Student Name: _____ Student ID # _____

OU Academic Integrity Pledge

On my honor I affirm that I have neither given nor received inappropriate aid in the completion of this exercise.

Signature: _____ Date: _____

Notes Regarding this Examination

Open Book(s) You may consult any printed textbooks in your immediate possession during the course of this examination.

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No Electronic Devices Permitted You may not use any electronic devices during the course of this examination, including but not limited to calculators, computers, and cellular phones. All electronic devices in the student's possession must be turned off and placed out of sight (for example, in the student's own pocket or backpack) for the duration of the examination.

Violations Copying another's work, or possession of electronic computing or communication devices in the testing area, is cheating and grounds for penalties in accordance with school policies.

Part I. Data Structures Comparisons

1. (2 points) The minimum Big O runtime to find an arbitrary element in an arbitrary *binary tree* is roughly equal to the minimum Big O runtime to find an arbitrary element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

2. (2 points) The minimum Big O runtime to find an arbitrary element in an arbitrary *binary search tree* is roughly equal to the minimum Big O runtime to find an arbitrary element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

3. (2 points) The minimum Big O runtime to find an arbitrary element in an arbitrary *AVL tree* is roughly equal to the minimum Big O runtime to find an arbitrary element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

4. (2 points) The minimum Big O runtime to find an arbitrary element in an arbitrary *Red-Black tree* is roughly equal to the minimum Big O runtime to find an arbitrary element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

5. (2 points) The minimum Big O runtime to find an arbitrary element in an arbitrary *undirected graph* is roughly equal to the minimum Big O runtime to find an arbitrary element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

6. (2 points) The minimum Big O runtime to find *the minimum* element in an arbitrary *minimum heap* is roughly equal to the minimum Big O runtime to find *the minimum* element in which other data structure?
   A. Queue
   B. Hash Table
   C. Sorted Array
   D. Linked List
   E. None of the Above

Part II. Graphs

7. (2 points) A *vertex* is another word for which of the following?
   - ***A. A node***
   - B. An edge
   - C. A link
   - D. A path
   - E. A value

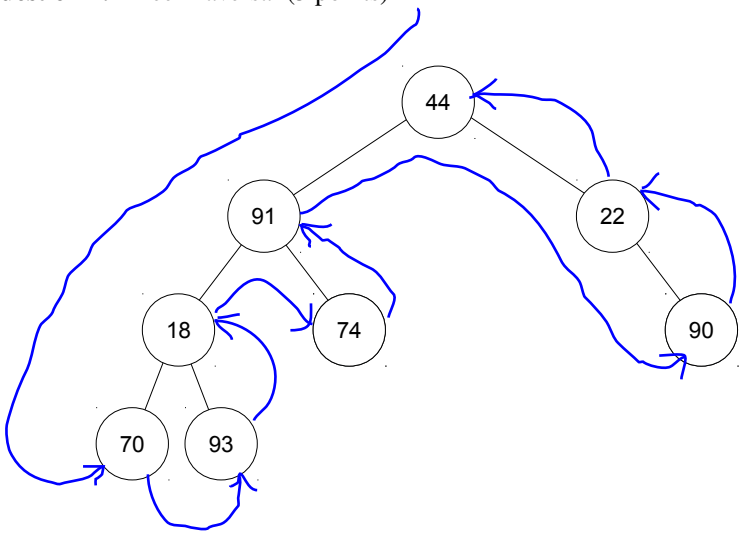
8. (2 points) For sparse graphs, which of the following data structures is more space efficient?
   - A. Adjacency queues
   - B. Adjacency trees
   - C. Adjacency matrices
   - ***D. Adjacency lists***
   - E. None of the above

9. (2 points) What is the time complexity for efficiently changing the edge cost in an efficient representation of a complete directed graph with n nodes?
   - A. $\Theta(n)$
   - B. $\Theta(\log_2 n)$
   - ***C.*** $\Theta(1)$
   - D. $\Theta(n^2)$
   - E. $\Theta(n \log_2 n)$

10. (2 points) Uniform cost search can be seen as a generalization of which of the following?
    - A. Depth-first search
    - ***B. Breadth-first search***
    - C. Binary search
    - D. Linear search
    - E. None of the above

Exam continues with short answer questions.

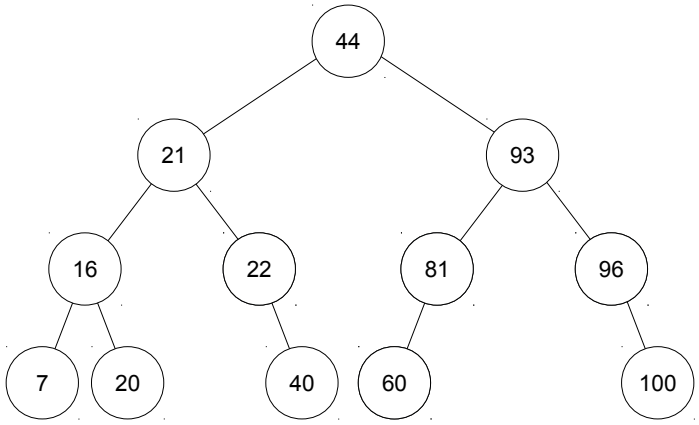
Short Answer Question 1: Tree Traversal (5 points)



Show the postorder traversal of the above binary tree.

The traversal order will be 70, 93, 18, 74, 91, 90, 22, 44, as shown above.

Short Answer Question 2: Binary Search Trees (10 points)



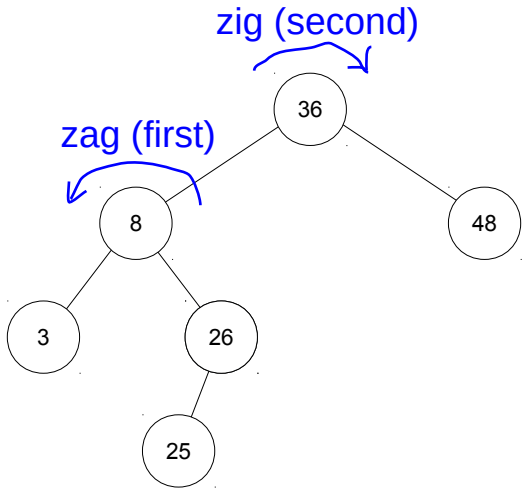
A. **Explain** how many key comparisons are necessary to perform a search for the key 83 in the tree above.

Three key comparisons are necessary.
83 is compared to 44 (at the root). Since 83 > 44, we follow the right branch.
83 is compared to 93 (the right branch of 44). Since 83 < 93, we follow the left branch.
83 is compared to 81 (the left branch of 93). Since 83 > 81, we follow the right branch.
Since the right branch of 81 is empty, the result returned is that 83 is not found.

B. **Explain** how many key comparisons are necessary to perform a search for the key 20 in the tree above.

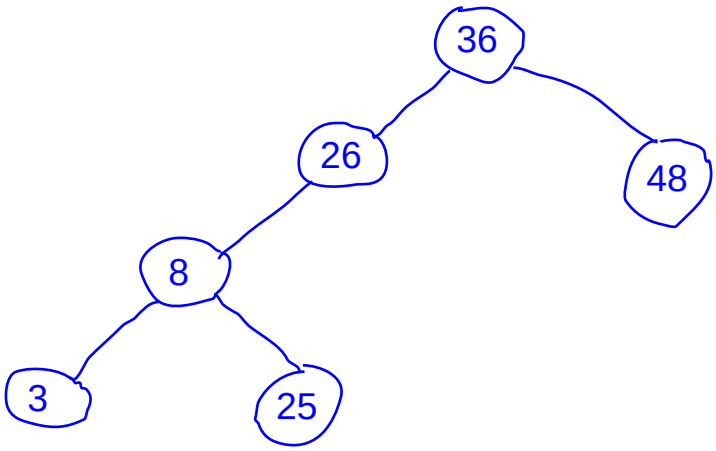
Four key comparisons are necessary.
20 is compared to 44 (at the root). Since 20 < 44, we follow the left branch.
20 is compared to 21 (the left branch of 44). Since 20 < 21, we follow the left branch.
20 is compared to 16 (the left branch of 21). Since 20 > 16, we follow the right branch.
20 is compared to 20 (the right branch of 16). Since 20 = 20, we return this location.

Short Answer Question 3: Self-Modifying Search Trees (10 points)

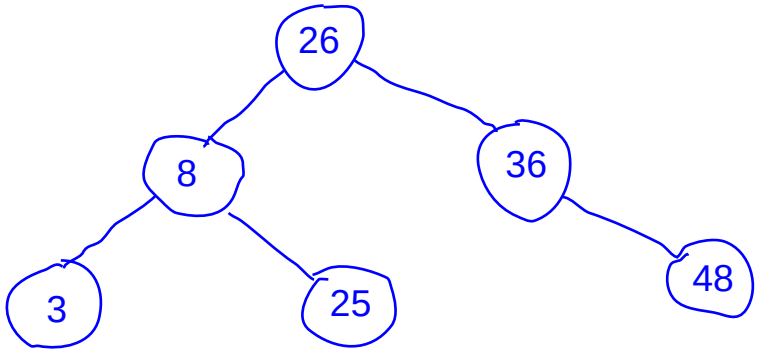


Explain the result of performing a zigzag operation on the node with key 36 in the tree above.

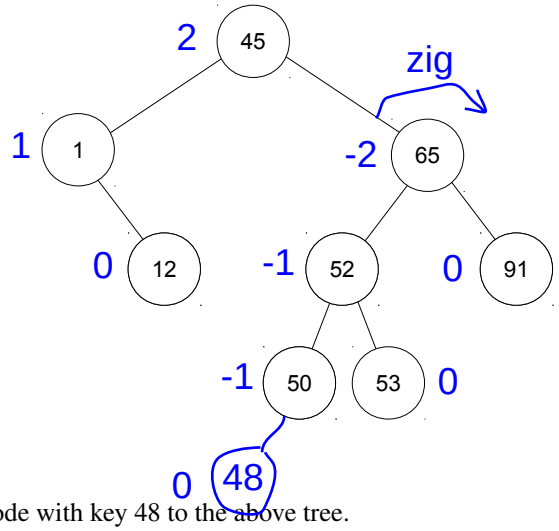
A zigzag on 36 means that first we do a zag on the left branch of 36 (here, node 8), then a zig on 36 itself. The zag on 8 results in the following tree:



The subsequent zig on 36 results in the following tree:

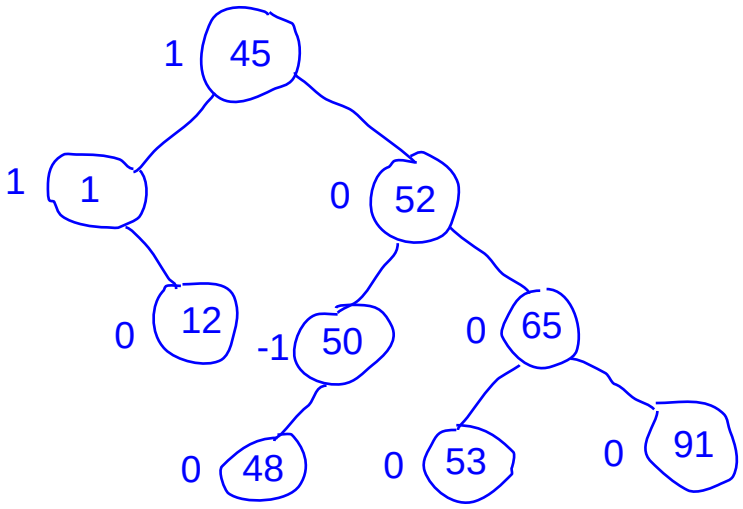


Short Answer Question 4: AVL Trees (15 points)



Explain the result of adding the node with key 48 to the above tree.

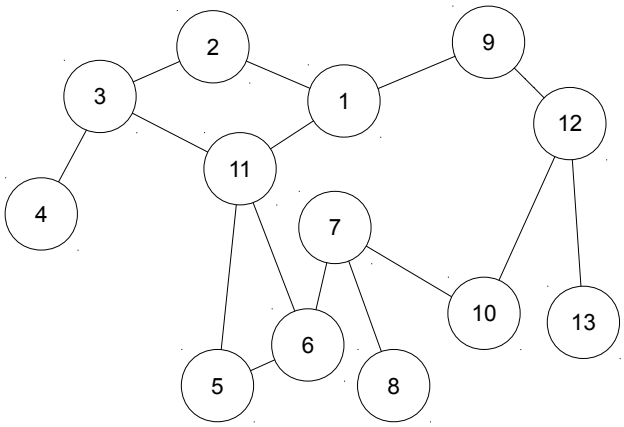
48 is added as the left child of 50. However, this causes a height imbalance of -2 at 65 and, since this is an AVL tree, that imbalance causes a zig operation at 65, resulting in the following tree:



This gives a tree that is imbalanced by, at most, an absolute value of 1 at any given node, so this is the final result for adding 48.

Short Answer Question 5: Graphs (20 points)

Explain the order of node traversal for the following graph for the specified search type. Assume that nodes with lower node numbers will be traversed before nodes with higher node numbers when multiple nodes are available as successors of a given node. Start at node 1.



A. Depth-First Search

B. Breadth-First Search

Short Answer Question 6: Ethics (20 points)

Angie walked in looking for Mic but he wasn't there. Not at his desk. Not at the printer. Not over by the water cooler. "Hey, Nan, did Mic already leave for the day?"

"What?" Nancy had to pull her mind out of her work to get the question to register. "Oh, yeah, he left about twenty minutes ago. Why?"

"Are you sure?" Angie probed. "He's still logged in on his machine."

"Yeah, Ang, I'm sure." Nancy assured her. "He always leaves himself logged in. He's even turned off the auto-lock because he says it's a waste of time. Julio gets on him for it now and then but he still does it."

"Rats!" This wasn't the news Angie wanted. "He was supposed to check his changes in to the repository before he left. How am I supposed to verify his code if it isn't in the repo?"

"Do it tomorrow, like always?"

"No, not like always. I've got plans for tomorrow. This time I was supposed to work late tonight, so I could take tomorrow off. Julio approved it. Now that's all messed up." Angie sighed.

"Oh, Ang, that's too bad. Mic is so irresponsible. Maybe you could try to get a hold of him."

Calls were made. Texts sent. Emails. PMs. Nothing. So, Angie moved on to trying to get a hold of Julio. Same story. Finally, it was time for Nancy to leave too.

"Listen," Nan said, "I gotta go but good luck. And, well, don't forget, Mic never logs out."

"Mic never logs out." Angie echoed the words in her mind. Maybe Nan was right. It shouldn't be hard to find the changed code on Mic's machine and check it in herself. Then she could get her job done and go on her way. That, or miss out on tomorrow's plans? No, this was Mic's fault and she wasn't going to let him mess this up for her. Angie sat down at Mic's machine and started looking.

A. Find at least one computer crimes law that is relevant to this scenario. List the name of the law and *explain* why you think it is relevant.

The Computer Fraud and Abuse Act (CFAA) is relevant because Angie logged into Mic's computer and started looking through his files, which would be accessing what is likely a protected computer without authorization, which is a crime under the CFAA.

[Note the name of an actual computer crimes law and the explanation drawing on elements of the story.]

B. Say whether you think Angie abided by (that is, followed) the law you listed and *explain* how you came to that conclusion.

While the scenario is a bit vague, it is likely that Angie did not abide by the CFAA. Mic's computer is likely a protected computer, since it probably has Internet access (it certainly has some networking capability to check code into a shared repo) and therefore has likely been used for interstate communication and maybe even interstate commerce. Also, it is unlikely that Angie has authorization to use Mic's computer, given how reticent she is to do so, trying it only after failing many ways to contact Mic and their apparent supervisor Julio.

[Note the explicit statement about whether the person abided by the law and the explanation drawing on elements of the story.]

C. Give one likely motivation for Angie's action and *explain* how you concluded that was a likely motivation.

Angie was likely motivated by her desire to stick to her plans for tomorrow and her blaming Mic for being irresponsible. I concluded this because the last thing in the scenario before she uses Mic's computer is the narration of her thoughts that "this was Mic's fault and she wasn't going to let him mess this up for her."

[Note the explicit statement of the motivation and the explanation drawing on elements of the story.]

D. List one ethical-decision-making problem (interfering factor) that is likely to have contributed to at least one of Angie's decisions and *explain* how you concluded that was a likely problem.

One interfering problem was likely letting her emotions, particularly annoyance, govern her thinking. Being annoyed at irresponsibility is a quite natural response and there are several clues in the story, from her language use ("messed up") to her sighing, to the fact that she blames Mic just before using his computer, that she is focused on his irresponsibility while making her decisions.

[Note that an EDM problem is not just a description of the situation the person is in (e.g., Angie needs access to the files on Mic's computer) but an element of the situation that may interfere with her decision making. There are other possible EDM problems here, such as focusing on only short-term consequences or having a conflict of interest between her personal and professional life.]

E. List one ethical-decision-making strategy that Angie could employ to improve ~~his~~ ethical decision making and *explain* how ~~he~~ might employ that strategy in this situation.

One EDM strategy that Angie could employ is to deal with her emotions. If she recognizes that a situation where her plans are (probably) ruined by an irresponsible individual is likely to make her annoyed, then she's likely to recognize that she is in fact annoyed at Mic and, further, that her decision-making is likely to be negatively impacted by that annoyance. Once she has recognized all that, she'll be in a better position to try to step back from the situation and look objectively for solutions.

[Note that an EDM strategy is not the final decision the person should reach. Rather, it is the approach the person should use to help reach a better final decision. It should match with the problem identified.]