



MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 509: ROBOTICS AND AUTOMATION

DATE: 7/12/2021

TIME: 11.00-1.00 PM

INSTRUCTIONS

- (a) This examination contains TWO SECTIONS-SECTION A AND SECTION B
- (b) SECTION A IS COMPULSORY
- (c) Select ANY TWO questions in SECTION B

SECTION A -COMPULSORY

QUESTION ONE (30 MARKS)

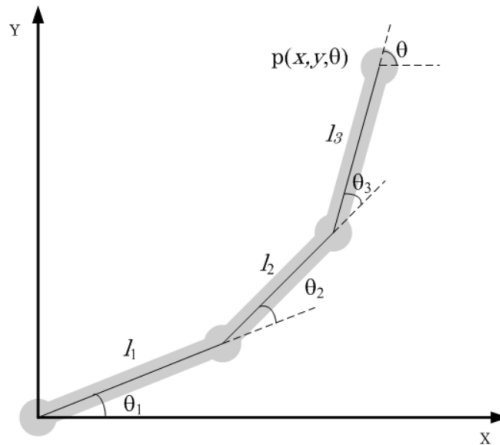
- a) Define an industrial robot (1 mark)
- b) Distinguish the two types of solenoid valves used in electro-pneumatic systems. (2 marks)
- c) State and describe the functionality of four Noncontact sensors. (4 marks)
- d) Discuss FOUR types of Flexible Manufacturing Systems (FMS) (4 marks)
- e) Outline the FOUR steps in the operations of a Programmable Logic Controller (PLC) (4 marks)
- f) 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)

- g) The coordinates of an end effector point q_{abc} are given by $(6,4,2)^T$ 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)
- h) Provide a comparison of at least three types of robots based on co-ordinate systems and enumerate the merits and demerits of each type. (6 marks)

SECTION B – SELECT ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

- a) Define the term automation. (2 marks)
- b) Using a diagram to describe how a simple basic PLC wiring works for both start and stop button. (4 marks)
- c) List five factors affecting the choice of indexing mechanism for an assembly machine. (5 marks)
- d) Outline the 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). $l_1 = 10mm, l_2 = 12mm, l_3 = 14mm, \theta_1 = 10^\circ, \theta_2 = 15^\circ, \theta_3 = 15^\circ$ (4 marks)



QUESTION THREE (20 MARKS)

- a) Define what a Programmable Logic Controller (PLC) is. (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 key parts of the system. (6 marks)
- d) List and outline the functions of four basic types of sensors used in robotics. (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. (4 marks)

QUESTION FOUR (20 MARKS)

- a) Outline two advantages of capacitive sensors in robotics (2 marks)
- b) Describe the two general categories of feed tracks in parts delivery automation. (4 marks)
- c) Outline the characteristics an End-of-arm tooling in a robot work cell should have. (5 marks)
- d) Describe the various factors that are requisite when specifying a Programmable Logic Controller (PLC) for a certain function (5 marks)
- 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 overlap. Determine the hourly production rate. (4 marks)

QUESTION FIVE (20 MARKS)

- a) Which are the two classification of Limit switches that depend upon the method of actuation of contacts (2 marks)
- b) Outline the four types of robot control systems (4 marks)
- c) Describe at least four advantages of a Programmable Logic Controller (PLC) control system (4 marks)
- d) Outline the key points that should be observed while working with electro-pneumatic systems (4 marks)
- e) Describe four types of joints considered in the robotics anatomy. (6 marks)