INSTRUCTIONS:

1. This assignment must be conducted in a group (**3 or 4 students**).
   Please clearly write the **group members name and matric number** in the front-page of the submission.

2. Solutions for each question must be readable and neatly written on plain A4 paper. Every step or calculation should be properly shown.
   Failure to do so will result in rejection of the submission of assignment.
   (D**ue date : 24 January 2025)**

1) You are given the following description of a tree

   " A rooted tree has a root node with three siblings. The left-most child of the root has three leaves, while the right-most child forms a subtree having an internal node with three children. The third node of the root is a binary subtree."

   From the description above,

   a) Draw the tree.   (4 Marks)

   b) How many edges and vertices does the tree have?   (2 Marks)

   c) Is the tree a full 3-ary tree? Justify your answer.   (2 Marks)

   d) Is the tree balanced? Justify your answer.   (2 Marks)

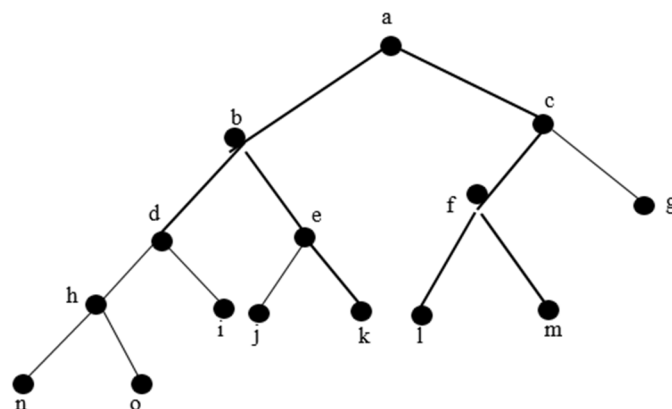2) Based on the rooted tree shown in Figure 1, answer the following question.

Figure 1: Rooted tree, *T*

a) List the children of vertex d. (1 mark)

b) List the sibling of vertex f. (1 mark)

c) Find the height of this rooted tree. (1 mark)

d) According to the universal address system, what is the address of vertex j? (1 mark)

e) Give the order of vertices produced by preorder, inorder and postorder traversal. (6 marks)

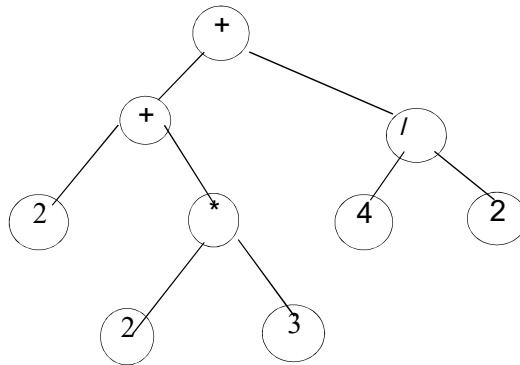3) Evaluate the expression obtained from in order traversal of the tree m Figure 2

Figure 2

4) Multi-level marketing starts when a person recruits 4 members. Each member can either recruit 4 other members or choose not to recruit any members. Suppose that 2,000 members are actively doing the recruitments before the maximum level of recruitment is reached and no members can be approached twice. How many members have been recruited and how many members who did not do any recruitment?

(4 marks)

5) Figure 3 represents a network of paths in a park. The number on each edge represents the length of the path in meters. The cost per meter is RM100. To gain as much profit, the contractor asked one of his staff to find the minimum network needed using Kruskal's algorithm.
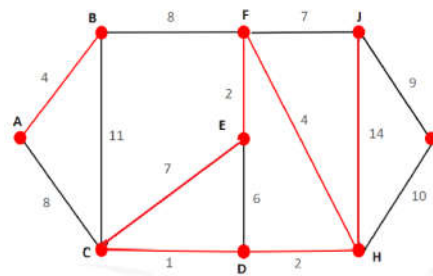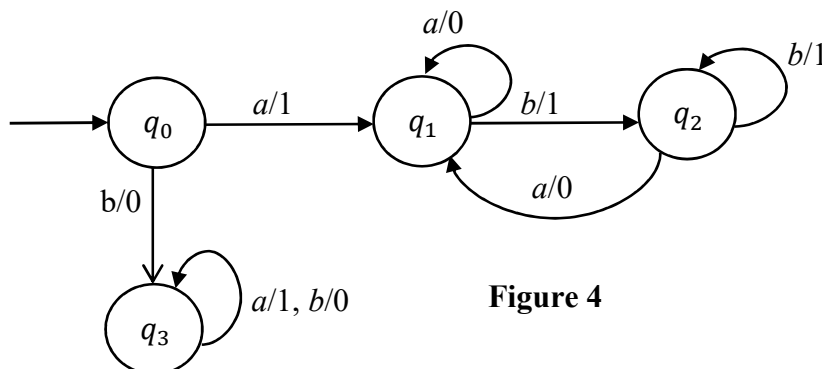

Figure 3

a) Explain why the staff's work which is highlighted in red is incorrect. (1 mark)

b) Help the staff to find the correct minimum network using Kruskal's algorithm and states its length and total cost. (7 marks)

c) Is there any possibiliy, more than one distint MST obtained for the Figure 3?. If yes, justify your answer and show the network. (2 marks)

6) Let $M = (\{q_0, q_1, q_2, q_3, q_4, q_5\}, \{x, y, z\}, q_0, f_s, \{q_2, q_5\})$ be the Deterministic Finite Automaton (DFA) with state transition function, f_s defined as follows:

$$f(q_0, x) = q_1 \qquad f(q_0, y) = q_2 \qquad f(q_0, z) = q_4$$

$$f(q_1, x) = q_1 \qquad f(q_1, y) = q_2 \qquad f(q_1, z) = q_2$$

$$f(q_2, x) = q_2 \qquad f(q_2, y) = q_3 \qquad f(q_2, z) = q_4$$

$$f(q_3, x) = q_5 \qquad f(q_3, y) = q_4 \qquad f(q_3, z) = q_4$$

$$f(q_4, x) = q_5 \qquad f(q_4, y) = q_0 \qquad f(q_4, z) = q_1$$

$$f(q_5, x) = q_5 \qquad f(q_5, y) = q_4 \qquad f(q_5, z) = q_0$$

i. Draw the transition diagram for the machine, M. (4 marks)

ii. What is the minimum length of strings that is accepted by the machine, M. (1 mark)

iii. Give ONE example of strings in (ii). Show the sequence of configurations (2 mark)

7) Construct a transition diagram for the following machines:

i. A DFA that accepts all string over $\{s, y\}$ that contain string 'sys'. (3 marks)

ii. A DFA that accepts all string over $\{1, 2\}$ that contain substring '22' and end in '1'. (3 marks)

8) Given the Finite State Machine (FSM) with four states q_0, q_1, q_2, and q_3 as in **Figure 4**.

Figure 4

a) Find out all the information for Deterministic Finite Automaton, M = {S, I, O, q_0, f_s, f_o} and provide the transition table of the FSM. (6 Marks)

b) What is the output string if the input string is *aaabbb*? Show the sequence of configurations and its output. Is the input string accepted by the machine?

(4 marks)

9) Figure 5 shows the design of a traffic light and barrier control at a crossing of a railway and a road. The railway consists of one track and is monitored by two sensors Left Sensor and Right Sensor which are located 1 kilometer away from the crossing.

Few assumptions for this design are:

- A train may come from either direction, and only one train can enter the sensor zone.
- A train may be long enough to cover one sensor or all two sensors at the same time.
- Each sensor (Left Sensor and Right Sensor) must send two signals to the controller. The first signal is to indicate that the train is entering the sensor zone while the second signal is to indicate that the train is leaving the sensor zone.
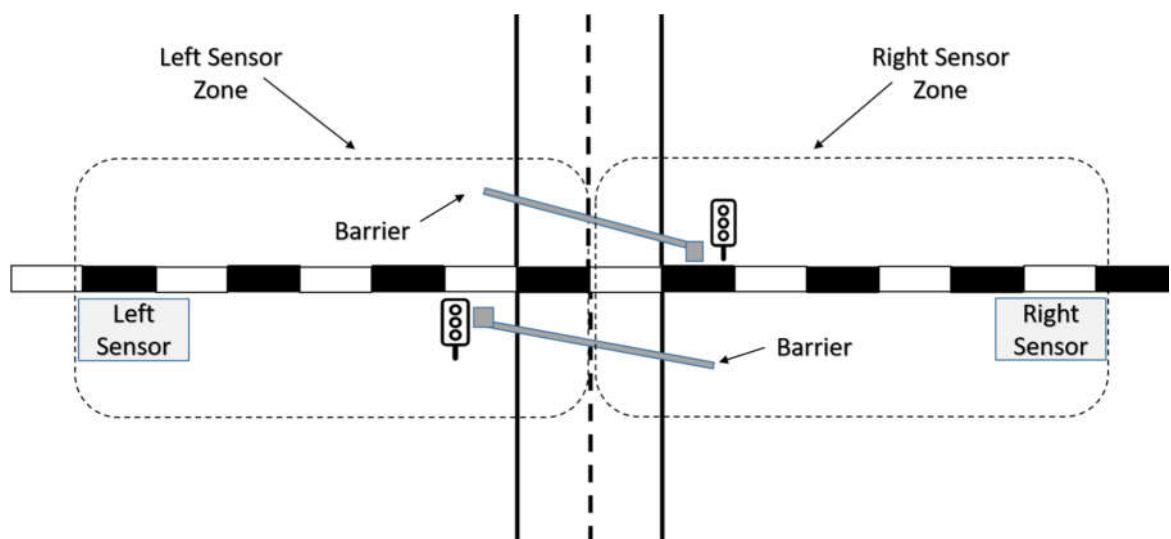

Figure 5

Let us consider a train is coming from the left side of the crossing. Construct a transition diagram for finite state machine to model the control system that switching the traffic lights and moving the barriers according to these following rules:

- Both traffic lights are in the state of showing green light with barriers are raised at the top position when there is no signal from any sensors

- Upon receiving the first signal from the Left Sensor indicating that a train is entering it sensor zone, the lights will be changed and the barriers will be lowered down. Both traffic lights will be in the state of flashing yellow light with lowering barriers.

- When the barriers are at the bottom position, the lights will be changed. Both traffic lights will be in the state of showing red light with the barriers at the bottom position.

- The Left Sensor will send the second signal when the train is leaving it sensor zone, while the Right Sensor will send it first signal indicating the train is entering it sensor zone. In this situation, both traffic lights and barriers remain in current state.

- Only when the Right Sensor sends it second signal which indicates that the train is leaving it sensor zone, the barriers will start raising up. In this condition, both traffic lights will remain in the state of showing red lights but the barriers now are raising to the top position.

- After the barriers reach the top position, the lights will be changed. Both traffic lights are in the state of showing green light with barriers have been raised at the top position.