UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME	:	INTELLIGENT ROBOT
COURSE CODE	:	BEM 4223
PROGRAMME	:	BEE
EXAMINATION DATE	:	JUNE 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Discuss the key features that distinguish intelligent robots from normal robots.

(3 marks)

(b) The robots can be classified according to the types of task, control, configuration and mobility. Illustrate and explain the different classes robots based on type of configuration classification including its workspace.

(8 marks)

(c) (i) List three (3) applications of robotic systems.

(ii) For each application discuss which type of the manipulator that would be best suited and least suited.

(iii) Justify your choices in each case.

(6 marks)

(d) Construct a block diagram of a closed loop control system of robot completed with labels and briefly define each part. The block diagram should indicate the block of kinematics, dynamics, trajectory, control system and sensor.

(3 marks)

Q2 (a) With the help of a block diagram, compare the usage of forward kinematic and inverse kinematic in relation to robotic manipulators.

(2 marks)

(b) With the help of appropriate figure, explain three (3) reasons why the inverse kinematic problem for robotic system is one of the most difficult to solve.

(3 marks)

(c) Figure Q2(c) shows a spherical arm with two rotary joints and a prismatic joint. By applying a Denavit-Hartenberg algorithm and the transformation matrix, solve the forward kinematic solutions of the robot manipulator to determine the position and orientation of the robot hand relative to the robot base frame.

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

(15 marks)

Q3 Figure Q3 shows a cylindrical arm with two prismatic joints and a rotary joint. The seven trigonometric equations and their solutions are given in Table Q3. The forward kinematic solution is given as below.

(a) Obtain the inverse position of the cylindrical arm from this forward kinematic, H_0^3.

(18 marks)

(b) Explain which is the correct angle and distance.

(2 marks)

$$H_0^3 = \begin{bmatrix} C_2 & 0 & -S_2 & -d_3S_2 + a_2C_2 \\ S_2 & 0 & C_2 & d_3C_2 + a_2S_2 \\ 0 & -1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

.

Q4 (a) (i) List two (2) main reasons to use the dynamics equations

(ii) With the help of a block diagram, distinguish the difference between forward and inverse dynamics.

(3 marks)

(b) Figure Q4(b) shows a θ-r robot manipulator with a revolute joint and a prismatic joint. Consider the point masses, m_1 and m_2 at the distal end of links. Evaluate the differential equations of motion of the θ–r manipulator by applying the Lagrange function as follows:

$$L = K(q,\dot{q}) - P(q)$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) - \frac{\partial L}{\partial q_1} = \tau_1$$

where

$K(q,\dot{q})$ is the total kinetic energy

$P(q)$ is the total potential energy store in the system

τ_1 is the external torque/force

(17 marks)

Q5 (a) Consider a single-link robot manipulator with a rotary joint. Design its trajectory with following two cubic segments. The first segment connects the initial angular position $\theta(0)=10°$ to the via point $\theta(1)=5°$, and the second segment connects the via point $\theta(1)=5°$ to the final angular position $\theta(2)=50°$. The designed trajectory should have zero initial velocity and zero final velocity. Also, at the via point $\theta(1)=5°$, the trajectory should have continous velocity and acceleration.

(16 marks)

(b) Explain why in some situations to design the trajectory it is necessary to specify the via points.

(2 marks)

(c) Disscuss why that LSPB (Linear segment with two parabolic blends) trajectory is much better in term of velocity and acceleration trajectory compared to normal trajectory.

(2 marks)

- END OF QUESTION -

FINAL EXAMINATION

SEMESTER/SESSION: SEM II/20122013 PROGRAMME : 4BEE

COURSE: INTELLIGENT ROBOT COURSE CODE: BEM 4223

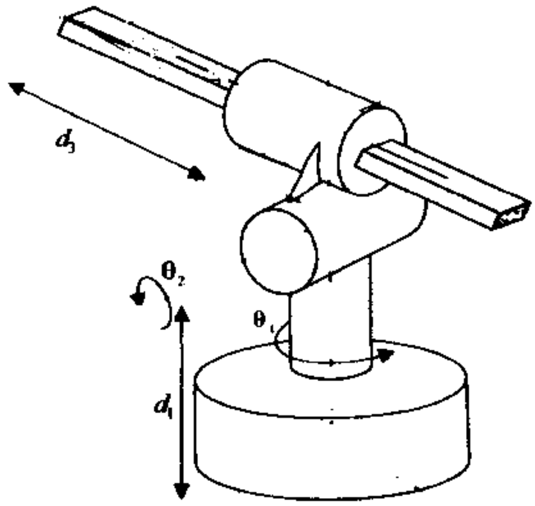

FIGURE Q2(c)

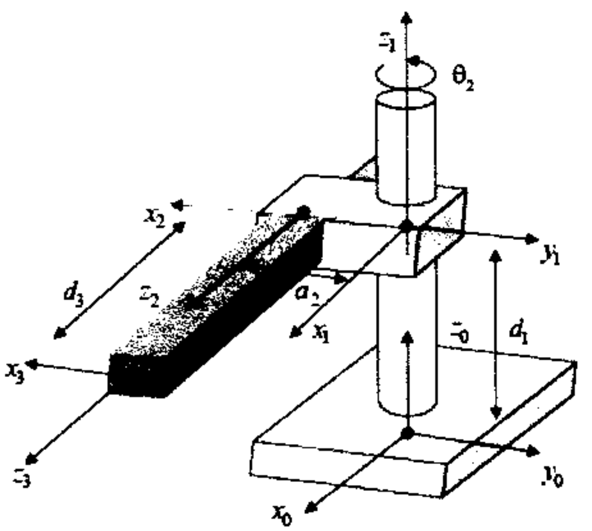

FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION: SEM II/20122013 | PROGRAMME : 4BEE

COURSE: INTELLIGENT ROBOT | COURSE CODE: BEM 4223

TABLE Q3

Equation(s)	Solution(s)
(a) $\sin\theta = a$	$\theta = Atan\,2\left(a,\ \pm\sqrt{1-a^2}\right)$
(b) $\cos\theta = b$	$\theta = Atan\,2\left(\pm\sqrt{1-b^2},\ b\right)$
(c) $\begin{cases} \sin\theta = a \\ \cos\theta = b \end{cases}$	$\theta = Atan\,2\ (a,\ b)$
(d) $a\cos\theta - b\sin\theta = 0$	$\theta^{(1)} = Atan2(a, b)$ $\theta^{(2)} = Atan2\ (-a, -b) = \pi + \theta^{(1)}$
(e) $a\cos\theta + b\sin\theta = c$	$\theta^{(1)} = A\tan 2\left(c,\ \sqrt{a^2+b^2-c^2}\right) - A\tan 2\ (a,\ b)$ $\theta^{(2)} = A\tan 2\left(c,\ -\sqrt{a^2+b^2-c^2}\right) - A\tan 2\ (a,\ b)$
(f) $\begin{cases} a\cos\theta - b\sin\theta = c \\ a\sin\theta + b\cos\theta = d \end{cases}$	$\theta = A\tan 2\ (ad - bc,\ ac + bd)$
(g) $\begin{cases} \sin\alpha\sin\beta = a \\ \cos\alpha\sin\beta = b \\ \cos\beta = c \end{cases}$	$\begin{cases} \alpha^{(1)} = A\tan 2\ (a,\ b) \\ \beta^{(1)} = A\tan 2\left(\sqrt{a^2+b^2},\ c\right) \end{cases}$ $\begin{cases} \alpha^{(2)} = A\tan 2\ (-a,\ -b) = \pi + \alpha^{(1)} \\ \beta^{(2)} = A\tan 2\left(-\sqrt{a^2+b^2},\ c\right) \end{cases}$