CMPT 125, Fall 2022

Final Exam
December 13, 2022

Name_____

SFU ID: |__|__|__|__|__|__|__|__|__|

Problem 1	
Problem 2	
Problem 3	
Problem 4	
TOTAL	

Instructions:

1. Duration of the exam is 180 minutes.
2. Write your full name and SFU ID NUMBER **clearly**.
3. This is a closed book exam, no calculators, cell phones, or any other material.
4. The exam consists of four (4) problems. Each problem is worth 25 points.
5. Write your answers in the provided space.
6. There is an extra page at the end of the exam. You may use it if needed.
7. Explain all your answers.
8. ***Really, explain all your answers.***

Good luck!

Problem 1 [25 points]

a) Consider the following function.

```
char* foo(int n) {
   char* str = malloc(n+1);
   str[0] = 0;
   for (int i=0; i<n; i++)
     strcat(str, "*");
   return str;
}
```

[6 points] Explain the functionality of foo().

[6 points] What is the running time of foo() as a function of n? Use big-O notation to express your answer. Explain your answer.

b) [7 points] Let T(n) be given using the recursive formula T(n) = T(n-1) + O(n), T(1) = 1. Use big-O notation to express the rate of growth of T as a function of n.

c) [6 points] Let T(n) be given using the recursive formula T(n) = T(n-1) + O(n), T(1) = 1. Write a recursive function whose running time is expressed as T(n).

Problem 2 [25 points]

a) [6 points] Write Insertion Sort in C.

```
void insertion_sort(int* A, int n) {




}
```

b) [8 points: 4 points each]
What is the worst case running time of Insertion Sort? Explain your answer.

What is the running time of Insertion Sort on a sorted array? Explain your answer.

c) [5 points] Consider the *QuickSort* algorithm that given an array A, chooses A[0] as the pivot. How many **swaps** will it perform on the array A = [10, 0, 2, 4, 6, 8]? Explain your answer. Write some intermediate steps of the algorithm when necessary.

d) [6 points] Explain what the function qsort() does. Write the signature of the function, and explain each of the parameters. Give an example of how qsort() is used.

Problem 3 [25 points]

In the problem a Linked List of ints is represented as follows.

```
struct LL_node {
  int data;
  struct LL_node* next;
};
typedef struct LL_node LL_node_t;

typedef struct {
  LL_node_t* head;
  LL_node_t* tail;
} LL_t;
```

a) [10 points] Write a function that gets a Linked List of ints and reverses it.
The running time of the function must be O(length of list).
For example, if the linked list is *1* → *-3* → *10* → *0* → *1* → *11*, then after applying the function it becomes *11* → *1* → *0* → *10* → *-3* → *1*.

```
void reverse(LL_t* list) {




}
```

b) [15 points: 5 points each] Implement the following standard functions on a Linked List with pointers to head and tail, using the struct above.

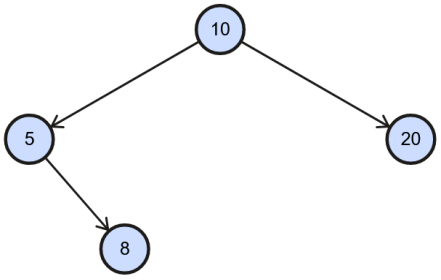
```
// adds a node with the given value to the head of the list
// the running time is O(1)
void add_to_head(LL_t* list, int val) {









}
// applies f to the value in each node of the list
// the running time is O(length of the list)
void map(LL_t* list, int (*f)(int)) {









}
// appends all nodes of src to the end of dest, and deletes src.
// after the application of the function, src cannot be used
// the running time is O(1)
void LL_cat(LL_t* dest, LL_t* src) {









}
```

Problem 4 [25 points]

In this problem use the following struct for Binary Tree of ints.

```
struct BTnode {
  int value;
  struct BTnode* left;
  struct BTnode* right;
  struct BTnode* parent;
};
typedef struct BTnode BTnode_t;
```

a) Consider the following Binary Search Tree.

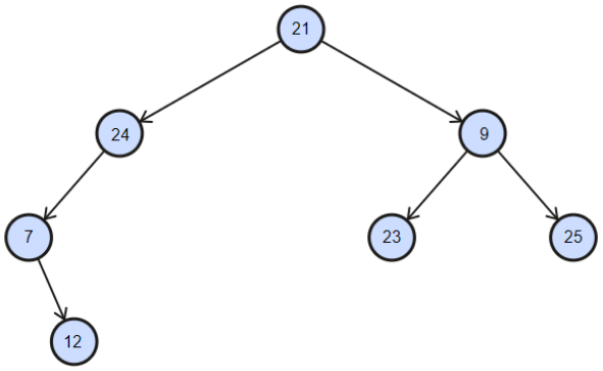


[5 points] Add the list of numbers to the Binary Search Tree in the given order: 2, 1, 6, 4, 7, 15. What will be the result in the end? Draw the resulting tree with the ten nodes.

[5 points] Remove 5 from the BST obtained above (tree with values 1,2,4,5,6,7,8,10,15,20). Draw the resulting BST.

b) [15 points] Write a function that gets a node in a binary tree (not necessarily the root), and returns the next node in the *post-order traversal order*.
The running time must be O(depth of three).
For example, in the tree below the post order traversal is [12,7,24,23,25,9,21]

- on input 12 the output should be 7
- on input 7 the output should be 24
- on input 23 the output should be 25
- on input 9 the output should be 21
- on input 21 the output should be NULL



Explain your answer before writing the code.

```
BTnode_t* next_postorder(BTnode_t* node) {




}
```

Extra page

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