UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME	:	INTELLIGENT ROBOT
COURSE CODE	:	BEM4223
PROGRAMME	:	BEE
EXAMINATION DATE	:	JUNE 2012
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS PAPER CONSISTS OF **SIX** (6) PAGES

Q1 (a) Illustrate a SCARA and an articulated robot.
(10 marks)

(b) Identifies four advantages of an articulated robot over a SCARA.
(10 marks)

(c) Discuss how an intelligent robot works.
(5 marks)

Q2 Consider the three coordinate frame $x_0y_0z_0$, $x_1y_1z_1$ and $x_2y_2z_2$ in Figure Q2. The distance from the origin of the frame $x_0y_0z_0$ to the origin of the frame $x_1y_1z_1$ is 1 meter, and the distance from the origin of the frame $x_1y_1z_1$ to the origin of the frame $x_2y_2z_2$ is also 1 meter.

(a) Compute H_0^1, H_1^2 and $H_0^1H_1^2$
(10 marks)

(b) Compute H_0^2
(10 marks)

(c) Show that $H_0^2 = H_0^1H_1^2$
(5 marks)

Q3 Consider the Stanford manipulator with six degrees-of-freedom (DOF) as shown in Figure Q3(a). The first three DOF determine the position of the robot wrist with respect to the base frame, the other three DOF at the wrist determine the orientation of the robot hand in the base frame. The frame assignment is shown in Figure Q3(b). Derive the kinematic solution of the Stanford manipulator using *Denavit-Hartenberg* algorithm.
(25 marks)

Q4 (a) A motor attached to a robot to move one of the its joints is represented by a transfer function shown in Figure Q4 where I and B are constants. Discuss how a PID controller can be used to control the motor so that its output satisfies a desired response.
(10 marks)

(b) Illustrate the PID controller used to control three joints using Independent-Joint PID controller.
(15 marks)

Q5 An intelligent mobile robot is required to travel from a starting point to a target point avoiding all obstacles it encounters during the traversal. Suggest and discuss the necessary sensors the robot should be used so that it can safely reach the target point.

(25 marks)

Q6 (a) Name the six principle steps in a robot vision system.

(9 marks)

(b) In the pre-processing step, Average and Median filters can be used to improve an image quality. Explain how each filter works and state their advantages and disadvantages.

(16 marks)

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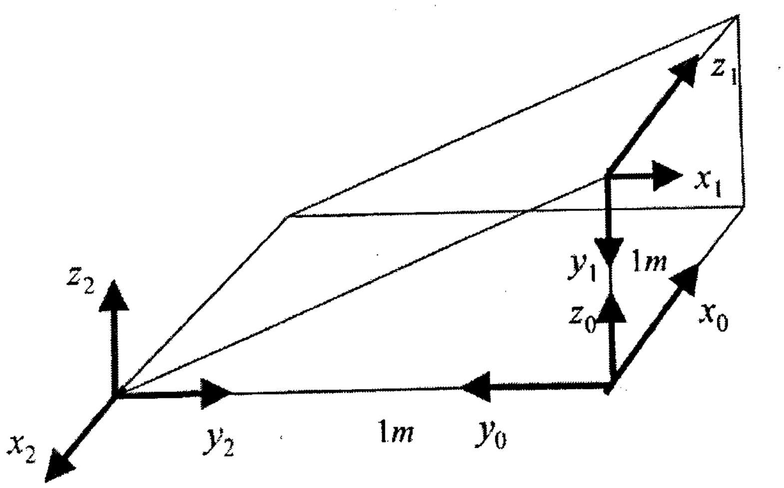

FIGURE Q2

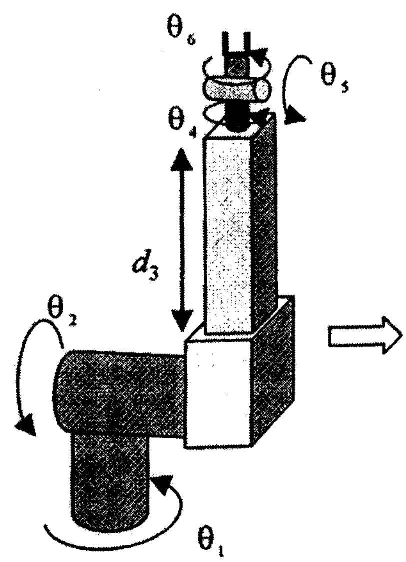

FIGURE Q3(A)

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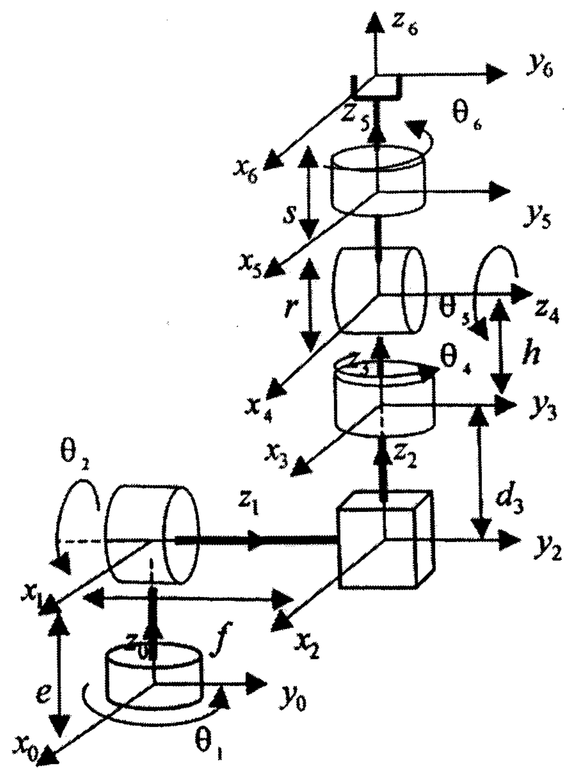

FIGURE Q3(B)

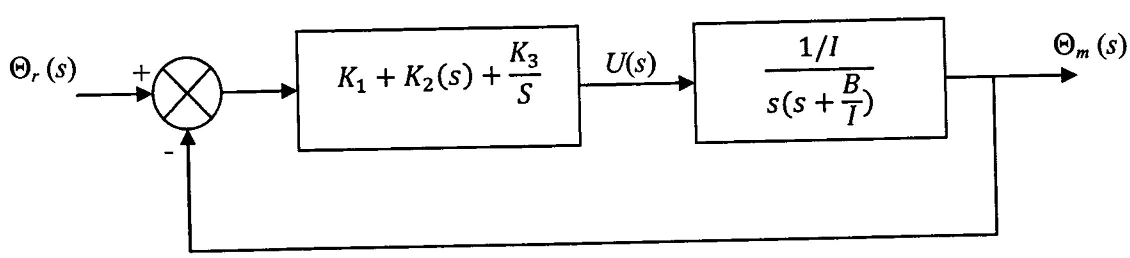

FIGURE Q4

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Homogeneous matrices

$$H_z(\gamma)=\begin{bmatrix} C\gamma & -S\gamma & 0 & 0 \\ S\gamma & C\gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad H_y(\varphi)=\begin{bmatrix} C\varphi & 0 & S\varphi & 0 \\ 0 & 1 & 0 & 0 \\ -S\varphi & 0 & C\varphi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad H_x(\psi)=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C\psi & -S\psi & 0 \\ 0 & S\psi & C\psi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H_{rpy}=\begin{bmatrix} C\gamma C\varphi & C\gamma S\varphi S\psi - S\gamma C\psi & C\gamma S\varphi C\psi + S\gamma S\psi & \Delta P_x \\ S\gamma C\varphi & S\gamma S\varphi S\psi + C\gamma C\psi & S\gamma S\varphi C\psi - C\gamma S\psi & \Delta P_y \\ -S\varphi & C\varphi S\psi & C\varphi C\psi & \Delta P_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Denavit-Hartenberg transformation matrices

$$H(\theta_i)=\begin{bmatrix} C\theta_i & -S\theta_i & 0 & 0 \\ S\theta_i & C\theta_i & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad Tran(d_i)=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad Tran(a_i)=\begin{bmatrix} 1 & 0 & 0 & a_i \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H(\alpha_i)=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C\alpha_i & -S\alpha_i & 0 \\ 0 & S\alpha_i & C\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad H_{i-1}^{i}=\begin{bmatrix} C\theta_i & -C\alpha_i S\theta_i & S\alpha_i S\theta_i & a_i C\theta_i \\ S\theta_i & C\alpha_i C\theta_i & -S\alpha_i C\theta_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$