MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING
FIFTH YEAR ….. SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 509: ROBOTICS AND AUTOMATION

DATE: **TIME:**

INSTRUCTIONS

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Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY)(30 MARKS)

a) Define the following terms:

i) Automation. (2 marks)

ii) Define an industrial robot (2 marks)

b) Describe at least five applications of Inductive sensors (5 marks)

c) With the help of a neat sketch, describe an 'articulated robot' (6 marks)

d) A feeder-selector device at one of the stations of an automated assembly machine has a feed rate of 25 parts per minute and provides a throughput of one part in four. The ideal cycle time of the assembly machine is 10 sec. The low-level sensor on the feed track is set at 10 parts, and the high-level sensor is set at 20 parts. (i) How long will it take for the supply of parts to be depleted from the high-level sensor to the low-level sensor once the feeder-selector device is turned off? (ii) How long will it take for the parts to be resupplied from the low-level sensor to the high-level sensor, on average, after the feeder-selector device is turned on? (iii) What proportion of the time the assembly machine is operating will turn the feeder-selector device on? Turned off? (6 marks)

e) The coordinates of an end effector point q_{abc} are given by $(5,3,2)^{T,}$ which are rotated about the X-axis of the reference frame XYZ, by the angle of 30°. Determine the coordinates of the point q_{xyz} (3 marks)

f) The following logic will be followed in automating a system, including the conveyor and milk filling line using the PLC system.

Switch 1 pressed, Lights Q0, Q1, Q2 and Q3 are on

Switch 2 pressed, Lights Q0 and Q3 are OFF

Switch 3 pressed, Lights Q1 is OFF and Q3 are on

Switch 4 pressed, Lights Q2 is OFF and Q0 is again ON

Draw the ladder logic network to represent the logic activities. (6 marks)

QUESTION TWO (20 MARKS)

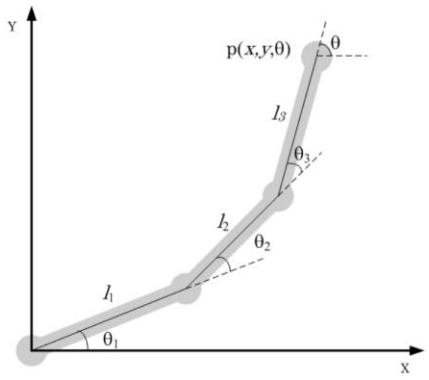
a) Distinguish the two types of solenoid valves used in electro-pneumatic systems.(2 marks)

b) Describe the functionality of four Non-contact sensors. (4 marks)

c) Describe the five basic motions or degrees of freedom in a robot (5 marks)

d) Outline five factors that influence the layout of a Flexible Manufacturing System (FMS). (5 marks)

e) Given the following robot arm configurations, determine the position of the end effector p (x, y, Θ). $l_1 = 15mm, l_2$ = 20mm, l_3 = 25mm, θ_1 = 18°, θ_2 = 25°, θ_3 = 35° (4 marks)



QUESTION THREE (20 MARKS)

a) Which are the two types classification of Limit switches depending upon method of actuations of contacts (2 marks)

b) Distinguish two types of electronic sensors classified by the polarity of output voltage.

(4 marks)

c) Draw a schematic representation of a parts delivery automated system and describe the purposes of the various critical parts of the system. (6 marks)

d) Considering the NOT logic gate in PLC, illustrate the NOT logic gate truth table and draw a simple ladder logic network. (4 marks)

Input	out
0	1
1	0

e) A robot performs a loading and unloading operation for a machine tool as follows:

- The robot picks up part from the conveyor and loads it into a machine (Time=5.5 sec)
- Machining cycle (automatic). (Time=33.0 sec)
- Robot retrieves part from machine and deposits to the outgoing conveyor. (Time=4.8 sec)
- The robot moves back to the pickup position. (Time=1.7 sec)

Every 30 work parts, the cutting tools in the machine are changed which takes 3.0 minutes. The uptime efficiency of the robot is 97%, and the uptime efficiency of the machine tool is 98% which rarely overlaps. Determine the hourly production rate. (4 marks)

QUESTION FOUR (20 MARKS)

a) Outline two disadvantages of direct control pneumatics (2 marks)

b) List five factors affecting the choice of indexing mechanism for an assembly machine (5 marks)

c) Discuss FOUR types of Flexible Manufacturing Systems (FMS) (4 marks)

d) Describe the two general categories of feed tracks in parts delivery automation (4 marks)

e) An eight-station assembly machine has an ideal cycle time of 6 sec. The fraction defect rate at each of the 8 stations is q = 0.015 and a defect always jams the affected station. When a breakdown occurs, it takes 1 minute, on average, for the system to be put back into operation. Determine the production rate for the assembly machine, the yield of a good product (final assemblies containing no defective components), and the proportion uptime of the system. (5 marks)

QUESTION FIVE (20 MARKS)

a) Outline two advantages of capacitive sensors in robotics (2 marks)

b) List and outline the functions of four basic types of sensors used in robotics. (4 marks)

c) Describe at least four advantages of a Programmable Logic Controller (PLC) control system (4 marks)

d) Draw a PLC ladder logic network that represents the following switch and output for the automation of a machine

Switch 1 or Switch 2 pressed, lamps Q0 and Q1 should be ON

Switch 3 pressed, lamps Q0 and Q1 should be OFF (4 marks)

e) Describe four types of Controllers used in Robotics. (6 marks)