



MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 509: ROBOTICS AND AUTOMATION

DATE

TIME

INSTRUCTIONS

This examination contains TWO SECTIONS-SECTION A AND SECTION B

SECTION A IS COMPULSORY

Select ANY TWO questions in SECTION B

SECTION A (COMPULSORY)

QUESTION ONE. (30 MARKS)

- a) Define the following terms: (2 marks)
- b) Describe at least five applications of Inductive sensors (5 marks)
- c) With the help of a neat sketch, give the description of '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 that the assembly machine is operating will the feeder-selector device be turned 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 X-axis of the reference frame XYZ, by angle of 30° . Determine the coordinates of the point q_{xyz} (3 marks)

- f) The following logic is to be followed in the automation of 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)

SECTION B – SELECT ANY TWO QUESTIONS

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). $l_1 = 15mm$, $l_2 = 20mm$, $l_3 = 25mm$, $\theta_1 = 18^\circ$, $\theta_2 = 25^\circ$, $\theta_3 = 35^\circ$ (4 marks)

QUESTION THREE. (20 MARKS)

- a) Which are the two types of classification of Limit switches depending upon the method of actuation of contacts (2 marks)
- b) Distinguish two electronic sensor types classified by the output voltage's polarity. (4 marks)
- c) Draw a schematic representation of a parts delivery automated system and describe the purposes of the various key 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. (3 marks)
- e) A feeder-selector device at one of the stations of an automated assembly machine has a feed rate of 17 parts per minute and provides a throughput of three parts in four. The ideal cycle time of the assembly machine is 5 sec. The low-level sensor on the feed track is set at 10 parts, and the high-level sensor is set at 34 parts. Compute the total cycle time of depletion and supply upon tuning off feeder-selector device (depletion) and turning on the feeder-selector device(re-supply)? (5 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) Draw a PLC ladder logic network that represents the following switch and output for 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)
- c) List and outline the functions of four basic types of sensors used in robotics. (4 marks)
- d) A robot performs a loading and unloading operation for a machine tool as follows:

Robot pick up part from conveyor and loads into machine (Time=5.5 sec)
Machining cycle (automatic). (Time=33.0 sec)
Robot retrieves part from machine and deposits to outgoing conveyor. (Time=4.8 sec)
Robot moves back to 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 overlap.
Determine the hourly production rate. (5 marks)
- e) Describe at least FIVE advantages of a Programmable Logic Controller (PLC) control system (5 marks)