



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FIFTH YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 509: ROBOTICS AND AUTOMATION

DATE: 25/3/2021

TIME: 8.30-10.30 AM

INSTRUCTIONS

- This paper contains of **FIVE** questions
- Answer question **one** and **any other two** questions
- Question **one** carries **30 Marks** and all the others carries **20 Marks** each
- Remember to indicate all steps and the relevant units in your calculations

QUESTION ONE (30 MARKS)

- a) Differentiate between the following terms in relation to robots
- links and joints (2 marks)
 - orientation axes and position axes (2 marks)
 - accuracy and repeatability (2 marks)
 - tool coordinates and joint coordinates (2 marks)
 - spatial resolution and control resolution (2 marks)
- b) Using simple diagrams, illustrate the different configurations of robots and in each give the number of revolute or prismatic joints. (10 marks)
- c) Several factors are considered in the design of End of Arm Tooling. Give at least 5 factors that are considered and in each explain at least 2 examples. (10 marks)

QUESTION TWO (20 MARKS)

- a) The payload is always specified as a maximum value that can be carried by a robot before failure of the joints and links or before any serious performance loss. Explain the two considerations made in designing for the payload giving examples in each. (4 marks)
- b) Using diagrams explain the four major configurations of typical gripper mechanisms as used in End of Arm Tooling Applications. (8 marks)
- c) Using a simple flow diagram, explain the basic components that make a robot (8 marks)

QUESTION THREE (20 MARKS)

- a) Give the two major classifications of End of Arm Tooling and explain two sub-classifications of each. (4 marks)
- b) Vacuum grippers use suction cups to grab onto items when used as End of Arm Tooling. Give 4 advantages and 2 disadvantages of using them as grippers. (3 marks)
- c) Explain the three contact gripper methods that do not require mechanical mechanisms to hold materials. (3 marks)
- d) Actuators in robots are powered by different types of power sources. Name the three major power sources and in each give at least 3 advantages and 1 disadvantage. (10 marks)

QUESTION FOUR (20 MARKS)

- a) Give at least 10 industrial or professional applications of robots. (5 marks)
- b)
 - i What do you understand by work envelope of a robot? (1 marks)
 - ii Sketch the top view of the work envelope of a SCARA robot and explain the typical application of it. (2 marks)
- c)
 - i Show the components of a homogeneous transformation matrix (H). (2 marks)
 - ii Derive (H) that represents a rotation of α degrees about the current x-axis followed by a translation of b units along the current x-axis, followed by a translation of d units along the current z-axis, followed by a rotation of θ degrees about the current z-axis. (5 marks)
- d) What do you understand by autonomously guided robots and how do they work? (3 marks)
- e) Give four disadvantages of legged robots compared to wheeled robots. (2 marks)

QUESTION FIVE (20 MARKS)

- a) State the forward kinematic problem and differentiate it from the inverse kinematic problem. Why is the inverse kinematic problem more difficult to solve? (4 marks)
- b) Denavit - Hartenberg method is often used to obtain forward kinematics for a robot mechanism in a systematic manner. For the 6-DOF Stanford Manipulator shown in Fig. Q. 5 (b);
 - i. Assign coordinate frames to every joint and show the direction of the link angles on the sketch. Hint: Base link is rotating clockwise.
 - ii. Fill in the link parameter table. (16 marks)

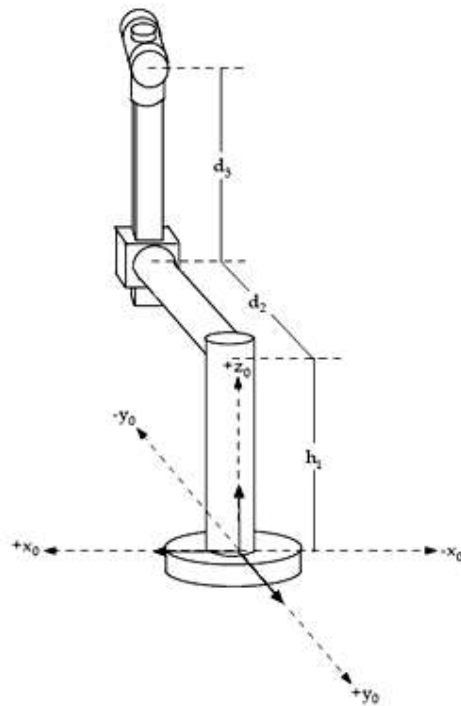


Figure 1: Question 5b