Autumn 2017 – Main Exam

SEAT NUMBER:

STUDENT NUMBER:

UTS
UNIVERSITY OF TECHNOLOGY SYDNEY

SURNAME:
(FAMILY NAME)

OTHER NAMES:

This paper and all materials issued must be returned at the end of the examination. They are not to be removed from the exam centre.

Examination Conditions:

It is your responsibility to fill out and complete your details in the space provided on all the examination material provided to you. Use the time before your examination to do so as you will not be allowed any extra time once the exam has ended.

You are **not** permitted to have on your desk or on your person any unauthorised material. This includes but not limited to:

- Mobile phones
- Smart watches and bands
- Electronic devices
- Draft paper (unless provided)
- Textbooks (unless specified)
- Notes (unless specified)

You are **not** permitted to obtain assistance by improper means or ask for help from or give help to any other person.

If you wish to **leave and be re-admitted** (including to use the toilet), you have to wait until **90 mins** has elapsed.

If you wish to **leave the exam room permanently**, you have to wait until **60 mins** has elapsed.

You are not permitted to leave your seat (including to use the toilet) during the final 15 mins.

During the examination **you must first seek permission** (by raising your hand) from a supervisor before:

- Leaving early
- Using the toilet
- Accessing your bag

Disciplinary action will be taken against you if you infringe university rules.

31251 Data Structures and Algorithms

Time Allowed: 2 hours and 10 mins

Includes 10 minutes of reading time.

Reading time is for reading only. You are not permitted to write, calculate or mark your paper in any way during reading time.

This is a Closed Book exam

Unauthorised materials as specified in the examination conditions are not allowed.

Materials provided for this exam:

- This examination paper
- One (1) multiple choice answer sheet (GPAS-240R)
- One (1) answer booklet (8 pages)

Students please note:

The exam consists of two parts:

- **Part A**: Multiple Choice (20 marks)
  Mark your answers on the multiple choice answer sheet.
- **Part B**: Short Answer (30 marks)
  Write your answers in the provided answer booklet. Start each question on a new page.

All code is written in C++.

Do not open your exam paper until instructed.

Rough work space
Do **not** write your answers on this page.

Part A: Multiple Choice Questions

Question 1 (1 mark)

What will the following code snippet print out?

```
int i = 5;
int * p = &i;
*p += 10;
cout << p;
```

A. The address of variable `i`.
B. 15
C. 10
D. An unknown value from memory.

Question 2 (1 mark)

Which of the following code fragments correctly dereferences a pointer called `p`?

A. `*p`
B. `&p`
C. `p*`
D. `+p`

Question 3 (1 mark)

Which of the following code fragments gives the address of an `int` variable called `i`?

A. `*i`
B. `&i`
C. `i->`
D. `i*`

Question 4 (1 mark)

What will the following code snippet print out?

```
int i = 5;
int * p = &i;
*p += 10;
cout << *p;
```

A. The address of variable `i`.
B. 15
C. 10
D. An unknown value from memory.

Question 5 (1 mark)

Which of the following data structures could be used to implement the List abstract data type?

A. An array.
B. A linked list.
C. A vector.
D. All of the above.

Question 6 (1 mark)

Given a Stack with the standard push and pop functions, what value is on the top of the stack after the following sequence of operations: `push(5), push(10), push(9), pop(), push(1), push(1), pop(), push(6), pop(), pop()`?

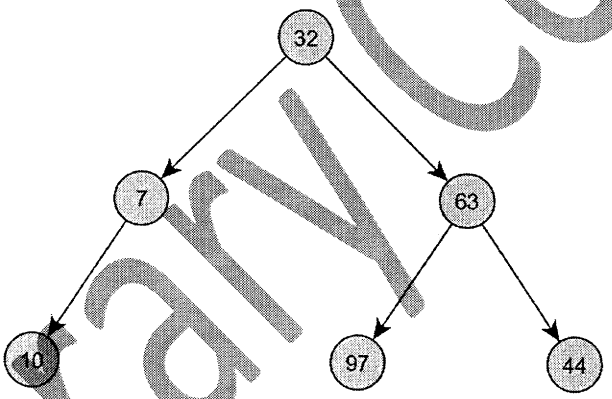
A. 5
B. 9
C. 10
D. 1

Question 7 (1 mark)

Given a standard linked list, what is the asymptotic (big-oh) time for inserting an element into the middle of a list of length n?

A. $O(1)$
B. $O(\log_2 n)$
C. $O(n)$
D. $O(n^2)$

Questions 8-11 refer to the following tree:



Question 8 (1 mark)

What is the visiting order of a depth-first preorder traversal of the tree?

A. 32, 63, 7, 10, 97, 44
B. 10, 7, 32, 97, 63, 44
C. 32, 7, 10, 63, 97, 44
D. 10, 7, 97, 44, 63, 32

Question 9 (1 mark)

What is the visiting order of a depth-first inorder traversal of the tree?

A. 10, 7, 32, 97, 63, 44
B. 10, 7, 97, 44, 63, 32
C. 32, 7, 63, 10, 97, 44
D. 44, 97, 63, 32, 7, 10

Question 10 (1 mark)

What is the visiting order of a depth-first postorder traversal of the tree?

A. 10, 7, 97, 44, 63, 32
B. 10, 7, 32, 97, 63, 44
C. 32, 7, 10, 63, 97, 44
D. 44, 97, 10, 63, 7, 32

Question 11 (1 mark)

What is the visiting order of a breadth-first traversal of the tree?

A. 10, 7, 32, 97, 63, 44
B. 10, 7, 97, 44, 63, 32
C. 32, 7, 63, 10, 97, 44
D. 32, 7, 10, 63, 97, 44

Question 12 (1 mark)

Which one of the following statements is TRUE?

A. $15n^2 + 3n + 2 \in O(n)$
B. $15n^2 + 3n + 2 \in \Omega(n^3)$
C. $15n^2 + 3n + 2 \in O(n^2)$
D. $15n^2 + 3n + 2 \in O(15)$

Question 13 (1 mark)

If a mathematical function g is at least as big as another mathematical function f for every value greater than 10, which of the following is definitely TRUE?

A. $g \in O(f)$
B. $f \in O(g)$
C. $f \in \Omega(g)$
D. $f \in \Theta(g)$

Question 14 (1 mark)

Which one of the following statements is FALSE?

A. $n^6 + 2n^4 - 2n + 2 \in O(n^7)$
B. $n^6 + 2n^4 - 2n + 2 \in \Omega(n^4)$
C. $n^6 + 2n^4 - 2n + 2 \in \Theta(n^6)$
D. $n^6 + 2n^4 - 2n + 2 \in \Theta(n^5)$

Question 15 (1 mark)

Which of the following operations is NOT normally included in a Map ADT?

A. add(K key, V value)
B. get(K key)
C. pop()
D. contains(K key)

Question 16 (1 mark)

Which of the following operations is NOT normally included in a List ADT?

A. void enqueue(V value)
B. void prepend(V value)
C. void append(V value)
D. bool isEmpty()

Question 17 (1 mark)

Assuming there is no collision, what is the best expected asymptotic (big-oh) running time of inserting a new element into a hashmap which already has n elements?

A. $O(1)$
B. $O(n)$
C. $O(n^2)$
D. $O(\log_2 n)$

Question 18 (1 mark)

Which algorithmic paradigm does the Rabin-Karp string searching algorithm best match?

A. Greedy Algorithms.
B. Dynamic Programming.
C. Divide and Conquer.
D. Binary Search.

Question 19 (1 mark)

Which algorithm paradigm does Mergesort best match?

A. Greedy Algorithms.
B. Dynamic Programming.
C. Divide and Conquer.
D. Binary Search.

Question 20 (1 mark)

Which of the following statements is FALSE?

A. Every recursive algorithm can be rewritten as an iterative algorithm.
B. Every iterative algorithm can be rewritten as a recursive algorithm.
C. Iteration is always better than recursion.
D. Recursion requires the explicit or implicit use of a stack.

Part B: Short Answer Questions

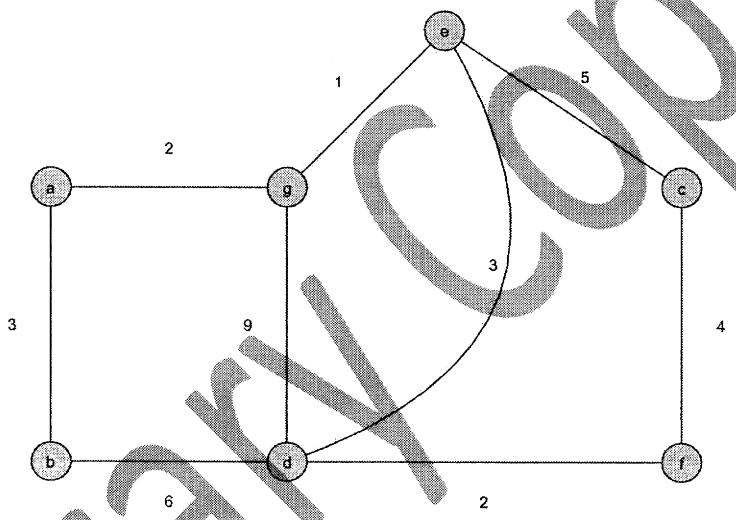
Question 21 (10 marks)

This question concerns hashmaps, hash functions, their properties and their implementation.

i. (2 marks) What is a hash function?
ii. (2 marks) List two desirable properties of a good hash function.
iii. (2 marks) What is a collision in the context of a hash function?
iv. (4 marks) Begin with an empty hashmap of size 7 (implemented using an array) which only stores integer data. Using the data as the key, insert one by one the entries 1, 3, 19, 22 and 51 into the hashmap using linear probing to resolve collisions and hash function h(K) = K mod N. Show the map after each insertion and indicate how you computed the insertion point.

Question 22 (10 marks)

This question concerns minimum spanning trees. Consider the following graph:



I. (4 marks) Starting at vertex (a), list in order the edges added to the spanning tree by Prim's algorithm.
II. (4 marks) List in order the edges added by Kruskal's algorithm. Briefly explain the mechanism you used to break ties.
III. (2 marks) Sketch the spanning tree and give its total weight.

Question 23 (10 marks)

This question concerns basic complexity theory.

i. (3 marks) What is the definition of the class **P**?
ii. (3 marks) What is the definition of the class **NP**?
iii. (3 marks) What is the definition of the class **NP**-hard?
iv. (1 mark) Is it important that we use Turing Machines as our model of computation for these definitions?