ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING

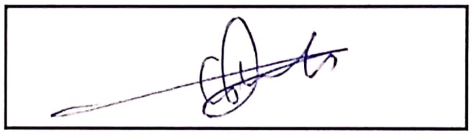
SECOND SEMESTER EXAMINATION, 2018/2019 ACADEMIC SESSION

COURSE TITLE: ROBOTICS AND AUTOMATION

COURSE CODE: ECE 526

EXAMINATION DATE: JULY 10, 2019

COURSE LECTURER: DR. O.K. OGIDAN & MR. ISAAC ELESEMOYO



HOD's SIGNATURE

TIME ALLOWED: 3 HOURS

INSTRUCTIONS:

1. ANSWER FOUR QUESTIONS ONLY, **QUESTION SIX IS COMPULSORY**.
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE **NOT** ALLOWED TO BORROW ANY WRITING MATERIALS DURING THE EXAMINATION.

QUESTION #1

a. What is a Robot? [1 mark]
b. List and the Discuss exhaustively the classes of Robots. [8 marks]
c. Derive the inverse kinematics for a two-link planar robot, given (x, y) coordinate. [6 marks]

QUESTION #2

a. Kinematics studies the inter-relationship existing between objects that are in motion.
   i. Define the term forward kinematics of a robot [2 marks]
   ii. Define the term reverse kinematics of a robot [2 marks]
   iii. Define the term Degree of freedom [1 mark]

b. Using Denavit-Hartenberg convention, write out the forward kinematics homogenous transformation representation of the robotic system illustrated in Figure 1.0.
[10 marks]

Hint: Remember to label the links, joints and origin appropriately

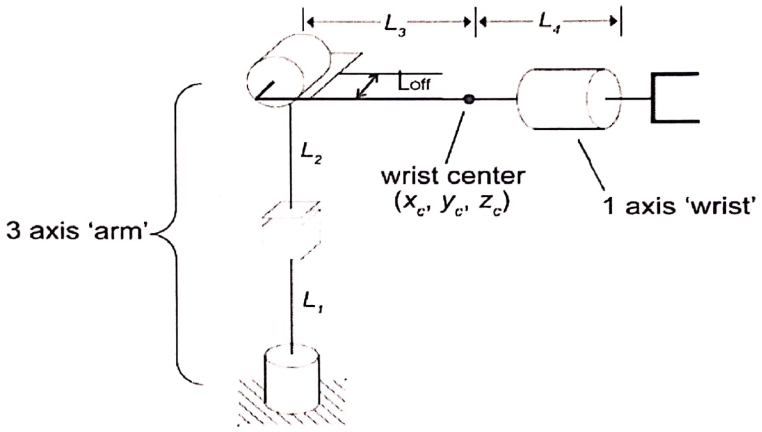


Figure 1.0: A 4 DOF Robot

QUESTION #3

a. Given in Figure 2 is a three (3) joint robot manipulator.
   i. Profer solution to the forward kinematic problem. [5 marks]
   ii. Develop the table representing the Denavit-Hatnberg parameters for the manipulator in question 3a. [5 marks]

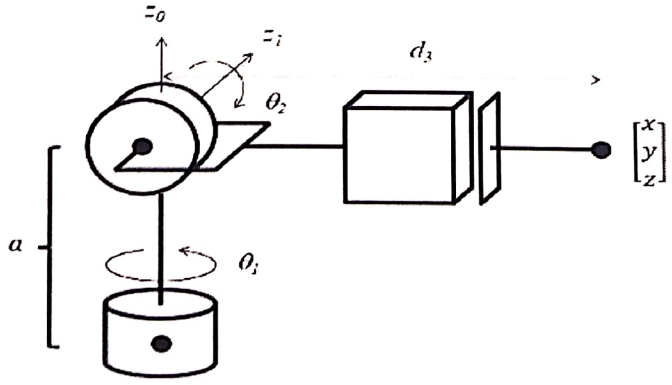


Fig. 2.0: A 3 Joint Robot Geometry

b. Solve the inverse kinematics problem presented in Figure 4, given that link d3 >= 0 and the end effector location is (x, y, z) T [5 marks]

Hint: Rotation matrix about x, y and z axes, and Homogeneous transformation matrix are given by:

$$R_X = \begin{bmatrix} 1 & 0 & 0 \\ 0 & cos\theta & -sin\theta \\ 0 & sin\theta & cos\theta \end{bmatrix} \quad R_Y = \begin{bmatrix} cos\theta & 0 & sin\theta \\ 0 & 1 & 0 \\ -sin\theta & 0 & cos\theta \end{bmatrix} \quad R_Z = \begin{bmatrix} cos\theta & -sin\theta & 0 \\ sin\theta & cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$H = \begin{bmatrix} C\theta & -S\theta C\alpha & S\theta S\alpha & rC\theta \\ S\theta & C\theta C\alpha & -C\theta S\alpha & rS\theta \\ 0 & S\alpha & C\alpha & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

QUESTION #4

a) You have been asked to develop a visual servo based robot using RGB camera. Your robot processes the ability to detect and classify objects; describe the stages involved in processing the image obtained from the camera with a detailed sketch [4 marks]

b) What are the two types of robot joints that are available? Define the Degree of Freedom (DOF) of a robot [4 mark]

(i.) Explain with the aid of a neat diagram, the three wrist motion associated with a robot wrist [2 mark]

c) Itemize the sources of energy in robots. Describe the important features of servo and stepper motors by emphasizing their limitations. [5 marks]

QUESTION 5

a.) What do you understand by automatic control system? [2 marks]

b.) With the aid of well labelled diagram (where necessary) discuss the differences between fixed/permanent automation and flexible/programmable automation. [4 marks]

c.) Briefly discuss the following (include diagrams where necessary)

i.) Pneumatic control system [1 marks]

ii.) Hydraulic control system [1 marks]

iii.) Electrical control system [1 marks]

d.) Consider the system given in Figure 3 where an electric motor is driving a gear train which is driving a winch. The motor (under these conditions) turns at 100 rpm for each Volt (V) supplied; the output shaft of the gear train rotates at one-half of the motor speed; the winch (with a 3-inch shaft circumference) converts the rotary motion (rpm) to linear speed.

i.) Calculate the overall transfer function of the system [4 marks]

ii.) Calculate the system output if the input to the system (gear) is 9 volts. [2 marks]

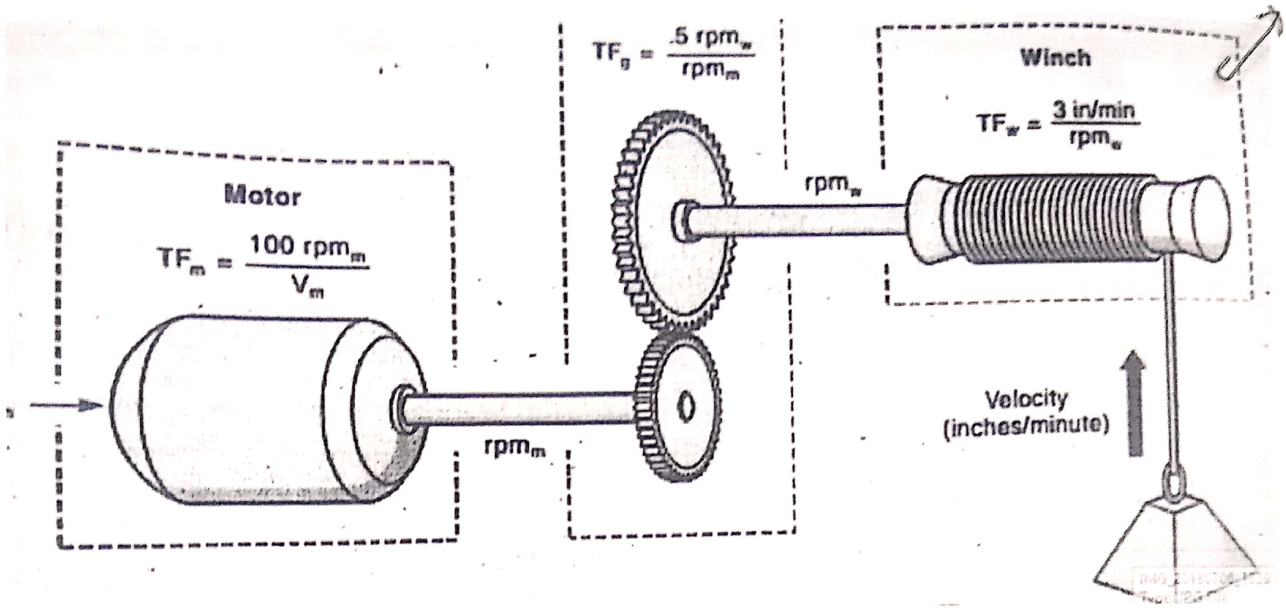


Figure 3: On/off controls for jars filling

QUESTION 6

a.) What are the differences between open loop and closed loop control system? [2 marks]

b.) List the programming languages commonly used for programming a Programmable Logic Controllers (PLC). [2 marks]

c.) Discuss the differences between a microcontroller and a microprocessor [5 marks]

d.) You are a power system engineer in a developing power distribution company. The power generation available to you is not enough - just one third (1/3) of the power required for the city. As a result, there is the need for load-shedding. The city under your control had been grouped into four divisions namely:

- Residential area = pin 3
- Industrial area = pin 4
- Commercial area = pin 7
- University Teaching Hospital = pin 6

i.) Prepare in a tabular form how you will implement a load-shedding activity within a period of twenty four (12) hours. (Hint: use 1 second to represent 1 hour) [3 marks]

ii.) Write a program that will implement the load-shedding plan using a modern power distribution controller [3 marks]

iii.) Draw a flowchart of the program you have written to implement the load shedding. [2 marks]