This problem set has 19 questions, for a total of 110 points. Answer the questions below and mark your answers in the spaces provided. Additionally, fill out the bubble sheet provided **clearly** for your Gradescope submission. If the question asks for showing your work, you must provide details on how your answer was calculated.

Your Name: _____

1. [5 points] Which of the following descriptions best describes what **mystery** does?

```
int mystery(int *arr, int n) {
    if(n == 1) return arr[0];
    int val = mystery(arr + 1, n - 1)
    return (arr[0] > val) ? arr[0] : val;
}
```

A. find the minimum element of arr B. find the maximum element of arr C. find the the sum of all elements of arr D. sort all elements of arr

1. _____

2. [5 points] Which of the following descriptions best describes what **mystery** does?

```
bool mystery(int n, int i) {
    if (n <= 2)
        return (n == 2) ? true : false;
    if (n % i == 0)
        return false;
    if (i * i > n)
        return true;

    return mystery(n, i + 1);
}
```

A. determine if n is an even number B. determine if n is a prime number C. determine if i evenly divides n D. determine if n is an odd number

2. _____

3. [5 points] Given the following sorting algorithm, determine if it is **stable**, **in-place**, **both**, or **neither**.

```
int sort(int *arr, int n) {
    if (n <= 1) return;
    sort(arr, n-1);
    int tmp = arr[n-1];
    int j = n-2;
    while (j >= 0 && arr[j] > tmp) {
        arr[j+1] = arr[j];
        j--;
    }
    arr[j+1] = tmp;
}
```

A. stable B. in-place C. both D. neither

3. _____

4. [10 points] Solve the following recurrence relation: $T(0) = 1; T(n) = T(n+1) + 3$

A. $3n + 1$ B. $3n - 1$ C. $1 - 3n$

4. _____

5. [10 points] Solve the following recurrence relation: $T(1) = 1; T(n) = 2T(n/2) + n$

A. $n + logn$ B. $nlogn$ C. $n + nlogn$ D. $n^2 + nlogn$

5. _____

6. [5 points] Is a vector the best underlying structure to implement a queue with? Justify your answer.

A. Yes B. No

6. _____

7. [3 points] Would a stack (A) or queue (B) be more efficient for an undo button in a text editor

7. _____

8. [3 points] Would a stack (A) or queue (B) be more efficient for a web server connection manager

8. _____

9. [3 points] Would a stack (A) or queue (B) be more efficient for a breadth-first search

9. _____

10. [3 points] Would a stack (A) or queue (B) be more efficient for a depth-first search

10. _____

11. [5 points] Given the following function **mystery**, determine its output assuming **stack** has had the following elements inserted in order: 7, 20, 300, 5, 10

```
int mystery(std::stack<int> stack) {
    int result = 0;
    int loop = stack.size();
    for(int i = 0 ; i < loop; i++) {
        if(!(i % 2)) {
            result += stack.top();
        }
        else {
            result *= stack.top();
        }
        stack.pop();
    }
    return result;
}
```

A. 2210 B. 60050 C. 7007 D. 10640

11. _____

12. [7 points] If a Binary Tree is complete, does that necessarily mean it is also full? Justify your answer with drawings of trees.

A. Yes B. No

12. _____

13. [8 points] If a Binary Tree is full, does that necessarily mean it is also complete? Justify your answer with drawings of trees.

A. Yes B. No

13. _____

14. [5 points] Assume a binary search tree has undergone the following insertions in order: 10, 7, 15, 12, 13, 4, 8, 1, 19, 20, 5. Which of the following represents the output of a post-order traversal on the resulting tree?

A. 10, 7, 15, 4, 8, 12, 19, 1, 5, 13, 20 B. 1, 4, 5, 7, 8, 10, 12, 13, 15, 19, 20 C. 10, 7, 4, 1, 5, 8, 15, 12, 13, 19, 20 D. 1, 5, 4, 8, 7, 13, 12, 20, 19, 15, 10

14. _____

15. [5 points] Assume a binary search tree has undergone the following insertions in order: 20, 10, 30, 5, 4, 1, 6, 24, 52, 28, 13. Which of the following represents the output of a pre-order traversal on the resulting tree?

A. 1, 4, 5, 6, 10, 13, 20, 24, 28, 30, 52 B. 20, 10, 5, 4, 1, 6, 13, 30, 24, 28, 52 C. 1, 4, 6, 5, 13, 10, 28, 24, 52, 30, 20 D. 10, 7, 4, 1, 5, 8, 15, 12, 13, 19, 20

15. _____

For questions 16 - 19, let T be a full k-ary tree, where $k = 2$ (a.k.a. *binary tree*), with n nodes. Let h denote the height of T.

16. [7 points] What is the minimum number of leaves for T of height h? Justify your answer.

    Example when $h = 0 : T$, being a *full tree* can have a minimum of 1 leaf.

A. 2^h B. $2h$ C. 2^{h-1} D. $2^h - 1$ E. $h + 1$

16. _____

17. [7 points] What is the maximum number of leaves for T? Justify your answer.

A. 2^h B. $2h$ C. 2^{h-1} D. $2^h - 1$ E. $h + 1$

17. _____

18. [7 points] What is the minimum number of internal nodes for T? Justify your answer.

A. 2^h B. $2h$ C. 2^{h-1} D. h E. $h+1$

18. _____

19. [7 points] What is the maximum number of internal nodes for T? Justify your answer.

A. 2^h B. $2h$ C. 2^{h-1} D. $2^h - 1$ E. $h+1$

19. _____