VIRTUAL SCHOOL VICTORIA

2023

SOLUTIONS

VCE ALGORITHMICS (HESS) UNIT 3

SAC Abstract Data Types (Part A)

Outcome 1

Reading Time: 5 minutes
Writing time: 55 minutes
TOTAL (60 minutes)

QUESTION AND ANSWER BOOK

Type	*Number of questions*	*Number of questions to be answered*	*Number of marks*
Short/ Extended Response	4	4	40
Total			40

Materials supplied

- Question and answer book of **x pages**

Materials permitted

- Pens/Stationary and one Scientific Calculator permitted.

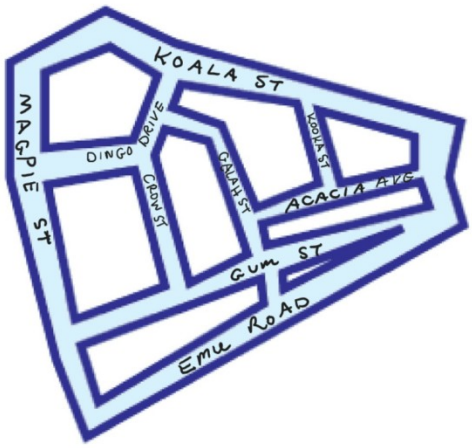
No Reference material permitted.

Instructions

- Write your **name** in the space provided above on this page.
- All written responses must be in English, point form is preferred.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the test room.

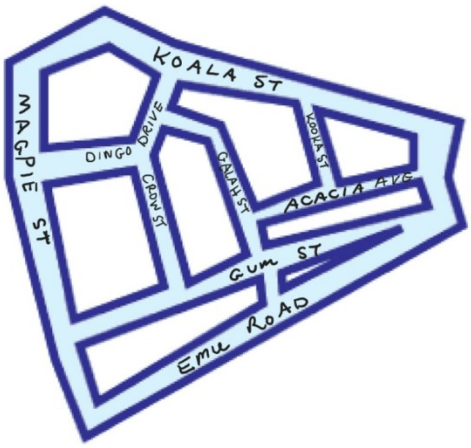
Question 1 (10 marks)

Here is an aerial map of some suburban streets. The council town planner needs to store the spatial information and non-spatial information related to the streets in a computer system that will be used for managing council services and for future urban planning.	

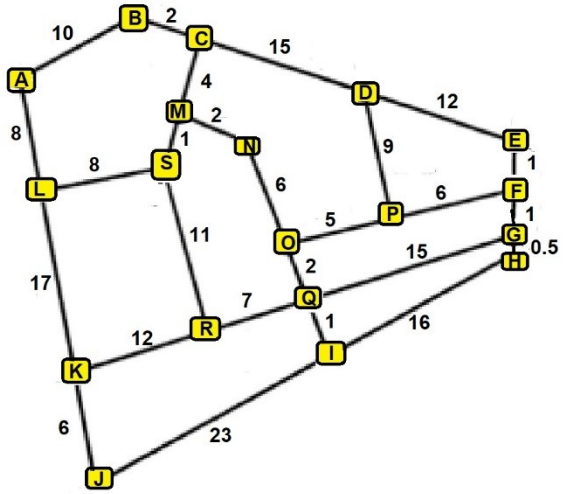
a) Describe how the spatial information and the following related details can be represented using the graph and other Abstract Data Type(s). (5 marks)

i. Streets	Graph adt, streets are edges, links between intersections
ii. Intersections	Graph adt, intersections are nodes, identify location
iii. Intersection (x,y) coordinates	Attributes on nodes or dictionary with key=node identification
iv. Street names	Attributes on edges or dictionary with key=edge identification
v. Distances between intersections	Attributes on edges or adjacency matrix, ease of access
	NOTE: **Answers will vary for student model.**

Question 1 (continued)



b) Give a detailed example of the Abstract Data Type model you have described in part a. for the given urban street map in the vicinity of Koala St (does not have to be to scale). (5 marks)



Graph ADT shows relationship of streets and intersections around Koala St

Dictionary of edges to store street name and distance
- Key=edge B-C, {name=Koala St, length=2}
- Key=edge C-D name=Koala St, length=15}
- Key=edge D-E name=Koala St, length=12}

Dictionary of nodes to store x,y location
- Key=node B, {x=100,y=500}
- Key=node C, {x=150,y=400}
- Key=node D, {x=300,y=300}

NOTE: **Answers will vary for student model.**

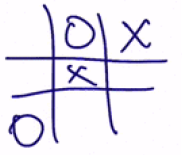
Question 2 (8 marks)

Many coding languages have built in elementary data types such as integer, real and Boolean. Many coding languages also have some built in structured data types such as array, list and set which are implementations of abstract data types used in pseudocode to define algorithms.

a) Describe the main features of the **array** abstract data type, and describe what distinguishes it from the **list** and the **set**. (2 marks)

It is a finite, ordered set of elements of the **same data type**. Finite means there is a specific number of elements and ordered implies that there is a first, second and third element of the array. Arrays are used when the size of the data structure is known in advanced, it is a static data structure and cannot grow or shrink as a list or set can. Unlike a set it can contain duplicate values.

Consider the following information representing a state of play in a game of tic-tac-toe.



b) Show the operations required to create a **one dimensional** array data structure to hold the state of play of the tic-tac-toe game and show the operations to capture the information in the data structure. (2 marks)

Create an array called A of 9 elements
A[1]:=blank, A[2]:=O, A[3]:=X, A[4]:=blank, A[5]:=X, A[6]:=blank, A[7]:=O, A[8]:=blank, A[9]:=blank

Note: must have operation to create a fixed size array and update it's elements

Question 2 (8 marks)

c) Describe the main features of the list abstract data type, and describe what distinguishes it from the array and the set. (2 marks)

An **abstract data type** consisting of **a number of items** in which unlike the set the **same item** may occur **more than once**. The list is s**equenced. A list is mutable and dynamic unlike the static array.** The list is sequenced and so can refer to first, second, third,……. Item and we can also refer to the last element of a list.

d) Complete the empty cells in the following table which has list operations. (2 marks)

List operation	Description	Example	List contents before	Return Value or updates list after
isEmpty(list)	Tests for empty list	myList.isEmpty()	[2,3,7,1]	False
append(item)	Adds a new item to the rear (end) of the list	myList.append(33)	[2,4,6]	[2,4,6,33]
remove(item)	Removes the first occurrence of an item form a list (decreases length of list by 1	myList.remove(13)	[4,13,6,8,13]	[4,6,8,13]

Question 3 (7 marks)

Consider a table of activities A, B, C, D, E, F, G and H and activity duration, where some activities have predecessor activities.

Activity Name	Predecessor Activity	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

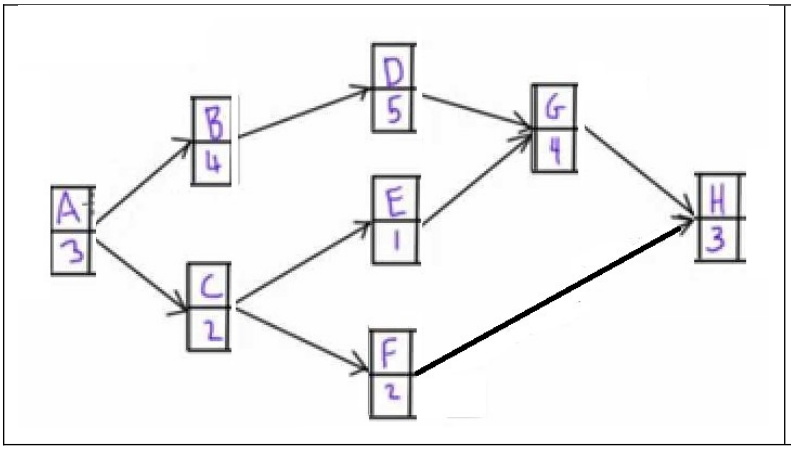
a) Should the activity names be stored as a set, list or an array? Justify your selection. (1 mark)

Each activity name is unique, a set data structure will ensure uniqueness of the activity names, while allowing new activity names to be included.

b) Using stack, queue or priority queue create a model of the information shown in the table above. Describe your model and how the ADTs are used to control the ordering of activities. (3 marks)

A minimum priority queue, enqueue A with 0 priority as has no dependency,
enqueue B,C with (priority of A)+1,
enqueue D with the (priority of B) + 1,
enqueue E, F with the (priority of C) + 1,
enqueue G with (priority of D) + (priority of E) + 1,
enqueue H with (priority of F) + (priority of G) + 1
will result in priority queue A 0, B 1, C 1, D 2, E 2, F 2,G 5, H 8

c) Using different ADTs to part a) and b) create a new model of the activities and dependencies. Describe and show the appearance your choice of ADT(s) depicting the activities shown below. (3 marks)



Directed graph with nodes as the activities and the directed edges to show the dependencies.

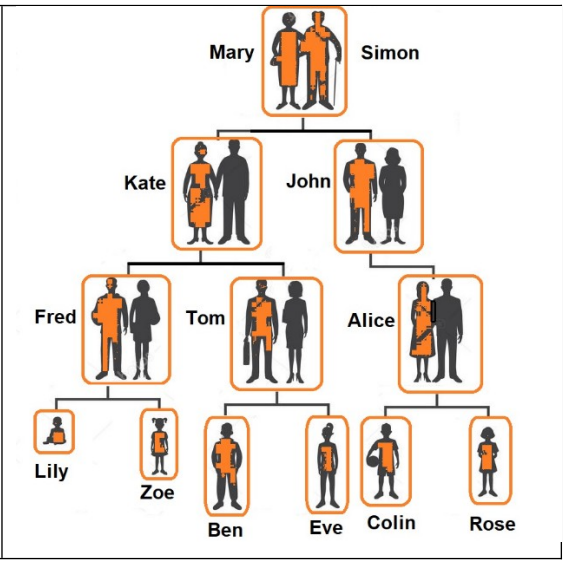
Each node has an attribute to inform of the activity duration.

(other answers may be valid)

Question 4 (15 marks)

The descendants of Mary and Simon are represented by a graph, with their

- children Kate and John,
- grandchildren Fred, Tom and Alice and
- great-grandchildren, Lily, Zoe, Ben, Eve, Colin, Rose



a) What operations according to the data signature of the graph ADT are required to build the graph model for Mary and Simon's family tree? (2 marks)

A new graph must be defined, for each person InsertNode(Graph, person) for each parent child relationship show the relationship InsertEdge(Graph, parent, child)

b) What operations according to the data signature of the graph ADT are required to add new descendants to Mary and Simon's family tree? (2 marks)

A new node and a new edge will need to be added to the graph showing the new descendant and their parent insertNode(Graph, new descendent) and InsertEdge(Graph, parent node, new descendant)

c) What are the properties, |V|, |E| and characteristics of the Mary and Simon's family graph? (2 marks)

Graph, acyclic, tree, connected, |V|=12, |E|=11 (marks off for incorrect descriptors)

Question 4 (continued)

d) What is the degree of the starting node shown in the graph in the diagram? In terms of graph terminology describe the characteristics of the nodes in the family graph. (2 marks)

Root node is degree 2, nodes between the root and leaf node have degree 2 or 3, the leaf node is degree 1, the great grandchildren are shown on the leaf nodes.

e) What is the **diameter** of the graph shown in the diagram? (2 marks)

The Diameter=6, which is also referred to as the width of the graph, the maximum count of edges between any two nodes in the graph, in this case it goes from a leaf to another leaf.

f) If a node of degree higher than 1 is removed from the graph in the diagram describe the characteristics of the result. What are the characteristics of the result when a node of degree 1 is removed? (2 marks)

- If a node of degree > 1 is removed the graph will become disconnected.
- If a node of degree=1 is removed then the nodes are reduced by 1 but the tree remains connected.

g) A bridge is an edge that if removed would make a connected graph disconnected. Provide an argument for why every edge in the diagram shown in Mary and Simon's family graph is a bridge. (3 marks)

In a tree by definition there are no cycles; therefore if any one edge is removed say connecting node "A" to node "B", then there will be no possible other way to get to from node "A" to node "B", this will result in a disconnected tree. This shows that every edge is therefore a bridge.

A connected tree of n nodes will have (n-1) edges, if we remove one edge we will then have (n-2) edges which will result in a disconnection in the tree. This will either create a forest or an isolated node. Therefore each edge is a bridge.

END OF TEST