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UNIVERSITY EXAMINATIONS 2024/2025

FOURTH YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

EET 3432: ROBOTICS AND AUTOMATION

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) A robot equipped with predictive maintenance software detects a degradation in motor performance. The algorithm predicts a 2% decrease in performance every day due to wear and tear. How many days will it take for the performance to drop below 80%? (4 Marks)

b) Explain the concept of degrees of freedom in robotic manipulators highlighting how the number of DOF affect a robot's workspace and flexibility (4 Marks)

c) You are assigned the task of designing a vision system for detecting defects in an automated assembly line. Discuss the design in the following aspects:

   i. **System Components** (4 Marks)
   ii. **Processing Steps** (4 Marks)
   iii. **Control Mechanisms** (3 Marks)

d) Discuss the following key aspects of automation and robotics,

i. robot anatomy,
ii. work volume,
iii. drive systems,
iv. control systems,
v. end effectors,
vi. sensors, (6 Marks)

e) Determine the position of the end-effector for a 2-link robotic arm (refer to fig. Q1e.) using the provided joint angles and link lengths. Link 1 has a length of 5 units, Link 2 is 6.3 units long, with joint angles $\theta_1 = 30°$ and $\theta_2 = 64°$. (5 Marks)

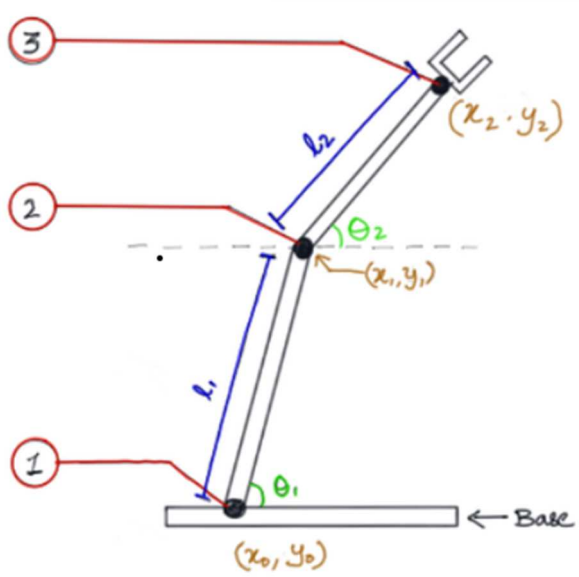

Fig .Q1e

QUESTION TWO (15 MARKS)

You are tasked with designing a robotic arm for a pick-and-place application in a factory setting. The robot must be able to pick small, fragile items and place them accurately on a conveyor belt.

a) Specify the kinematic structure (DOF, joints, and link lengths). (5 Marks)

b) Suggest which sensors (tactile, proximity, etc.) would be required and why. (5 Marks)

c) Describe the control strategy you would implement to achieve precise and safe movement. (5 Marks)

QUESTION THREE (15 MARKS)

a) In an automated assembly line, a robot uses machine vision to inspect products. If the system detects defects in 1% of the products and can inspect 1000 products per hour, Compute how many defective products are expected in a 24-hour production cycle. Additionally, discuss ways in which AI techniques be employed to reduce this defect rate. (9 Marks)

b) Discuss how simulations contribute to the design and testing of robotic programs before physical deployment (6 Marks)

QUESTION FOUR (15 MARKS)

a) A machine vision system is required to sort objects by color and size on a conveyor belt. Describe how you would implement this system, detailing the following steps as involved:

   i. System Components
   ii. Processing Steps
   iii. Control Mechanisms
   iv. System Calibration and Training (11 Marks)

b) Discuss the following terms as applied to robotics and automation

   i. Forward Kinematics
   ii. Inverse Kinematics
   iii. Denavit-Hartenberg (D-H) Parameters (4 Marks)

QUESTION FIVE (15 MARKS)

a) Discuss ways in which the implementation of automated systems in manufacturing industries enhance efficiency, improve quality, and boost overall competitiveness (8 Marks)

b) Determine the joint angle required to place the end-effector's position for a 3-link robotic arm (x= 3, y=7) with the following lengths refer to fig Q5b.: Link 1 is 5 units long, Link 2 is 6.3 units long, link 3= 7 units. (7 Marks)

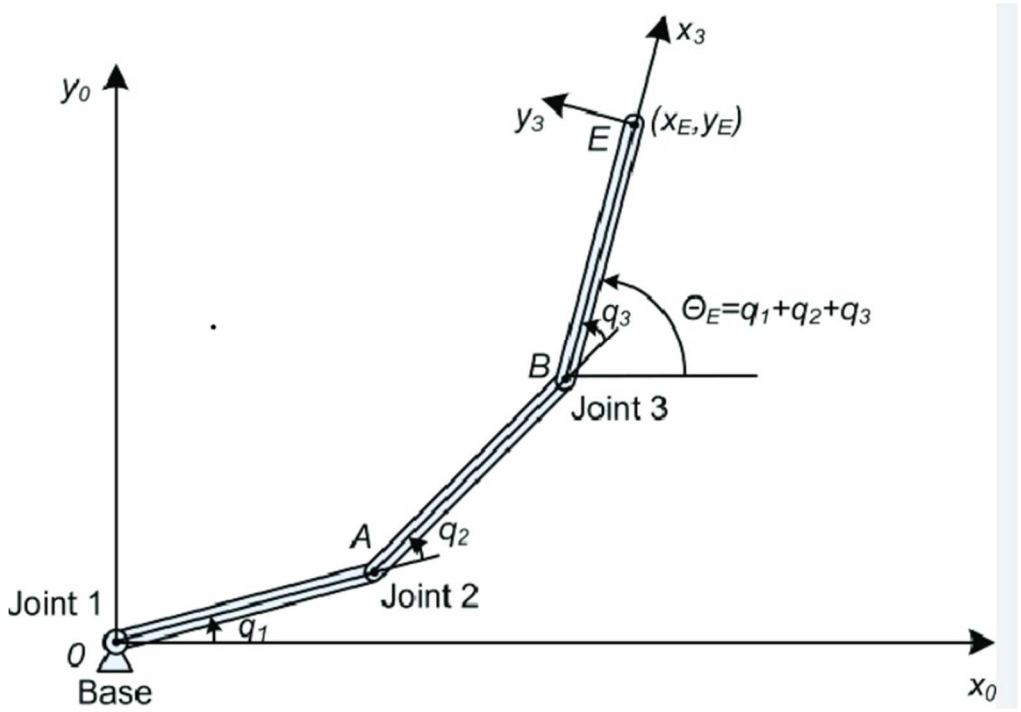

Fig. Q5b