



UTHM

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION SEMESTER I SESSION 2022/ 2023

- COURSE NAME : ROBOTICS AND AUTOMATION SYSTEM
- COURSE CODE : DAE 32503
- PROGRAMME CODE : DAE
- EXAMINATION DATE : FEBRUARY 2023
- DURATION : 3 HOURS
- INSTRUCTION :
1. ANSWERS ALL QUESTIONS
 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.
 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF NINE (9) PAGES

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SECTION A

- Q1** The causes of worker injury in a robotic environment vary and include the following, **EXCEPT**.
- (a) Excessive physical strain.
 - (b) Being struck by a robot gripper.
 - (c) Failing to follow the working procedures.
 - (d) Parts falling within work envelope during normal operation.
- Q2** For eliminating hazards in workplace, professional organizations have defined the following guide. Rearrange them by priorities.
- i. Use warning sign and labels.
 - ii. Apply safeguarding technology.
 - iii. Prescribe personal protective equipment and devices.
 - iv. Train and instruct the worker, programmer and maintenance personnel.
- (a) i, ii, iii, iv
 - (b) iii, iv, ii, i
 - (c) ii, i, iv, iii
 - (d) iv, iii, ii, i
- Q3** Which is **NOT TRUE** about autonomous system?
- (a) Home gate uses camera to recognize owner and open the gate and close after the car safely park.
 - (b) Bread is put in a toaster, the lever is pushed down, and when the toast is done, it shuts off and pops up.
 - (c) Vacuum cleaner that deliver excellent cleaning floor, avoid obstacles, self-battery charging and self-empty dustbin.
 - (d) The traffic light uses a camera and moves its camera to detect people who want to cross the street and change its light accordingly.
- Q4** Die casting is an application of industrial robot for loading and unloading process. State a problem encountered during this process.
- (a) The cycle time of the machine may be relatively always synchronous compared to the robot's cycle time.
 - (b) The difference in cycle time between the robot and the production machine.
 - (c) Robot too heavy to handle the process.
 - (d) Tedious job that makes robot can't complete the task.

- Q5** The **DISADVANTAGE** of the industrial robot is _____
- (a) capabilities in the real-time response.
 - (b) priority working in radiation exposure environment.
 - (c) flexibility in taking new task requires human intervention.
 - (d) the superior capabilities with the sensors and vision system.
- Q6** In modern robot installations, appropriate sensors orientate the gripper of the end effector to deal with random entry of parts into the cell. For material handling operations, the robot must have the following features, **EXCEPT**:
- (a) The manipulator must be able to lift the part safely.
 - (b) The robot must have the reach needed.
 - (c) The robot must be a SCARA coordinate type.
 - (d) The robot must have the speed necessary for meeting the transfer cycle of the operation.
- Q7** Basic component of an industrial robot are;
- (a) Controller, manipulator, end-effector and power supply
 - (b) Joint, computer, manipulator and conveyor
 - (c) Teach pendant, power-supply, link and chain
 - (d) Controller, joint, conveyor and gripper.
- Q8** According D-H convention, the following are transformation required **EXCEPT**;
- (a) Translate about the z_0 -axis an angle of θ , to make x_0 parallel to x_1 .
 - (b) Since x_0 and x_1 are in the same plane, translation d along the z_0 -axis is zero.
 - (c) Translate along the (already rotated) x_0 -axis a distance of a_1 .
 - (d) Since z_0 and z_1 - axis are parallel, the necessary rotation α about the x_1 -axis is zero.
- Q9** Choose the **CORRECT** motion for arm geometry robot;
- (a) Cartesian: 2 Rotary, 1 Linear
 - (b) Spherical: 3 Rotary
 - (c) Articulated (vertical): 3 Linear
 - (d) Cylindrical: 2 Linear, 1 Rotary

- Q10** Which geometry coordinated robot arm is not suitable for assembly application?
- (a) Cylindrical
 - (b) Rectangular
 - (c) Spherical
 - (d) SCARA
- Q11** The advantage of rectangular coordinated robots is _____
- (a) They make maintenance easy for some models with overhead drive mechanisms and control equipment.
 - (b) They can carry heavy loads because the weight-lifting capacity does not vary at different locations within the work envelope.
 - (c) Their movement is not limited to one direction at a time.
 - (d) Their linear movement allows for complex controls.
- Q12** Level of robot programming from Level 1 to Level 4 are;
- (a) Primitive Motion Function → Task-oriented Function → Structured Programming Function → Joint Control Function
 - (b) Joint Control Function → Primitive Motion Function → Structured Programming Function → Task-oriented Function
 - (c) Structured Programming Function → Task-oriented Function → Joint Control Function → Primitive Motion Function
 - (d) Primitive Motion Function → Joint Control Function → Structured Programming Function → Task-oriented Function
- Q13** Sensor are used in work cells for following reasons **EXCEPT**.
- (a) To detect health condition of a worker who operate machine in production line system
 - (b) To detect a condition where a robot or other machine could be harmed by some other manufacturing equipment
 - (c) To monitor the work-cell operation to detect and analyse system malfunction
 - (d) To measure production parts to determine the current level of product quality
- Q14** Vision system are being used with robot automation to perform the following tasks, **EXCEPT**.
- (a) Part identification and orientation
 - (b) Part location and range finding
 - (c) Part inspection
 - (d) Find mass value

- Q15** What is the primary advantage of hydraulic actuators?
- (a) A very high power-to-size ratio that affords large load capability.
 - (b) Regular testing of the hydraulic fluid is required to determine the wear on actuator.
 - (c) Even the best hydraulic system will leak eventually.
 - (d) Hydraulic oil can become a fire hazard in arc welding application.
- Q16** The PLC is a computer designed for control of manufacturing process, assembly systems and general automation. What is **NOT** true about PLC from the following statements?
- (a) The PLC components are power supply, input and output modules, processor and communication modules
 - (b) The PLC communication modules are not used as frequently as input and output modules
 - (c) Input modules receives electrical signal from PLC processor
 - (d) The output modules are wired to system components that control the process.
- Q17** From the following, which is not composed of an automated machine?
- (a) Electronic circuit.
 - (b) Mechanical part including the actuators/drives.
 - (c) Operator who controls the machine.
 - (d) Control system that represents the intelligence of the system.
- Q18** Identify typical features of fixed automation.
- (a) Low number of different parts in product variety relative to high production volume.
 - (b) High production volume relative with low product variety.
 - (c) Low investment for custom-engineered equipment.
 - (d) Relatively flexible in accommodating product changes.
- Q19** Which is **NOT TRUE** about programmable automation.
- (a) Most suitable for batch production.
 - (b) Low production rates relative to fixed automation.
 - (c) Low investment in general-purpose equipment.
 - (d) Flexibility to deal with changes in product configuration.

- Q20** Why designer for automation should consider about shapes for feeding parts?
- (a) To make components stuck together.
 - (b) To prevent parts from wedging together.
 - (c) To stick part easily together.
 - (d) To make parts jam in feeding line.
- Q21** What is the best suit characteristic of robots to perform arc welding jobs?
- (a) Programming is typically done by walk-thru method.
 - (b) SCARA coordinate robots are frequently used.
 - (c) The robot must be capable of continuous path control.
 - (d) The robot should have only 3 to 4 axes.
- Q22** The primary reason for selecting a robot is to reduce labour costs. Other reasons for using robots are as follow **EXCEPT**.
- (a) Increase output rate
 - (b) Eliminate dangerous job
 - (c) Reduce product flexibility
 - (d) Improve product quality
- Q23** The following characteristic of industrial environment were promoted the used of robot in replacing human labour **EXCEPT**.
- (a) Repetitive tasks.
 - (b) Maximizing variations.
 - (c) Multi-shift operations
 - (d) Performing at a steady pace.
- Q24** The following are basic categories of industrial robot applications **EXCEPT**.
- (a) Processing operations.
 - (b) Assembly operations.
 - (c) Freight operations.
 - (d) Inspection operations.
- Q25** Spot welding, spray painting and deburring are examples of industrial robot applications in;
- (a) material handling.
 - (b) assembly operation.
 - (c) inspection operation.
 - (d) processing operations.

(25 marks)

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SECTION B

Q1 (a) There are numbers of sensors grouped into the non-contact sensor. **Figure Q1 (a)** shows one of them detecting a line of bottle caps in a production. Based on the figure;



Figure Q1 (a)

- (i) Describe the function of the sensor. (1 mark)
- (ii) Choose the suitable type of sensor. (1 mark)
- (iii) Explain the working principle of the sensor. (4 marks)

(b) Industrial robots can be classified into **five (5)** configurations. **Figure Q1 (b)(i)** and **Figure Q1 (b)(ii)** show the work envelope of the robots. From the figures, classify the following characteristics and compare them in a table form;

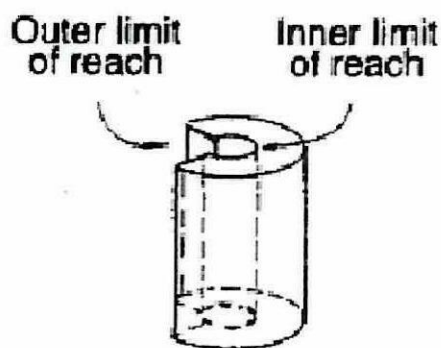


Figure Q1 (b)(i)

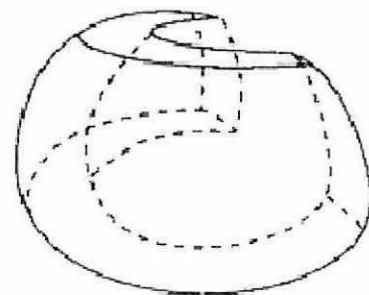


Figure Q1 (b)(ii)

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- (i) Type of arm geometry. (2 marks)
 - (ii) Sketch the appropriate robot manipulator. (4 marks)
 - (iii) Advantages of manipulator configuration. (2 marks)
 - (iv) Disadvantages of manipulator configuration. (2 marks)
- (c) For each situation below, choose the category and gripping mechanism of end-effectors for a robot in completing the task.
- (i) Lifting multiple layers of metal sheets one-by-one.
 - (ii) Spot welding and screwing nut in cars production line.
 - (iii) Insert pin into 5mm diameter hole. (9 marks)

Q2

- (a) (i) Draw a frame {B} rotated by θ degrees with respect to reference frame {W} about x-axis. (2 marks)
- (ii) From the drawing, imagine a point, P with coordinate (P_{y_1}, P_{z_1}) in frame {B}. To find its coordinate in terms of the origin reference frame {W} with (P_{y_0}, P_{z_0}) coordinate, it is necessary to find out the contribution of the y_1 and z_1 axis to the x_0 and y_0 axes. Show the derivation of the equation of the pure rotation around the x-axis and present the equations in a matrix form. (10 marks)
- (b) Find the coordinates of point $P = [7, 3, 11]^T$ relative to the reference frame after a rotation of 30 degrees about the y-axis. (3 marks)
- (c) A point P in space is defined as ${}^B P = [8, 5, 4]^T$ 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 compute the AP.
- Rotate $\theta = 45^\circ$ about the x-axis.
 - Then, translate 5 units about the x-axis, 3 units about the y-axis and 6 units about the z-axis.
 - Then, rotate $\theta = 90^\circ$ about the z-axis. (10 marks)

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- Q3 (a) **Figure Q3(a)** shows the schematic diagram of a robot arm and its D-H parameters listed in **Table 3(a)**. Find the overall transformation matrix of the robot.

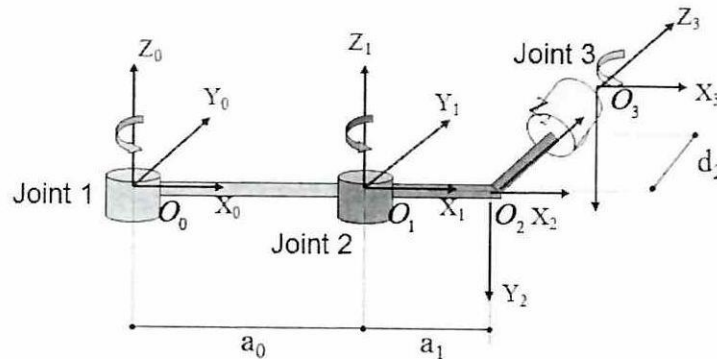


Figure Q3 (a)

Hint:

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

Table 3(a)

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)

- (b) 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 operation in the same system.
- Describe all standard types of automation system and give an example each. (6 marks)
 - Explain **two (2)** benefits of automation using appropriate example each. (4 marks)
 - Company T intends to manufacture three (3) different types of products that are not identical to one another. Suggest of the type of automation that fits requirement. Provide further specification assumptions for the system required by the firm to support your choice. (5 marks)

(5 marks)

- END OF QUESTIONS -