Name: ________________________________

<table>
<thead>
<tr>
<th>Question</th>
<th>Possible Points</th>
<th>Received Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

This exam is closed notes.

You have 50 minutes to complete the 5 questions on this exam.

Please write your answers clearly.

Good luck!
Question 1: Truth or Consequences
Consider whether each of the following statements is True or False. Circle the correct answer.

True False With an unsorted list, a linear search must look through every element of the list to find the maximum element

True False A binary search assumes that the keys in the list are sorted

True False A binary search assumes that the key being searched for exists in the list

True False In a game of twenty questions, the best guessing strategy allows one to identify on the order of $20^2$ different items

True False A recursive algorithm can be defined by a base case and a set of rules reducing other cases towards the base case

True False An insertion sort requires $O(N^2)$ operations

True False Merging two lists of size $N$ into a list of size $2N$ requires $O(N \log N)$ operations

True False A successful merge of the list “2 6 8 9” with the list “4 7 10 11” is “2 4 6 7 8 9 10 11”

True False For a very large number of keys, Selection Sort is usually faster than Merge Sort.

True False For Quicksort, the best pivot is the key with the maximum value in the list.

True False In Quicksort, a correct partition of the List “8 9 3 2 0 7 2 1” around the pivot 7 is “3 2 0 2 1 7 8 9”

True False For very large values of $N$, an algorithm that requires $O(N^2)$ operations is probably faster than one that requires $O(N \log N)$ operations

True False Web browsers contact web servers with a special type of address called a URL

True False A correct simulation computes the same output regardless of the initial conditions

True False With cryptography, clear text is confidentially sent over an unprotected network

True False The complexity of solving a problem is equivalent to the complexity of creating that problem

True False The algorithm for finding a minimal spanning tree is greedy

True False The minimal spanning tree of a weighted graph is the path a traveling salesperson should use to minimize his or her distance

True False An algorithm that requires $2N^5$ steps has complexity represented by $O(N^5)$

True False All computational problems can be solved in polynomial time
Question 2: List your complaints here
Imagine you have eight different Scratch programs, each which manipulates a list “Mystery List”. Your job is to “execute” the scripts in your head to repeat the exact same steps and operations that Scratch would. For each of the following 8 scripts, show the contents of “Mystery List” at the end of the script. Be careful of the tiny but important differences across scripts!
**Question 3: Searching doesn’t have to be difficult**

Imagine that the Green Flag is clicked and the script “Create Valuable Numbers” creates the two Lists “Valuable Numbers” and “Names” shown below.

If Key is set to each of the following numbers, what will the scripts “say” to the user? (In other words, what will be the output of the program?) In each case, how many items in Valuable Numbers list will be accessed (or examined)? In each case, how many items in the Names list will be accessed (or examined)?

<table>
<thead>
<tr>
<th>Key Input</th>
<th>Say?</th>
<th># Items examined in Valuable Numbers List?</th>
<th># Items examined in Names List?</th>
</tr>
</thead>
<tbody>
<tr>
<td>785</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>166</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>121</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>734</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Imagine that a similar script “Find Max” is run instead with the same Valuable Numbers and Names lists.

What will the scripts “say” to the user? How many items in Valuable Numbers list will be accessed? How many items in the Names list will be accessed?

<table>
<thead>
<tr>
<th>Say?</th>
<th># Items examined in Valuable Numbers List?</th>
<th># Items examined in Names List?</th>
</tr>
</thead>
</table>

What assumptions does this implementation of “Find Max” make about the list of Valuable Numbers?
Question 4:
Consider the following implementations of Selection Sort:

```
when I receive Sort List
set List to 1
repeat until i > List Length
    set min to item i of Unsorted List
    set Index of min to i
    set j to 1
    repeat until j > List Length
        if item j of Unsorted List < min
            set min to item j of Unsorted List
            set Index of min to j
    change List by 1
    replace item Index of min of Unsorted List with item i of Unsorted List
    replace item i of Unsorted List with min
    change List by 1
```

and Insertion Sort:

```
when I receive Sort List
set List to 1
repeat until i > length of Unsorted List
    set Item to item i of Unsorted List
    delete i of Unsorted List
    set j to 1
    repeat until item j - 1 of Unsorted List < Item or j = 1
        change j by -1
    insert Item at j of Unsorted List
    change List by 1
```
Assume Unsorted List begins by containing the following 10 integers in this order:

Now, either Selection Sort or Insertion Sort is started on the list of 10 integers. The problem is, we don’t know which algorithm is being used! The sorting algorithm is then stopped after each iteration of the “repeat until” outer loop (that is, just after the last block “change i by 1” increments i to some value) and the contents of the Unsorted List are displayed. We’ve taken 10 screenshots of Unsorted List over time lettered (a) - (j).

The following page shows the contents of each of the Unsorted Lists, but they have been all mixed up! That is, the picture (a) of Unsorted List could have happened after picture (b) of Unsorted List. Your job is to figure out the correct order!

1. Using the contents of the Unsorted Lists and your knowledge of the algorithms, was Selection or Insertion sort used?

2. Order the pictures of Unsorted List to show the sequence in which they must have occurred when the algorithm was run. Write the correct order here.

3. You will notice that some of the Unsorted Lists from different iterations are identical; explain why this is the case!
Question 5: What is the meaning of Life?
The Game of Life is a simulation in which cells are in a 2-D grid; each cell can be either alive (black) or dead (white). The next generation of cells is calculated from the previous generation using a set of rules. Each cell will be alive or dead in the next generation depending upon the current state of its 8 nearest neighbors (the 8 nearest neighbors are the cells directly adjacent above, below, left, right, and the four diagonal cells).

- If (cell is alive)
  - If < 2 neighbors are alive, then the cell dies
  - If > 3 neighbors are alive, then the cell dies
  - If 2 or 3 neighbors are alive, then the cell stays alive

- If (cell is dead)
  - If 3 neighbors are alive, then the cell becomes alive

Consider the following six (6) different worlds lettered A-F that each has the current state shown. Some of the shown worlds are stable and will remain constant across future generation while others of the shown worlds will change in some way across generations (e.g., die out, move, or oscillate).

Which worlds are stable and will remain identical through all generations? To help you with your reasoning, you may want to label each cell with its number of live neighbors. Write the letters of the stable worlds here:

A)  
B)  
C)  
D)  
E)  
F)