Beijing-Dublin International College

SEMESTER 2 FINAL EXAMINATION - 2022/2023

School of Computer Science

COMP2014J Data Structures and Algorithms II (Software Engineering)

Dr. Robert Ross
Assoc. Prof. Neil Hurley
Dr. David Lillis *

Time Allowed: 120 minutes

Instructions for Candidates

Answer any 2 questions. All questions carry equal marks.

BJUT Student ID: _____ **UCD Student ID: _____**

I have read and clearly understand the Examination Rules of both Beijing University of Technology and University College Dublin. I am aware of the Punishment for Violating the Rules of Beijing University of Technology and/or University College Dublin. I hereby promise to abide by the relevant rules and regulations by not giving or receiving any help during the exam. If caught violating the rules, I accept the punishment thereof.

Honesty Pledge：_____ (Signature)

Instructions for Invigilators

No special instructions.

Question 1:

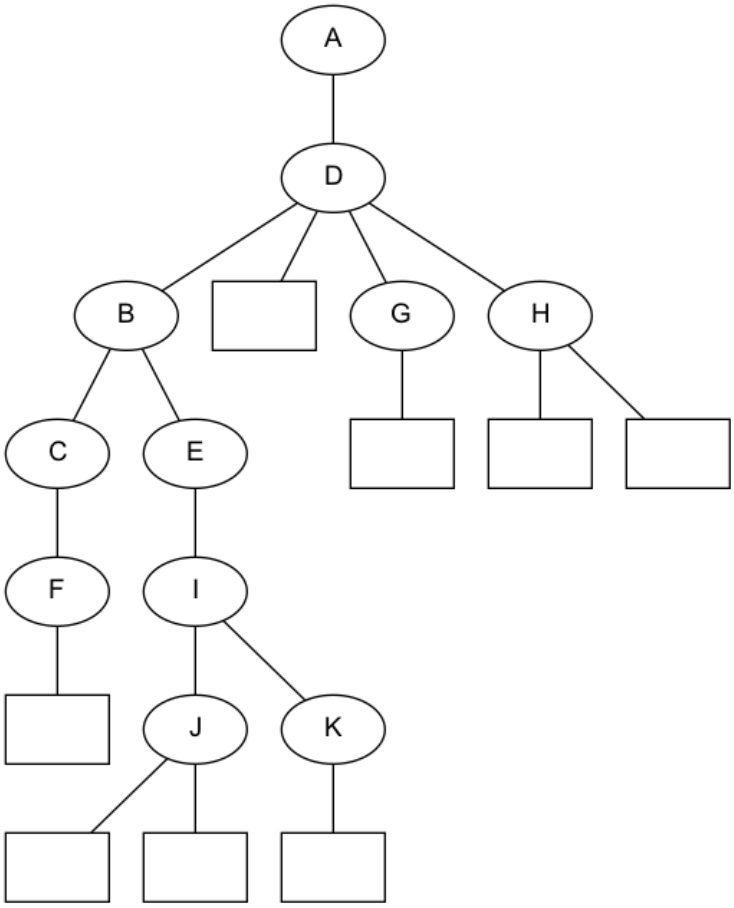


Figure 1

(a) Study the tree in Figure 1 and answer the questions that follow.

(i) List the siblings of E.

(ii) What is the depth of H?

(iii) List the ancestors of G.

(iv) What is the degree of D?

(v) List the descendants of E.

(vi) Is (A,D,B,C) a path? Explain your answer.

(vii) How many leaf nodes are in the tree?

(viii) List the nodes that are in the subtree that is rooted at C.

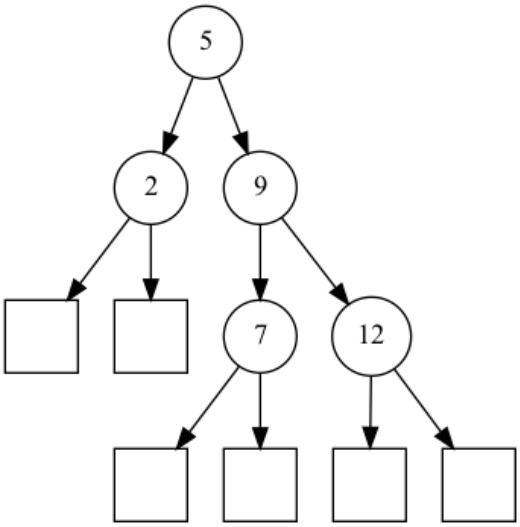
[8 marks]

(b) Briefly describe the differences between a *tree*, a *binary tree*, a *proper binary tree*, a *complete binary tree,* and a *binary search tree*.

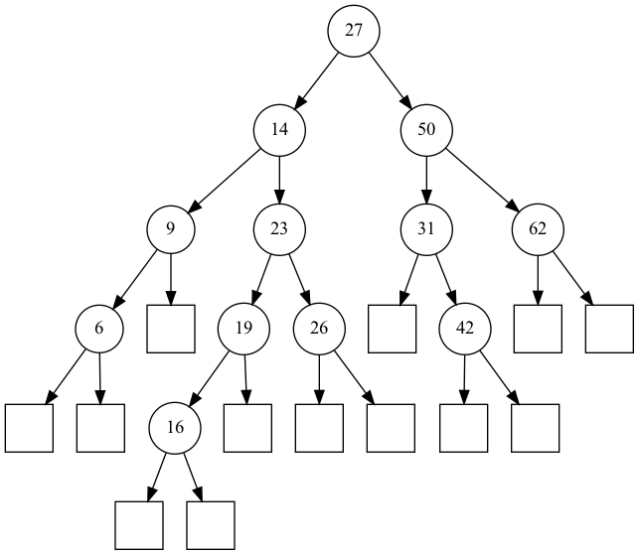
[6 marks]

(c) For each of the figures (i) to (vi) below, assume that the tree is an **AVL Tree**. Draw the state of the tree after performing the operation written above the figure. In your answer, also mention any restructuring that is required.

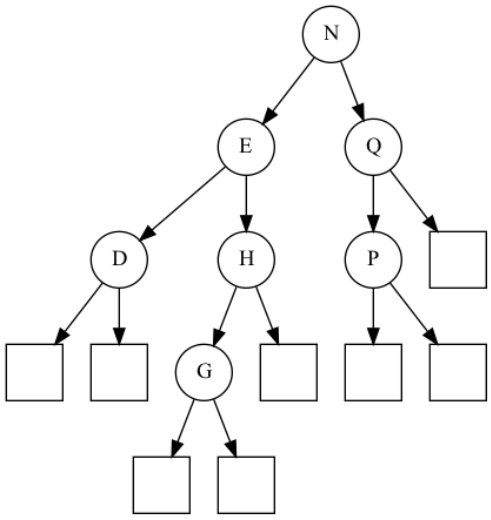
(i) Insert 8



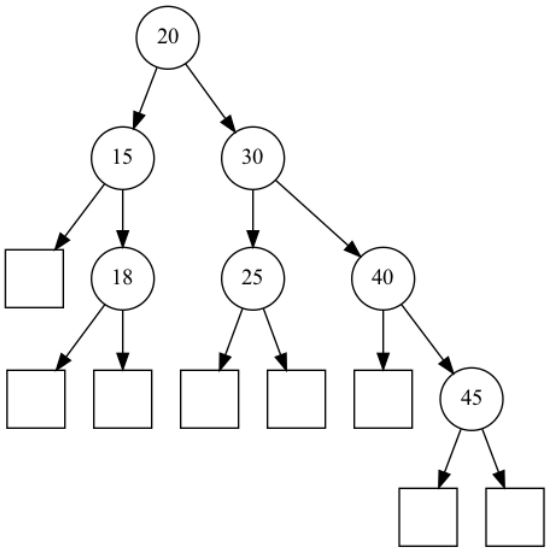
(ii) Remove 27



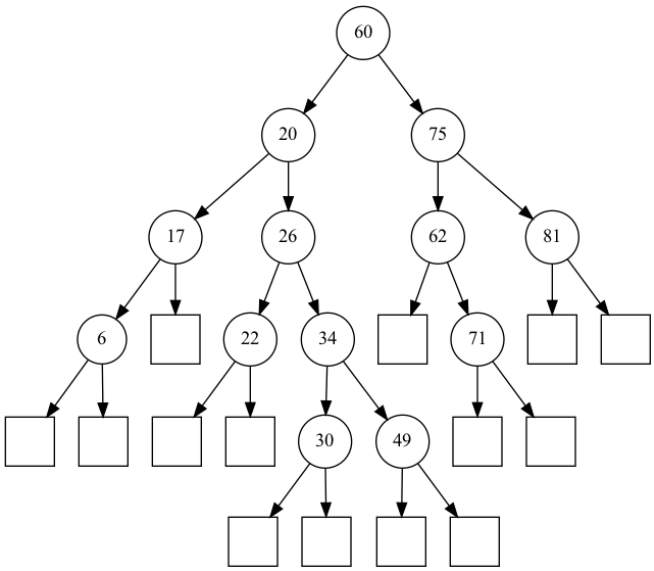
(iii) Remove D



(iv) Insert 50



(v) Insert 37



(vi) Remove 11

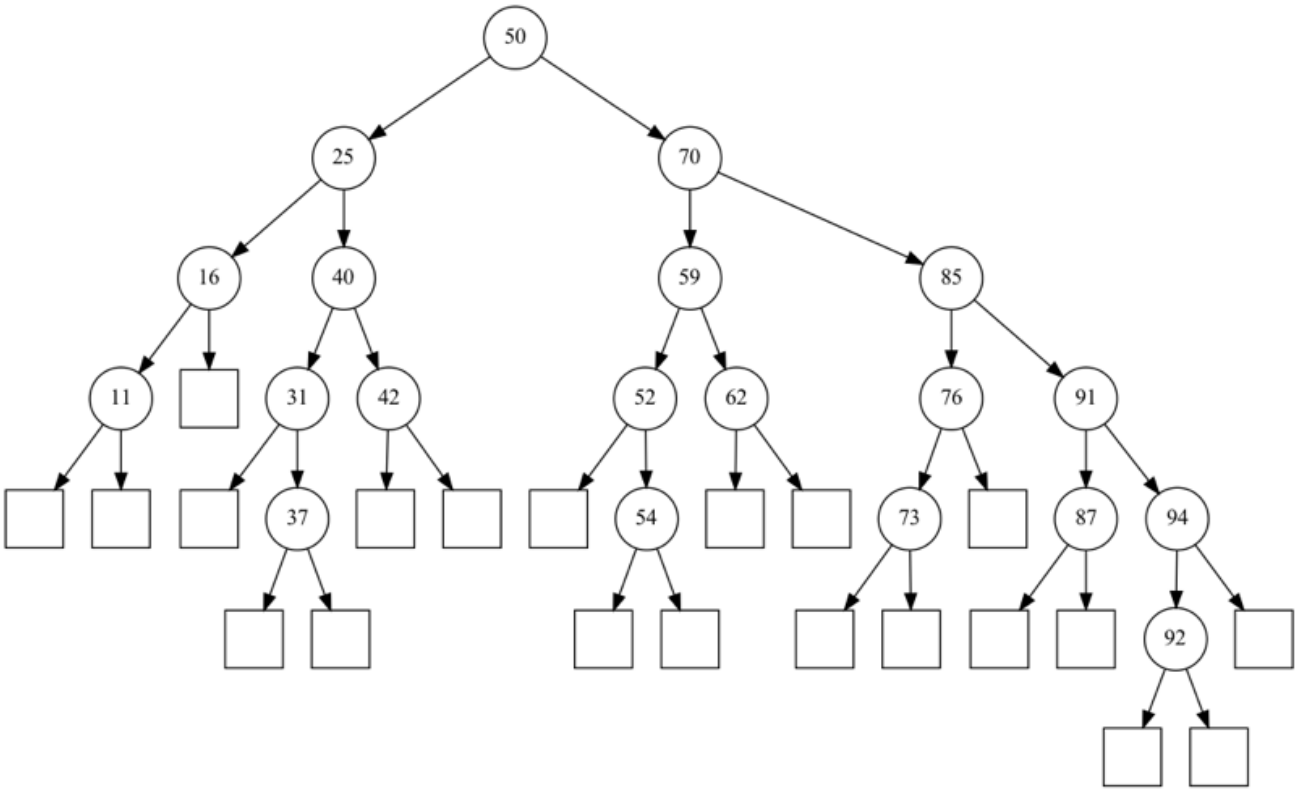
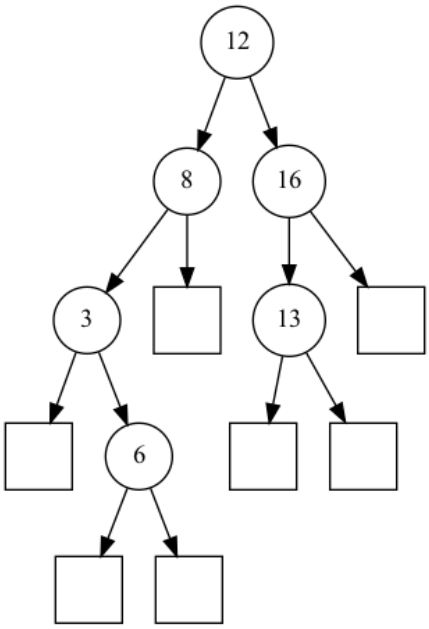


Figure 2

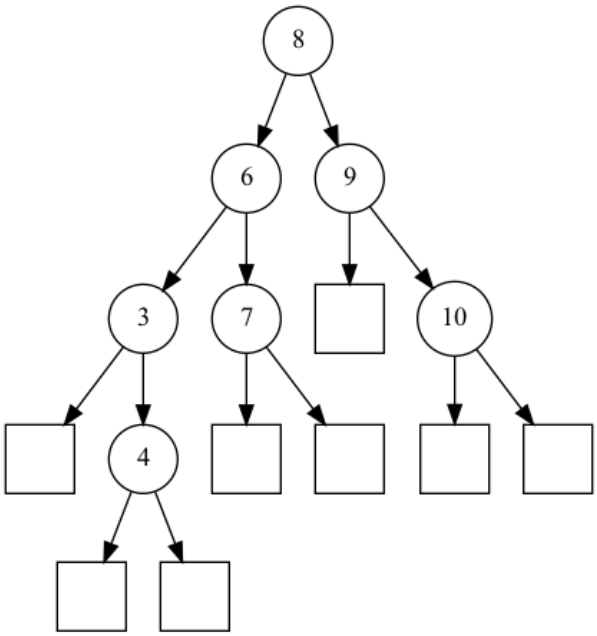
[16 marks]

(d) For each of the figures (i) to (vi), assume that the tree is a **Splay Tree**. Draw the state of the tree after performing the operation written above the figure. In your answer, also mention any restructuring that is required.

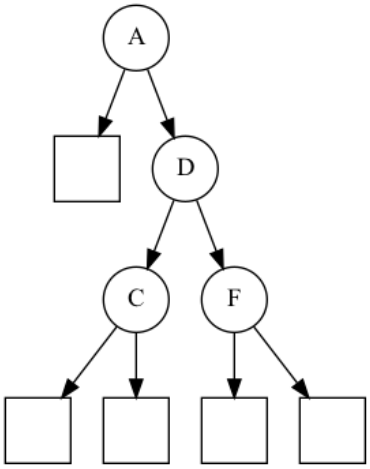
(i) Insert 4



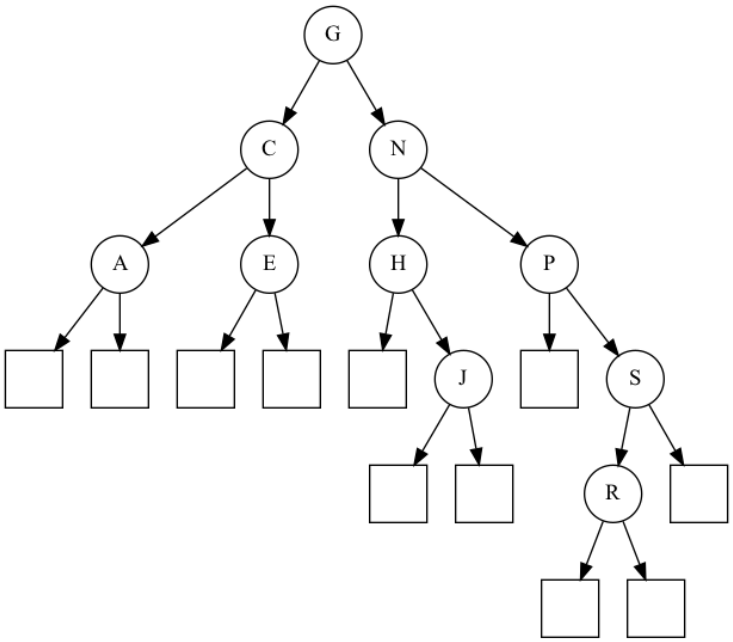
(ii) Insert 11



(iii) Contains F



(iv) Remove G



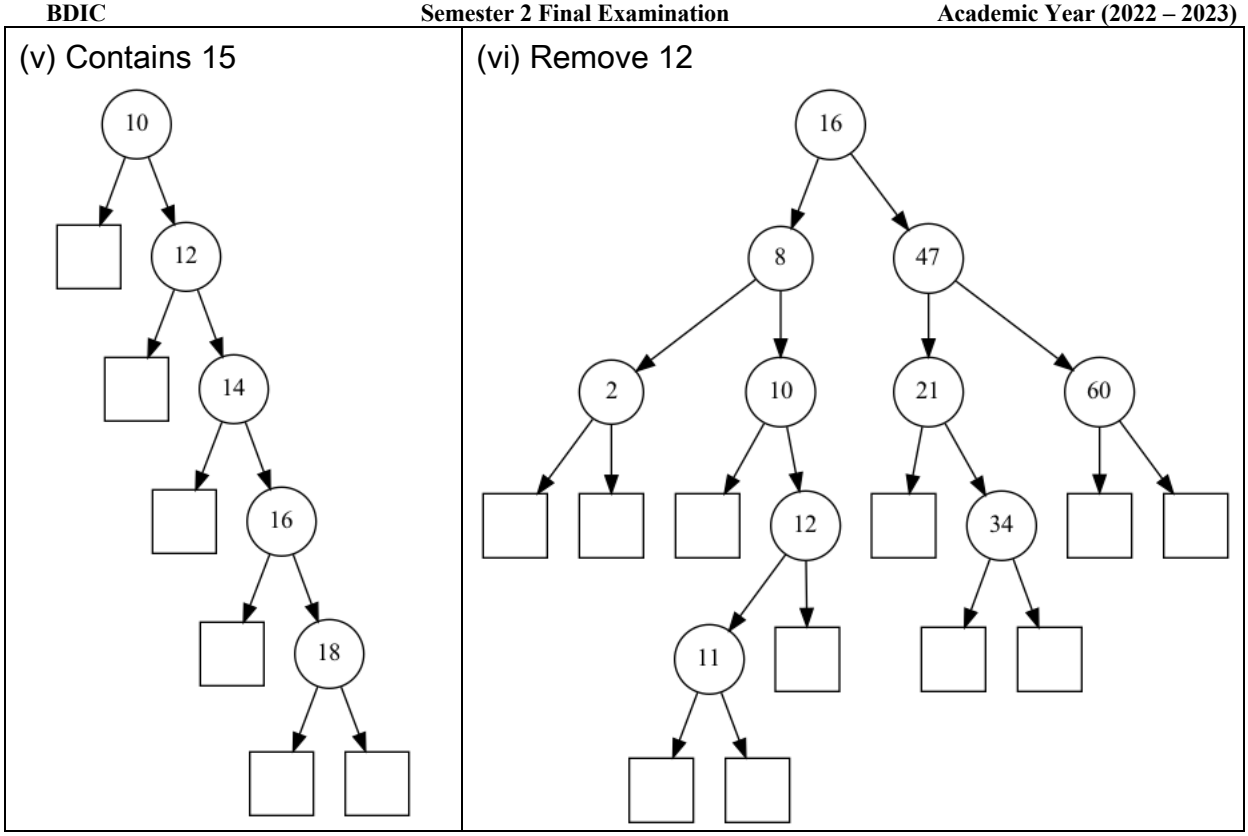


Figure 3

[12 marks]

(e) Explain how you would implement a *link-based binary tree*. In your answer, describe the internal structure of a node, identify what key data you must keep track of, and illustrate your description with a diagram of an example tree that contains three nodes.

[8 marks]

[Total 50 marks]

Question 2:

(a) Give definitions of the following graph concepts: *parallel edges, directed graph, endpoints of an edge, path, self-loop, spanning forest.*

[6 marks]

(b) One implementation of a *priority queue* ADT is to use a *heap*.

(i) Draw the heap that would be obtained after each of the following operations (your answer should show 12 heap diagrams).

insert(5), insert (3), insert(4), insert(6), remove(), insert(2),
insert(7), insert(3), insert(1), remove(), remove(), remove().

(ii) In a heap, what is the time complexity of an *upheap* operation? Explain your answer.

[12 marks]

(c) Figure 2 represents a Complete Binary Tree (CBT)

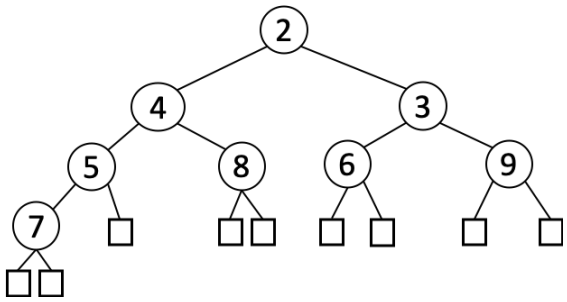


Figure 4

(i) Show how the CBT in Figure 4 can be represented using an array-based implementation.

(ii) If we know that a node is at index “i” in the array, what the indices of its parent and children?

(iii) Briefly explain why an array-based implementation would **not** be suitable for a Splay Tree.

[15 marks]

(d) This part relates to *Huffman Encoding*.

(i) What is Huffman Encoding used for?

(ii) A string contains six unique characters with the following distribution:

Character	Frequency
c	34
d	9
g	35
u	2
m	2
a	100

Using this string as an example, describe in detail how a Huffman Tree is created.

(iii) Using the tree you created in part (ii), what is the code that represents the string "dacm"?

[17 marks]

[Total 50 marks]

Question 3:

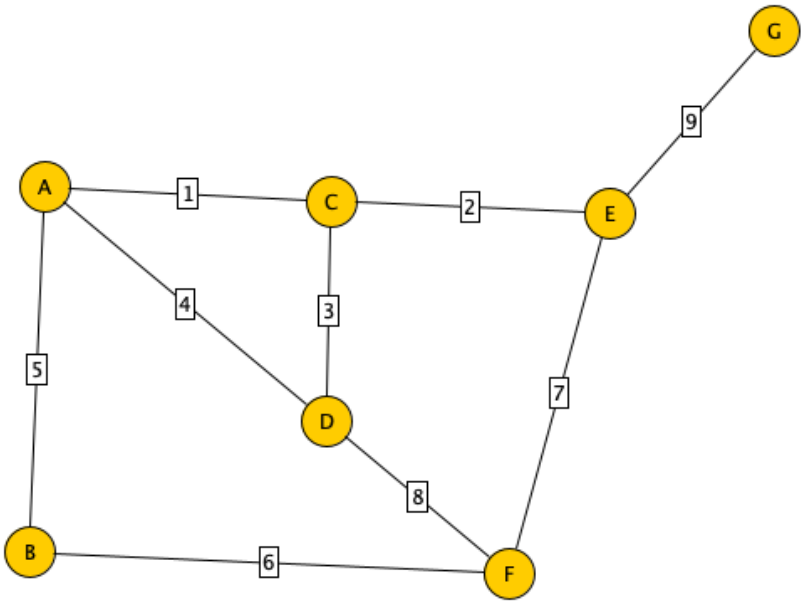


Figure 5

(a) Using the graph in Figure 5 as an example, show how Kruskal's algorithm can be used to compute a Minimum Spanning Tree. In your answer, you must explain each step that you take.

[12 marks]

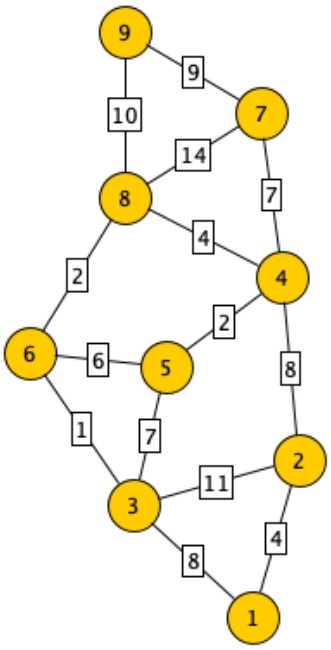


Figure 6

(b) Using the graph in Figure 6 as an example, show how Dijkstra's Algorithm can be used to compute a shortest path tree beginning at 1. In your answer, you must explain each step that you take.

[14 marks]

(c) With the aid of a diagram, describe in detail how the graph in Figure 7 could be represented using an *edge list* structure.

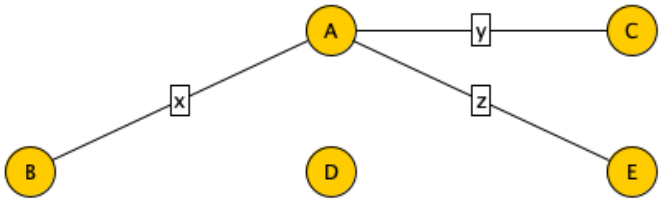


Figure 7

[12 marks]

(d) An *adjacency list* structure is one way in which a graph can be implemented. For each of the following graph methods, state what the time complexity performance is when using an adjacency list. Explain the reasons for this complexity in each case.

i) incidentEdges(v)

ii) areAdjacent(v,w)

iii) insertEdge(v, w, o)

iv) removeVertex(v)

[12 marks]

[Total 50 marks]