Name:	
Student Number:	
Signature:	

UNIVERSITY OF NEW SOUTH WALES

SAMPLE FINAL EXAMINATION

Summer Session 2009

COMP1927

Higher Data Structures and Algorithms

THIS IS A SAMPLE ONLY

Time allowed: 3 hours

Total Marks: 100

Number of Parts: 5

- You must hand in this entire paper and ALL your answer booklets. Otherwise you will get zero marks for the exam and a possible charge of academic misconduct.
- Ensure that you fill in all of the details on the front of this pink paper and the 5 answer booklets and then sign everything. Mark one booklet PART B, PART C, PART D, PART E and one WORKING ONLY. The working only booklet will not be marked. PART A, must be answered on this pink exam paper.
- Do not use red pen in this exam.
- Candidates must bring their student card for identification
- Candidates MAY NOT use any aids apart from the provided C Reference Card and their own pens and pencils
- Candidates MAY NOT communicate with any person besides the supervisor
- Mobile Phones must be switched off

Part A: Short Answer Questions

Answer these questions in the spaces provided on this pink question paper. DO NOT answer these questions in an answer booklet!

Write your answers clearly. Keep your answers neat and brief. For multiple choice questions, circle one answer only.

Question 1

(1 Mark)

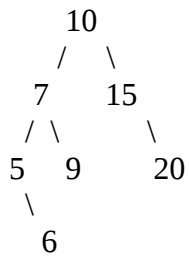
Which of the following sorting algorithms would change the order of the duplicates when sorting the following data set: aa AA cc dd bb. Assume that the algorithm treats 'a' and 'A' as equal.

1. Shell sort
2. Merge sort
3. Quick sort with Median of Three Partitioning
4. Selection Sort
5. None of the above

Question 2

(1 Mark)

Consider the following Binary Search Tree.



Which kind of traversal will give output in the following order: 6 5 9 7 20 15 10

1. Breadth first
2. Preorder
3. Post-order
4. In-order
5. None of the above

Question 3

(4 Marks)

What are two common ways or representing graphs in C? Explain the differences between the two representations and state two advantages of each approach.

Question 4

(4 Marks)

Discuss a way in which the naïve bubble sorting algorithm can be improved. What difference does the improvement make on the time complexities for random, reverse ordered and ordered data sets?

Part B: Sorting and Analysis of Algorithms

Answer this part in your part B answer booklet. Start each question on a new page. Make your answers as clear and easy to understand as possible. Provide type definitions and brief comments where necessary. Confusing or illegible solutions will lose marks

Question 5

(6 Marks)

Consider the following C code fragment for Insertion Sort with Sentinel and Shift, (the numbers on the left hand side are line numbers).

```
    void insertionSort(int sequence[], int numElements) {
       int i;

       // Move smallest element to the left
1      for (i = numElements - 1; i > 0; i--) {
2         if (sequence[i] < sequence[i - 1]) {
3            swap(&sequence[i], &sequence[i - 1]);
          }
       }

4      for (i = 2; i < numElements; i++) {
5         int j = i;
6         int key = sequence[i];
7         for (j = i; key < sequence[j - 1]; j--) {
8            sequence[j] = sequence[j - 1];
          }
9         sequence[j] = key;
       }
    }
```

[A] With each line of the Insertion Sort with Sentinel and Shift Algorithm above that is prefixed with a line number, associate a cost and a formula expressing the number of times that line of C code will be executed when sorting n items in the worst case.
[B]Using the cost and the formulas determined in [A], write a formula expressing the time complexity T(n) of this algorithm in the worst case.
[C] Use big-O notation to express the asymptotic worst case time complexity of this algorithm.

Question 6

(4 Marks)

You are given C code for an algorithm capable of sorting data consisting of strings and characters. The code ignores the case of the alphabetic characters when comparing strings (i.e. ‘a’ and ‘A’ are treated as equal). On testing the algorithm’s performance on sorting 10 000 randomly generated strings, 100 000 randomly generated strings, 10 000 ordered strings, 100 000 ordered strings, 10 000 reverse ordered strings and 100 000 reverse ordered strings (in all cases strings are a fixed length of 4 characters) you obtain the following timings (in seconds).

10 000 random	100 000 random	10 000 ordered	100 000 ordered	10 000 reversed	100 000 reversed
0.016	0.304	0.006	0.108	0.010	0.138

[A] In point form, briefly state the conclusions that you can draw from the test results above.

[B] Name the sorting algorithm(s) from lectures that are consistent with these conclusions.

[C] If you listed more than one algorithm in [B], what further test(s) would you conduct in order to try and isolate the algorithm under study? Include a description of the data you would use.

Part C: Abstract Data Types

Answer this part in your Part C answer booklet. Start each question on a new page. Make your answers as clear and easy to understand as possible. Provide type definitions and brief comments where necessary. Confusing or illegible solutions will lose marks.

Question 7

(10 Marks)

You have been asked to write an ADT to represent a priority queue. You need to write the ADT in files called pq.h and pq.c. You may assume the priority queue stores integers only and that these integers represent priorities. You may also assume that integers with smaller values are considered to have a higher priority.

[A] What are two examples of ways you could implement a priority Queue in C?
[B] Briefly state two advantages of each method.
[C] Give a complete definition and implementation of the Priority Queue ADT in C using one of the methods you have listed in the answer to part [A]. Make it clear in which file, or files, the code should go and how you have made it abstract.
[D] Write 4 interface tests and 4 implementation tests for your priority queue, stating clearly which files they will go in.

Part D: Trees

Question 8

(6 Marks)

Write a function called isBST that takes an arbitrary binary tree and returns an indication of whether it is a binary search tree.

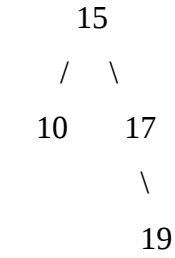
You may assume that you are writing it in the same file as the following tree definition:

```
typedef struct node Node:
typedef  Node * Tree;
struct node{
     int data;
     struct node * left;
     struct node * right;
}
```

Question 9

(4 Marks)

Consider the following splay tree.



[A] Show the effect of inserting the following items into this splay tree one at a time: 1 12 13 18. Draw the splay tree produced after each insertion.

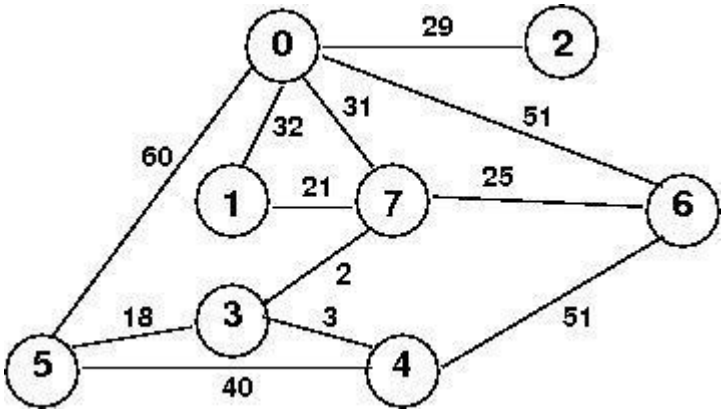
[B] What is the height of the resulting tree?

Part E: Graphs

Question 10

(5 Marks)

Consider the following weighted graph:



[A] Trace through Dijkstras's algorithm starting from the node labeled 6, showing the contents of the st and dist arrays as each vertex is visited.

[B] What is the shortest path from 6 to 5?

[C] What is the cost of this path?

Question 11

(5 Marks)

Using the same graph from question 10:

[A] A detective using the DFS strategy from assignment 3 starts in the city with the vertex id 3 from the graph above. Write down the cities the detective visits in the next 10 cycles. You may assume the detective has unlimited stamina.

[B] If another detective used BFS to find a path traveling through the least number of cities from the starting point of city 2 to the end point of city 3, what is the path the detective would take?

Question 12

(5 Marks)

Using the same graph from question 10:

[A] Trace through Prim's algorithm to find the MST of the graph. Show the st and dist arrays at each step. What is the total cost?

[B] Trace through Kruskal's algorithm for finding the MST of the graph. Show the order in which the edges are considered and indicated whether they are accepted as part of the MST or rejected. What is the total cost?