



TECHNICAL UNIVERSITY OF MOMBASA

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONICS ENGINEERING

EEE 4518: ROBOTIC SYSTEMS MODELLING

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: April 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions.

Answer QUESTION ONE AND ANY OTHER TWO questions.

Do not write on the question paper.

QUESTION ONE (30 Marks)

- (a) In relation to the study of robotics describe the following terms. [6 Marks]
- (i) Kinematics
 - (ii) Frame
 - (iii) Degrees of Freedom
- (b) Distinguish between Translation, Rotation and Transformation as used in robotic, give an example in each case. [6 Marks]

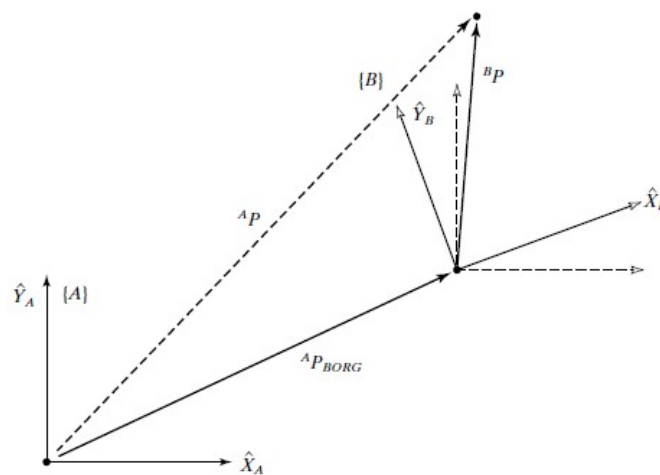
(c) A vector ${}^A P$ is rotated about $\hat{Y}_A$ by 30 degrees and is subsequently rotated about $\hat{X}_A$ by 45 degrees. Give the rotation matrix that accomplishes these rotations in the given order.

[10 Marks]

(d) Figure 1 shows a frame {B}, which is rotated relative to frame {A} about $\hat{Z}$ by 30 degrees, translated 10 units in $\hat{X}_A$, and translated 5 units in $\hat{Y}_A$. Find ${}^A P$, where ${}^B P = [3.0 \ 7.0 \ 0.0]^T$.

[8 Marks]

Figure 1



QUESTION TWO (20 Marks)

(a) Figure 2a shows a three-link planar arm. Assign link frames to the mechanism and give the Denavit-Hartenberg parameters

[10 Marks]

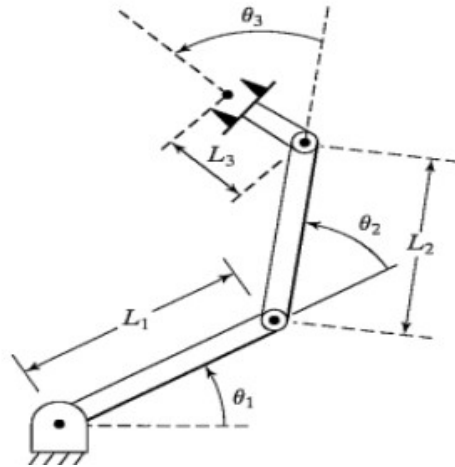


Figure 2a

- (b) Describe any TWO types of manipulator joints [4 Marks]
- (c) Assign link frames to the RPR planar robot shown in Figure 2b, and give the linkage parameters. [6 Marks]

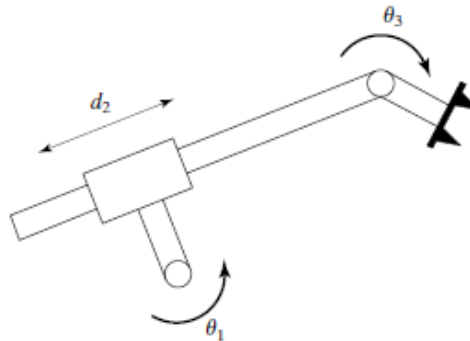


Figure 2b

QUESTION THREE (20 Marks)

- (a) Describe the following terms as employed in robotic [4 Marks]
- (i) Trajectory
 - (ii) Effector
- (b) You are designing a robotic arm to perform a pick-and-place operation in a manufacturing setting. The arm needs to pick objects from one location and place them at another. Describe the key aspects of trajectory planning for this robotic arm, including the methods and

considerations involved. Provide a step-by-step explanation of how you would plan the trajectory for this task. [10 Marks]

(c) Distinguish between joint spaces and Cartesian spaces as used in robotics [6 Marks]

QUESTION FOUR (20 Marks)

(a) For the following frame, find the values of the missing elements and complete the matrix representation of the frame: [10 Marks]

$$F = \begin{bmatrix} ? & 0 & ? & 5 \\ 0.707 & ? & ? & 3 \\ ? & ? & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(b) A vector is described as $p = 3i + 5j + 2k$ [6 Marks]

(i) Express the vector in Matrix form with a scale factor of 2

(ii) Write the vector as a unit vector

(c) A vector p is 5 units long and is in the direction of a unit vector q described below. Express the vector in matrix form [4 marks]

QUESTION FIVE (20 Marks)

(a) Discuss the THREE levels of robot programming [6 Marks]

(b) Figure 3 shows an automated work-cell that completes a small subassembly in a manufacturing process. It consists of a conveyor under computer control that delivers a workpiece; a camera connected to a vision system, used to locate the workpiece on the conveyor; an industrial robot equipped with a force-sensing wrist; a small feeder located on the work surface that supplies another part to the manipulator; a computer-controlled press that can be loaded and unloaded by the robot; and a pallet upon which the robot places finished assemblies. Outline the entire process as controlled by the manipulator's controller in a sequence. [14 Marks]

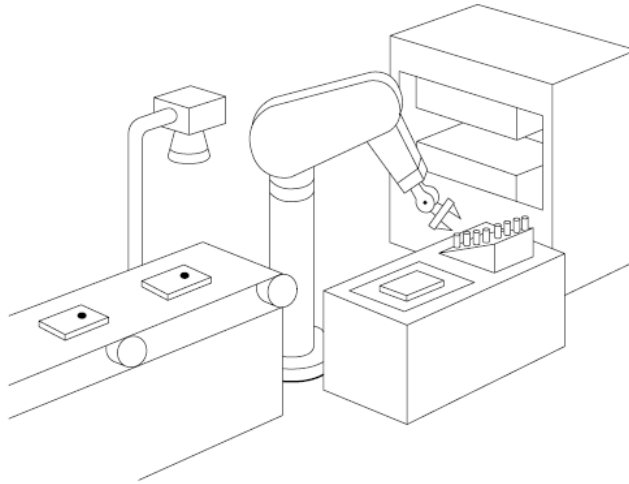


Figure 3