

Prelim 2

CS 2110, 7:00 PM, November 17, 2016

Question	Short	Graphs	Sorting	GUIs	Spanning	Heaps	Complexity	Total
Max	18	18	14	10	10	14	16	100
Score								
Grader								

The exam is closed book and closed notes. Do not begin until instructed.

You have **90 minutes**. Good luck!

Write your name and Cornell **NetID** at the top of **every** page! There are 7 questions on 9 numbered pages, front and back. Check that you have all the pages. When you hand in your exam, make sure your pages are still stapled together. If not, please use our stapler to reattach all your pages!

We have scrap paper available. If you do a lot of crossing out and rewriting, you might want to write code on scrap paper first and then copy it to the exam so that we can make sense of what you handed in.

Write your answers in the space provided. Ambiguous answers will be considered incorrect. You should be able to fit your answers easily into the space provided.

In some places, we have abbreviated or condensed code to reduce the number of pages that must be printed for the exam. In others, code has been obfuscated to make the problem more difficult. This does not mean that its good style.

Academic Integrity Statement: I pledge that I have neither given nor received any unauthorized aid on this exam.

(signature)

1. Short Answer [18 pts]

(a) [4 pts] A traversal of an expression tree produces the string "+ * 2 5 + 1 3".

i. What kind of traversal is it?

ii. What is the result of evaluating the expression?

(b) [4 pts] Which of the following must be true (there may be more than one)?

i. if $x.hashCode() == y.hashCode()$ then $x.equals(y)$

ii. if $x.hashCode() == y.hashCode()$ then $x == y$

iii. if $x.equals(y)$ then $x.hashCode() == y.hashCode()$

iv. if $x == y$ then $x.hashCode() == y.hashCode()$

(c) [3 pts] A developer wants to use the observer pattern to react when the value of a counter changes. Which of the following steps should the program take *during initialization*? Note: there may be more than one.

i. Create a new CounterListener object

ii. Call addCounterListener

iii. Call counterChanged

(d) [7 pts] Let $f(n) ::= n + n \log n$. Then $f(n)$ is $O(g(n))$ for which of the following g ? Note: there may be more than one.

• $g(n) ::= n \log n$

• $g(n) ::= n$

• $g(n) ::= 2^n$

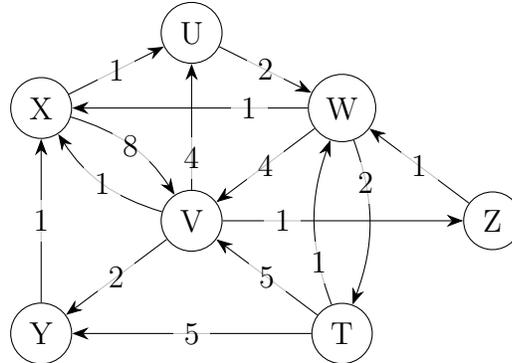
• $g(n) ::= \log n$

• $g(n) ::= (n + n \log n)/2$

• $g(n) ::= n + n \log n - 1$

• $g(n) ::= \sqrt{n + n \log n}$

2. Graphs [18 pts] Consider the following graph:



- (a) [5 pts] List the nodes in the order they would be visited by DFS, starting from X. When there are multiple valid options, list the lower-letter nodes first. (e.g. if you can visit either V or Y next, visit V next)
- (b) [5 pts] List the nodes in the order they would be visited by BFS, starting from X.
- (c) [5 pts] List the nodes in the order they would be visited by Dijkstra's algorithm, starting from X. Write down the resulting path lengths.
[TODO — clarification: “settled” instead of “visited”]
- (d) [3 pts] Is the graph planar?

3. **Sorting** [14 pts] In this question we develop a sorting algorithm using invariants. b is an array of integers; $b[h..k]$ is to be sorted.

- Precondition: b is an array with $0 \leq h \leq k < b.length$ (nothing is known about the values).
- Postcondition: $b[h..k]$ is sorted.
- Invariant: $h \leq i \leq k$ and $b[i..k]$ is sorted.

(a) [2 pts] Give an array diagram that captures this invariant.

(b) [2 pts] Give the initialization statements that make the invariant true.

(c) [2 pts] Give the loop condition.

(d) [2 pts] Give a statement that makes progress towards termination (it may violate the invariant).

(e) [3 pts] Describe in English what must be done in the loop body before part (d) to preserve the invariant. Your answer should be roughly one sentence.

(f) [3 pts] What is the asymptotic worst-case running time of this algorithm?

4. GUIs [10 pts] Consider the program on the next page.

(a) [5 pts] Draw the GUI resulting from running the program on the following page.

(b) [5 pts] The code doesn't work: nothing happens when the button is pressed. Explain why not, and fix it. Hint: this requires a one-line change. Don't worry if you don't remember the exact names of any swing methods you may need.

```
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

class GUI extends JFrame {

    /** invariant: label.getText() = count */
    private JLabel label;
    private int    count;

    private class IncrementButton
        extends JButton
        implements ActionListener
    {
        public IncrementButton() {
            super("Increment");
            addActionListener(this);
        }

        /** increment count and update label. */
        public void actionPerformed(ActionEvent e) {
            count = count + 1;
        }
    }

    public GUI() {
        super("GUI");

        this.label = new JLabel("0");
        this.count = 0;

        setLayout(new FlowLayout());
        add(new IncrementButton());
        add(label);
        pack();
    }

    public static void main(String[] args) {
        new GUI().setVisible(true);
    }
}
```

Name:

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5. Spanning Trees [10 pts] Recall the following definition:

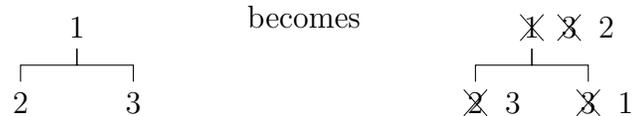
Definition: A spanning tree T of a connected graph G is a subgraph of G containing all the nodes of G and a minimal set of edges that connects them.

Based on this definition, describe a high-level algorithm (as done in lecture) to find a spanning tree of G .

6. Heaps [14 pts]

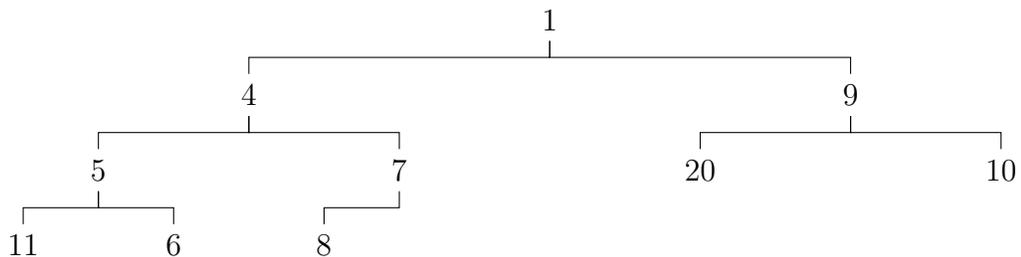
In this question, you will perform operations on a min-heap in which the values are the priorities. When you change the value of a node, cross out the old value and write the new value next to it. For example, after swapping the root with the left child and then swapping the root with the right child,

[TODO — there is a typo in the example; should be right then left]

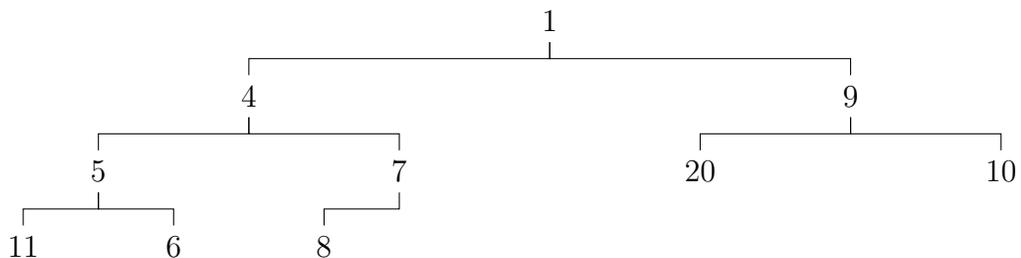


If you make a mistake, be sure that you differentiate between the mistake and the values that you are crossing out!

(a) [7 pts] Perform poll on the following min-heap:



(b) [7 pts] Perform add(3) on the following min-heap:



7. Complexity [16 pts]

(a) [4 pts] What is the definition of “ $f(n)$ is $O(g(n))$ ”?

(b) [6 pts] Prove that $2n^2 + 2$ is $O(n^3 - 1)$.

(c) [6 pts] Give the worst-case and expected case run times of quicksort on an array b of size n . Describe a situation in which it will take the worst-case time.