Computer Science 302 Spring 2016 Practice Examination for the First Examination, February 10, 2016

Name:_____

No books, notes, or scratch paper. Use pen or pencil, any color. Use the rest of this page and the backs of the pages for scratch paper. If you need more scratch paper, it will be provided.

The entire examination is 225 points.

1. True or False. [5 points each]

   (a) _____ $n = O(n^2)$

   (b) _____ $\log(n^2) = O(\log n)$

   (c) _____ Binary search on an ordered list of length n takes $O(\log n)$ time.

   (d) _____ In the worst case, mergesort uses $O(n \log n)$ comparisons to sort n items

   (e) _____ In the worst case, quicksort uses $O(n \log n)$ comparisons to sort n items

   (f) _____ An abstract stack can hold any number of items.

2. Fill in the blanks.

   (a) [5 points] Any comparison-based sorting algorithm on a list of n items uses at least _____ comparisons in the worst case. (Give an asymptotic answer.)

   (b) [5 points] The operation which inserts a new item into a stack is usually called _____.

   (c) [10 points] The **only** abstract difference between a stack and a queue is

   _____

   _____

   (d) [15 points] There are three solutions to the *false overflow problem* for an array implementation of a queue. Briefly, what are they? (Even though I am giving you a whole line for each answer, your answers could be very short.)

   _____

   _____

   _____

3. Using "Big O" notation state how many times "Hello world" will be printed for each of the pseudo-code fragments below, in terms of n. Give the best possible answer. For example, if you write $O(n^2)$ as the answer to (a), technically that is correct but it will be marked wrong because $O(n)$ is a better answer.

   (a) [0 points]

```
for(int i=1; i<n; i++)
  cout << "Hello world" << endl;
```

   (b) [10 points]

```
for(int i=1; i<n; i++)
  for(int j=i; j<n; j++)
    cout << "Hello world" << endl;
```

   (c) [10 points]

```
for(int i=1; i<n; i++)
  for(int j=1; j<i; j=2*j)
    cout << "Hello world" << endl;
```

   (d) [10 points]

```
for(int i=1; i<n; i++)
  for(int j=i; j<n; j=2*j)
    cout << "Hello world" << endl;
```

   (e) [10 points]

```
for(int i=2; i<n; i=i*i)
  cout << "Hello world" << endl;
```

4. [20 points]

Order the following functions by asymptotic class. Be sure to indicate which functions are in the same asymptotic class.

n, n^2, $\log n$, $n \log n$, $n \log \log n$, $\log(n^2)$, $\log^2 n$, $\sqrt{n}$, $\frac{(2n+3)^4}{(n+2)^3}$, $n!$, $\log(n!)$, 2^n, n^n, 3^n, $5n + \sqrt{n} + \log n + 15$

5. [20 points]

Using the stack algorithm given in class, evaluate the postfix expression

```
22*357+3-*+
```

showing the stack after each step. Each numerical input is a single digit; for example "22" is not twenty-two, but is rather the number two written twice. However, numbers on the stack can have any size.

6. [30 points] Suppose that the items of a queue Q are C, H, A, T in that order, meaning that C is the front item and T is the rear item.

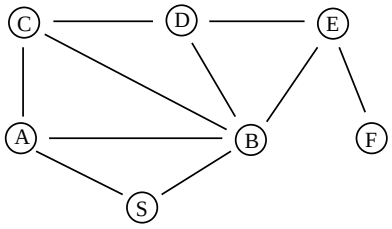
   (a) Sketch the appearance of a circular linked list implementation of Q, as we did in class (or in any other reasonable style).

   (b) When you evaluate the function *dequeue*(Q), what will be the return value of that function?

   (c) Show the appearance of the circular linked list after evaluating that function.

   (d) After evaluating that function, execute *enqueue*(Q, E). Show the steps. (You should draw at least two additional figures.)

7. [30 points] Step through the algorithm that visits all the nodes of this graph in breadth first order, starting with S. At each step, show the queue, using the simple array implementation.



8. [20 points] **Challenge Problem.** Using "Big O" notation state how many times "Hello world" will be printed for the pseudo-code fragment below, in terms of n. Give the best possible answer, just as for Problem 3.

   Warning: The purpose of this problem is to challenge the top students in the class. Do not attempt to work it unless you have answered all other questions and are satisfied with your answers.

```
for(int i=1; i<n; i=2*i)
  for(int j=i; j<n; j=2*j)
    cout << "Hello world" << endl;
```