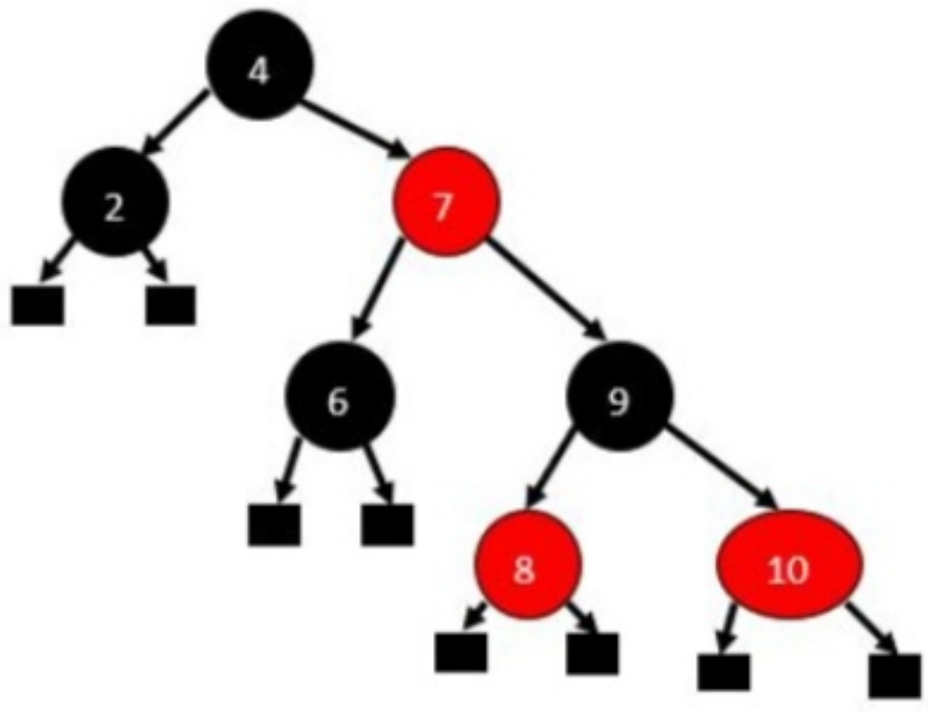
1. Consider the following tree with nodes colored red/black. Sentinels (NIL) are shown by black squares. 1 / 1 point



Answer the following questions below based on the black height of various nodes.

- [x] Each leaf has black height 0.

Correct
Correct – black height does not include the node you are starting from.

- [x] The node labelled 9 has black height 1.

Correct
Every path from the node to a leaf has one black node that includes the sentinel node itself.

- [x] The node labelled 7 has black height 2.

Correct
Look at every path from the node 7 to a sentinel. It has two black nodes including the sentinel.

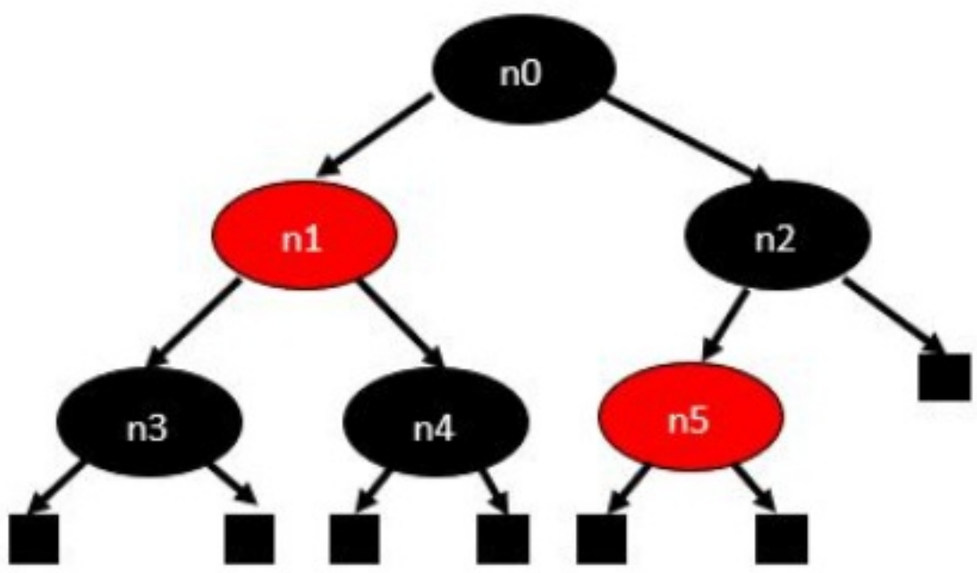
- [x] The root node has black height 2.

Correct
Note that every path from the root to a leaf has 2 black nodes. In this we do not count the root node itself but count the sentinel node.

- [ ] The node labeled 2 has black height 2.
- [x] The tree is a valid red-black tree that satisfies all the conditions of a red-black tree.

Correct
This is correct.

2. Consider the tree below with nodes labeled red/black. 1 / 1 point



Select the correct fact from the list below.

- [ ] There is a red node which has a red child.
- [ ] The black height at node n2 is not well defined.
- [ ] The black height at node n1 is not well defined.
- [x] The black height at the root is 2.

Correct

- [x] This is a valid red/black tree.

Correct

1 / 1 point

3. Consider a red-black tree with $n \geq 128$ nodes. Select all the true facts about the tree.

- [ ] The tree can have height more than n/2.
- [x] If the longest path from root to leaf is 12 then every path must have size at least 6.

Correct

note that the black height must be the same. In the worst case every other node in the longest path is a red node. This means that the shortest path must have length at least 6.

- [x] Finding a key will take time $\Theta(\log n)$.

Correct

- [x] The difficulty in red-black trees consists of maintaining the red-black property when we insert/delete elements.

Correct