

CONFIDENTIAL



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014**

COURSE NAME	:	ROBOTICS & AUTOMATION SYSTEM
COURSE CODE	:	DAE 32503
PROGRAMME	:	3 DAE / 3 DAL
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER FOUR (4) QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

CONFIDENTIAL

- Q1** (a) Explain each of the terminology below;
- (i) Safeguards
 - (ii) Guards/ Barriers Guards
 - (iii) Personal Protective Equipment
- (6 marks)
- (b) Presence-Sensing Devices is a type of safeguards. Give two (2) examples of these devices and describe the functionality for each of them.
- (10 marks)
- (c) Refer to **Figure Q1(c)**.
- (i) Name the configuration of this robot by referring to its geometry manipulators. Suggest a suitable application for this robot in performing a task.
- (3 marks)
- (ii) Describe all motion regards to the manipulator.
- (3 marks)
- (iii) Draw the 3D view of the robot work envelope.
- (3 marks)
-
- Q2** (a) In industrial control system, an actuator is a hardware device that converts a controller's command signal into a change in physical parameter. Each actuator is controlled and driven by a controller.
- (i) List three (3) types of actuator.
- (3 marks)
- (ii) Give a brief explanation for each type of actuator.
- (6 marks)
- (iii) Differentiate the characteristics of these actuators in term of technical specification.
- (6 marks)
- (b) Proximity sensors and photoelectric sensors are grouped into non-contact sensor. **Figure Q2(b)** shows a clear bottle pass by a sensor in production line. Explain the operation of sensing the bottle by the sensor regarding of choose the appropriate type sensor and functionality.
- (4 marks)

(c) For each situation below, state the category and gripping mechanism of end-effectors for a robot in completing the task.

- (i) Lift the multiple layers of plywood sheets one-by-one.
- (ii) Spot welding and screwing nut in cars production line.
- (iii) Insert pin into 5mm diameter hole.

(6 marks)

Q3 (a) **Figure Q3(a)** shows frame {B} rotated by θ degrees with respect to reference frame {A} about x -axis, y -axis and z -axis. Derive the matrix that represents a pure rotation about the:

(i) x -axis of the reference frame.

(3 marks)

(ii) y -axis of the reference frame.

(3 marks)

(iii) z -axis of the reference frame.

(3 marks)

(b) Find the coordinates of point $P = [3, 5, 7]^T$ relative to the reference frame after a rotation of 45 degrees about the y -axis.

(3 marks)

(c) The following frame {B} is moved a distance of $d = [5, 2, 6]^T$ from reference frame {A}.

$$\{B\} = \begin{bmatrix} 0 & 1 & 0 & 2 \\ 1 & 0 & 0 & 4 \\ 0 & 0 & -1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Find the new location of frame {B} relative to reference frame {A}.

(3 marks)

(d) A point P in space is defined as ${}^B P = [5, 3, 4]^T$ relative to frame {B}. Initially, frame {B} has the same origin as frame {A} and is parallel to it. Apply the following transformations to frame {B} and find ${}^A P$.

(1) Rotate $\theta = 90^\circ$ about the x -axis.

(2) Then, translate 5 units about the x -axis, 3 units about the y -axis and 6 units about the z -axis.

(3) Then, rotate $\theta = 90^\circ$ about the z -axis.

(10 marks)

- Q4** (a) Define forward kinematics. (2 marks)
- (b) List down the four (4) important steps of Denavit-Hartenberg (D-H) convention. (4 marks)
- (c) **Figure Q4(c)** shows the schematic diagram of a PUMA 560. Fill in the Denavit-Hartenberg (D-H) parameters table below.

Joint i	α_i	a_i	d_i	θ_i
1				
2				
3				
4				
5				
6				

(9 marks)

- (d) The Denavit-Hartenberg (D-H) parameters of a robot arm are as given below. Find the overall transformation matrix of the robot.

Hint:

$${}^nT_{n+1} = \text{ROT}(z, \theta_{n+1}) \text{TRANS}(0, 0, d_{n+1}) \text{TRANS}(a_{n+1}, 0, 0) \text{ROT}(x, \alpha_{n+1})$$

D-H parameters of a robot arm:

Joint i	α_i	a_i	d_i	θ_i
1	0	20	0	30°
2	-90	10	0	45°
3	0	0	10	60°

(10 marks)

- Q5** (a) Automated manufacturing systems operate in the factory on the physical product. They perform different types of operation and in some cases accomplishing more than one operations in the same system.
- (i) Describe all standard types of automation system and give an example each. (6 marks)
 - (ii) Explain three (3) benefits of automation using appropriate example each. (6 marks)
 - (iii) Company A is planning to produce three (3) types of product. Each product is not exactly identical to each other. Which type of automation fits the requirement? Come up with additional specification assumption for the system required by company A to back up your decision. (4 marks)
- (b) The products handled in automation system must be designed for producibility and in particular, the ability to be assembled.
- (i) **Figure Q5(b)(i)** shows two (2) types of design for Part A and Part B. Choose the preferred design for each part and explain why. (3 marks)
 - (ii) By referring to **Figure Q5(b)(ii)**, suggest a design modification required by each part and explain the significance of the change. (6 marks)

- Q6** (a) Industrial robot applications can be divided into 4 basic categories. List all four (4) and give example of application for each category. (6 marks)
- (b) The programmable logic controller (PLC) is a computer designed for control of manufacturing processes, assembly systems and general automation.
- (i) **Figure Q6(b)** shows an example of a PLC application in manufacturing process. Draw the PLC system block diagram accordingly. (8 marks)
- (ii) Explain the general function of the PLC main components. (5 marks)
- (c) **Figure Q6(c)** shows an automated manufacturing cell with two CNC machine tools and a robot.
- (i) Explain the main criteria of a flexible manufacturing system. (4 marks)
- (ii) Can the manufacturing cell shown considered as a flexible manufacturing system? (2 marks)

- END OF QUESTION -

FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

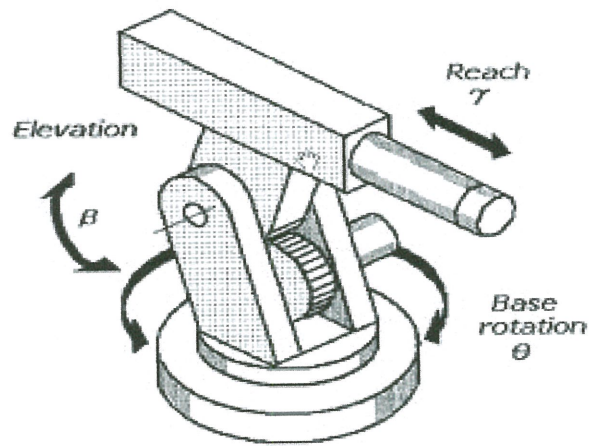


FIGURE Q1(c)

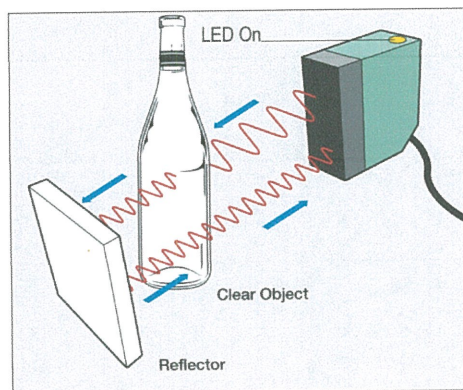


FIGURE Q2(b)

FINAL EXAMINATION

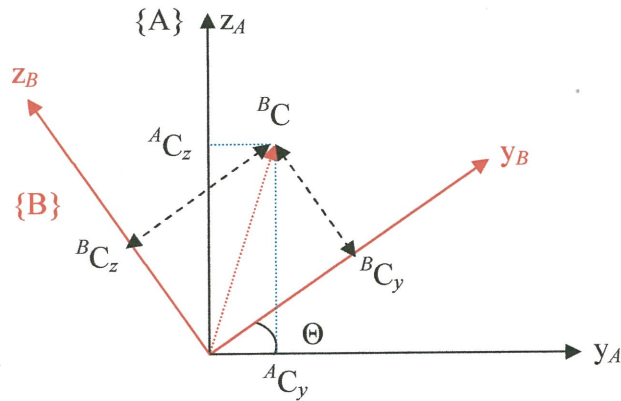
SEMESTER/SESSION: SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

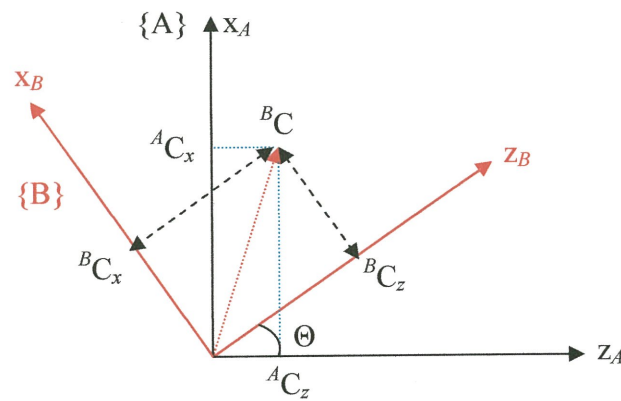
COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

(i) Frame {B} rotated about x-axis relative to frame {A}.



(ii) Frame {B} rotated about y-axis relative to frame {A}.



(iii) Frame {B} rotated about z-axis relative to frame {A}.

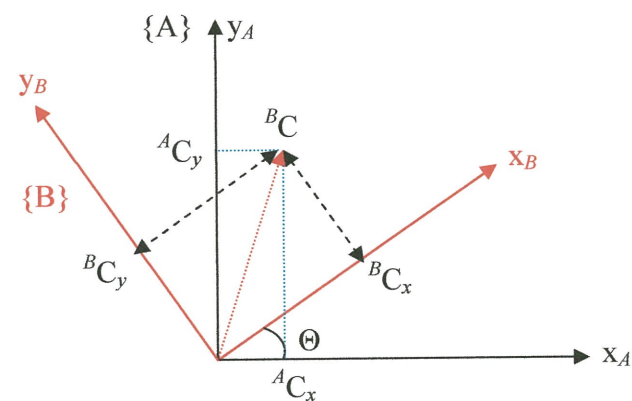


FIGURE Q3(a)

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

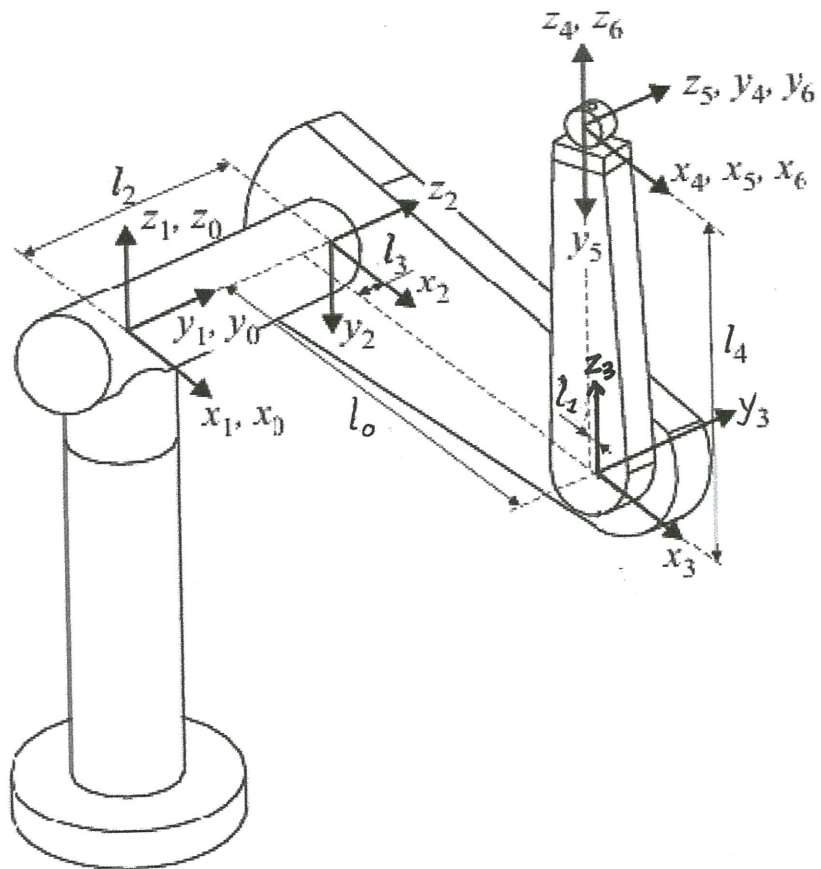


FIGURE Q4(c)

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

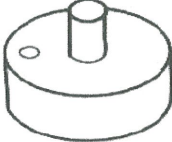
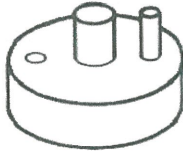
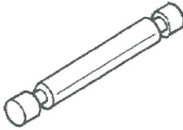
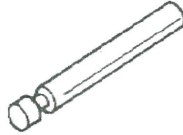
	Design 1	Design 2
Part A		
Part B		

FIGURE 5(b)(i)

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

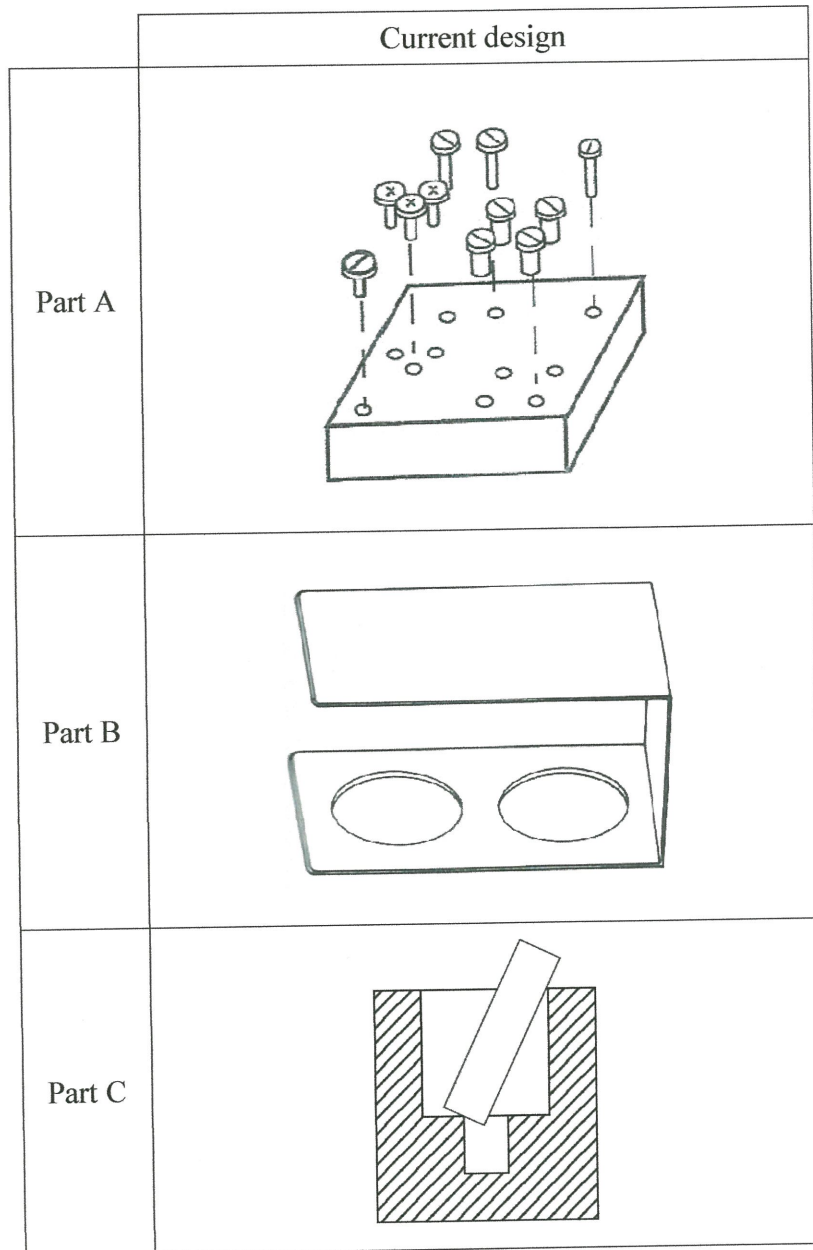


FIGURE 5(b)(ii)

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2013/2014

PROGRAMME : 3DAE/3DAL

COURSE NAME : ROBOTICS & AUTOMATION SYSTEM

COURSE CODE: DAE 32503

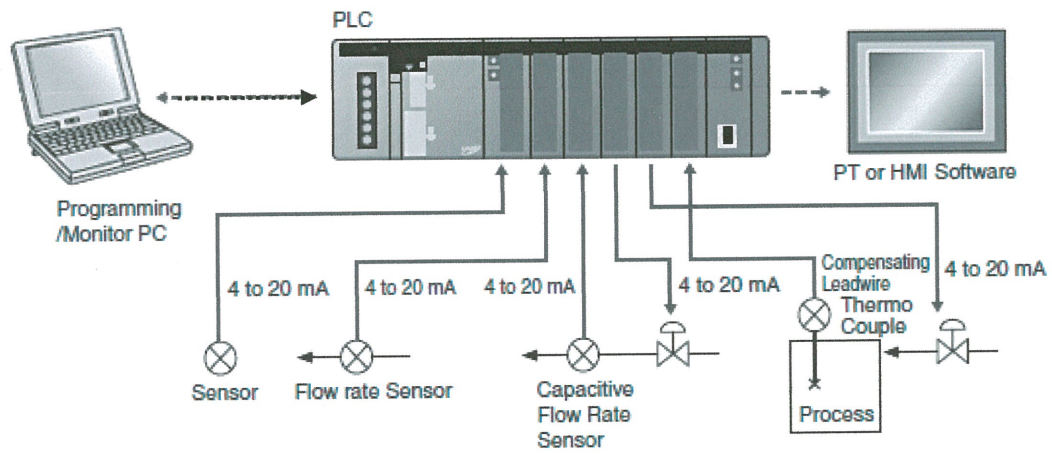


FIGURE Q6(b)

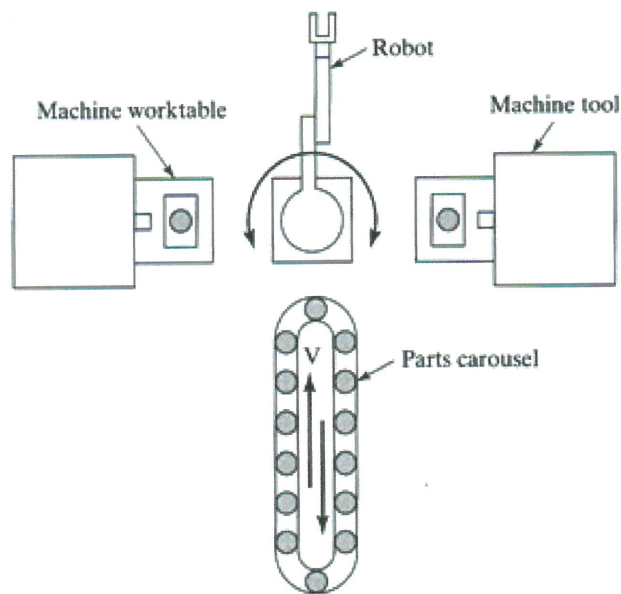


FIGURE Q6(c)