketch. 15

4(c) A two-link manipulator consists of two revolute joints. Calculate the velocity of the tip of the manipulator as a function of joint rates. Also calculate the Jacobian matrix. 15

SECTION-B

5(a) What is sensor? Describe the mechanism of following sensors with their applications: 15
(i) Piezoelectric sensor, (ii) LVDT sensor, and
(iii) Eddy current proximity sensor.

5(b) Briefly explain the importance of sensors and actuators in robotics. 08

5(c) Define actuator. Also explain the characteristics of different actuators commonly used in Robotics. 12

6(a) Define path and trajectory? Differentiate the path generation between joint space and Cartesian space. 08

6(b) Derive the equations of motion of a robot trajectory by using the cubic polynomial with a via points. 10

6(c) A single-link robot with a rotary joint is motionless at $\theta_0 = 5°$. It is desired to move the joint in a smooth manner to $\theta_g = 40°$ in 2 s. (i) Find the coefficients of a cubic polynomial that accomplishes this motion and brings the manipulator to rest at goal. Plot the position, velocity and acceleration of the joint as a function of time. (ii) Consider, there is a via point at $\theta_v = 15°$, and each segment lasts 1 s. Derive the equations of motion and plot the position, velocity and acceleration graphs. 17

7(a) What is the purpose of Robot control? Explain feed forward and feed backward control for robotic systems. 12

7(b) Derive the control law for force control of a mass-spring system. 14

7(c) Define the following control terms: 09
(i) Open–loop, (ii) Closed–loop, and (iii) Transfer function.

8(a) Robotics is a multi-disciplinary field of research – Justify. 07

8(b) Mention the different methods of robot programming? What are the requirements of a robot programming language? 13

8(c) Design a Robot that will be used after 20 years with necessary sensors and actuators. Explain the required characteristics of the sensors and actuators, and the trajectory the robot should follow. Sketch the robot. 15

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