

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

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Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX7303 Control of Robotic Manipulators
Academic Year	: 2022/23
Date	: 05 th February 2024
Time	: 1330 -1630 hrs.
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions. Answer **All** questions.
3. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use Red colour pen.

Question 01

- (a) Industrial robotic manipulators are widely employed to perform various tasks in modern factory environments. Differentiate robotic manipulators from other types of robots.
(05 Marks)
- (b) Around 80% of the robots used in industry in the world today are of the First generation type. Even though the evolution has leaped to Fourth generation, what are the reasons for the use of First generation robots in the industry? Elaborate by taking suitable examples.
(06 Marks)
- (c) Three types of robotic manipulators can be found when classifying robotic manipulators based on its control system/mechanism. Briefly discuss these three types along with their applications in industry.
(09 marks)

Question 04

- (a) What does the Jacobian matrix mean in relation to robotic manipulators? (04 marks)
- (b) Obtain an expression for the Jacobian matrix for a Cartesian type robotic manipulator. (16 marks)

Note:

1. You may use the following table in obtaining the Jacobian matrix.

	Prismatic	Revolute
Linear	${}^0\mathbf{R}_{i-1} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$	${}^0\mathbf{R}_{i-1} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times ({}^0\mathbf{d}_n - {}^0\mathbf{d}_{i-1})$
Rotational	$\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$	${}^0\mathbf{R}_{i-1} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

2. You may use the results obtain in Question 02 to aid your derivation.

Question 05

- (a) Show that the cubic polynomial of a trajectory defined in joint space trajectory scheme, is given by; $q(t) = q_s + \left\{ \frac{3}{t_g^2} (q_g - q_s) \right\} t^2 - \left\{ \frac{2}{t_g^3} (q_g - q_s) \right\} t^3$ (6 marks)

Where;

- q_s – Joint variable value at start position.
- q_g – Joint variable value at goal position.
- t_g – Time value at goal position.

State any assumptions made during your derivation.

- (b) The elbow joint of a PUMA manipulator is to move from an initial position of -5° to a final position of 75° in 5 seconds. Assuming that the joint starts and finishes at zero velocity, find the cubic polynomial that satisfies this motion. Also determine the position, velocity and acceleration of this joint at intervals of 1 second and plot these against time. (14 marks)

END

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