Exam review

CS 261 Lab #10

Oregon State University OSU

The exam will be **comprehensive**
(so don't forget to review the midterm slides!)

Similar style as midterm
(multiple choice, matching, true/false, code)

This review will focus on **trees, heaps,**
hash tables, and **graphs**

Draw a **complete binary search tree**
that contains the following letters:
A, B, C, D, E, F, G, H, I, J, K

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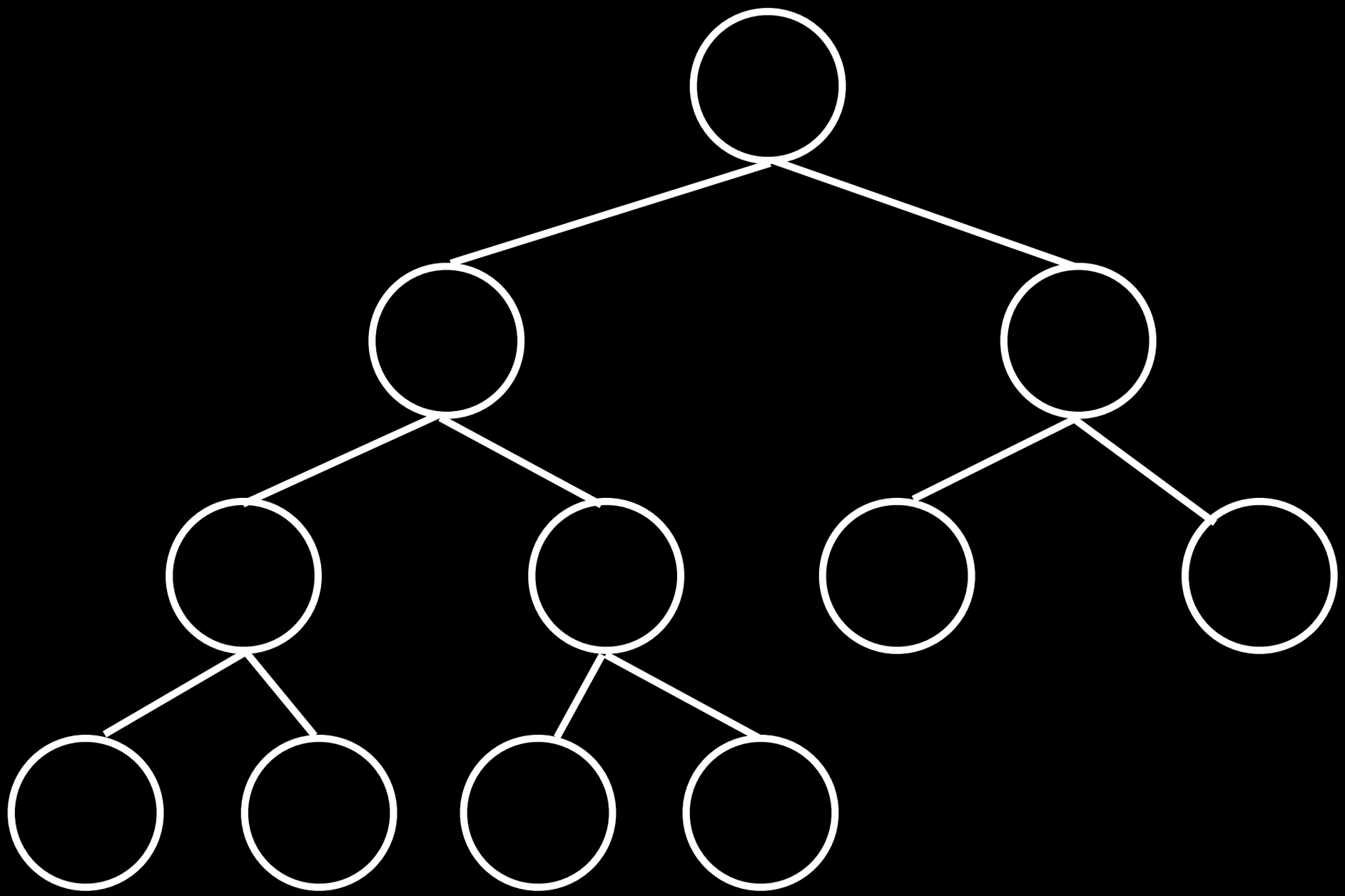

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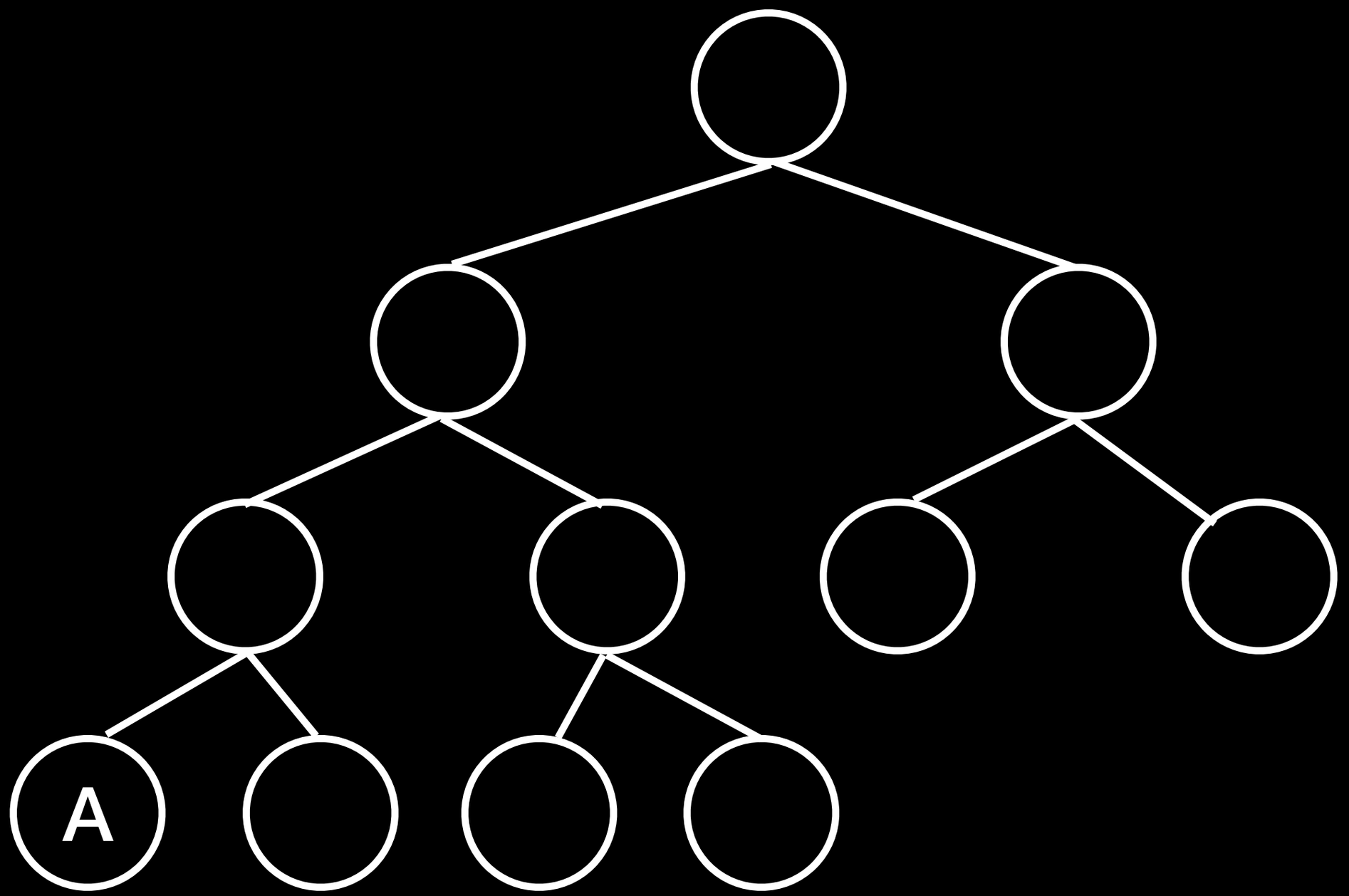

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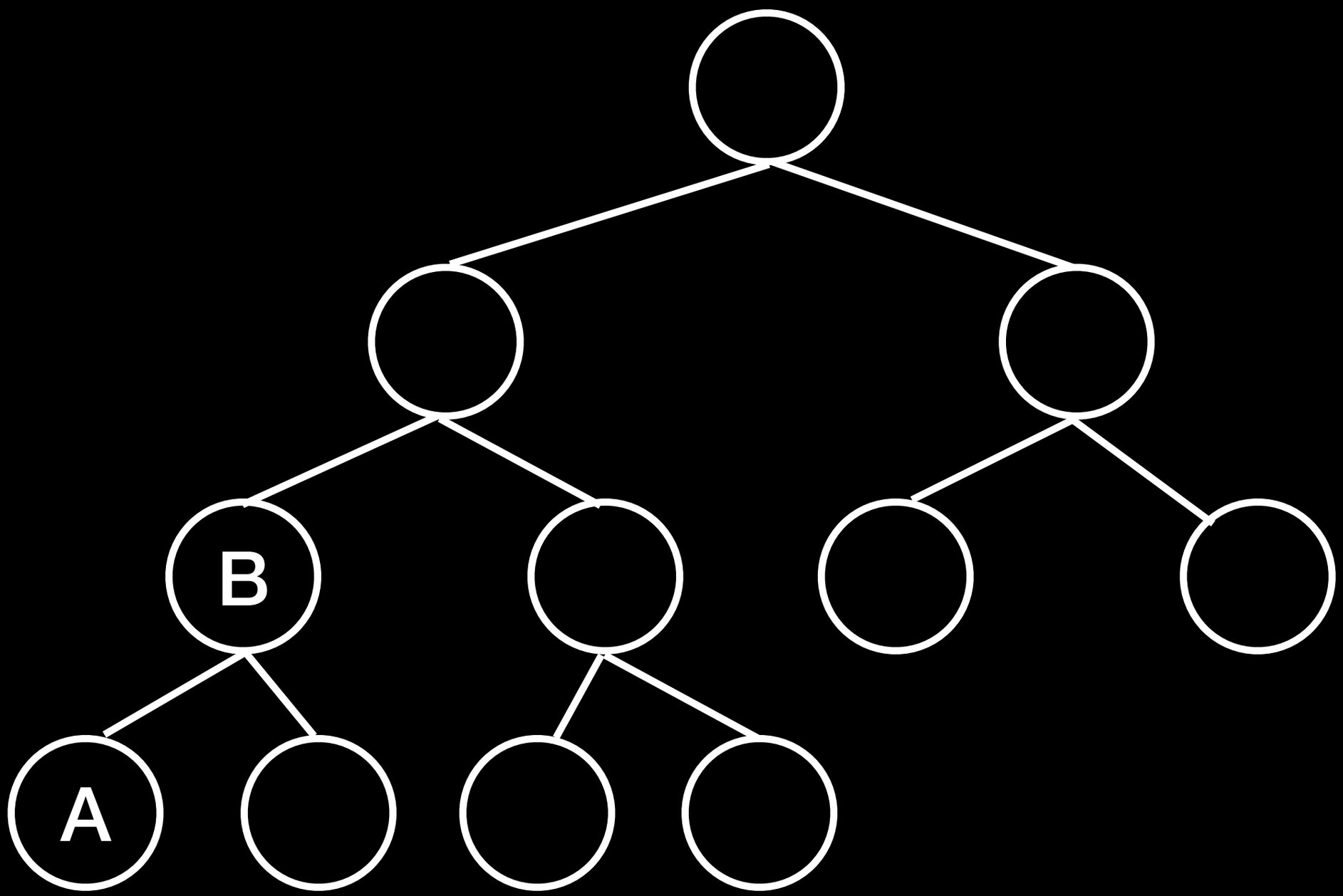

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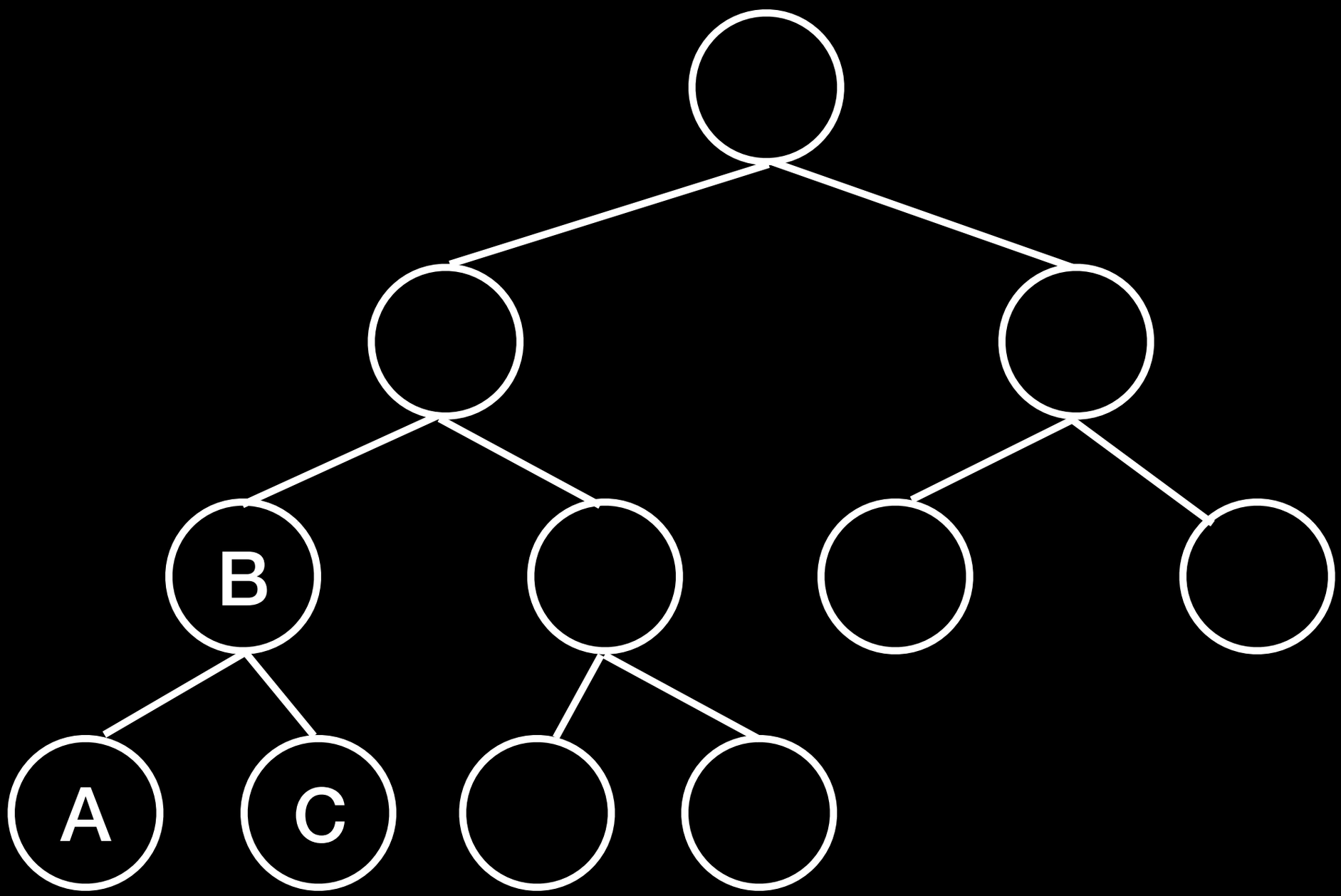

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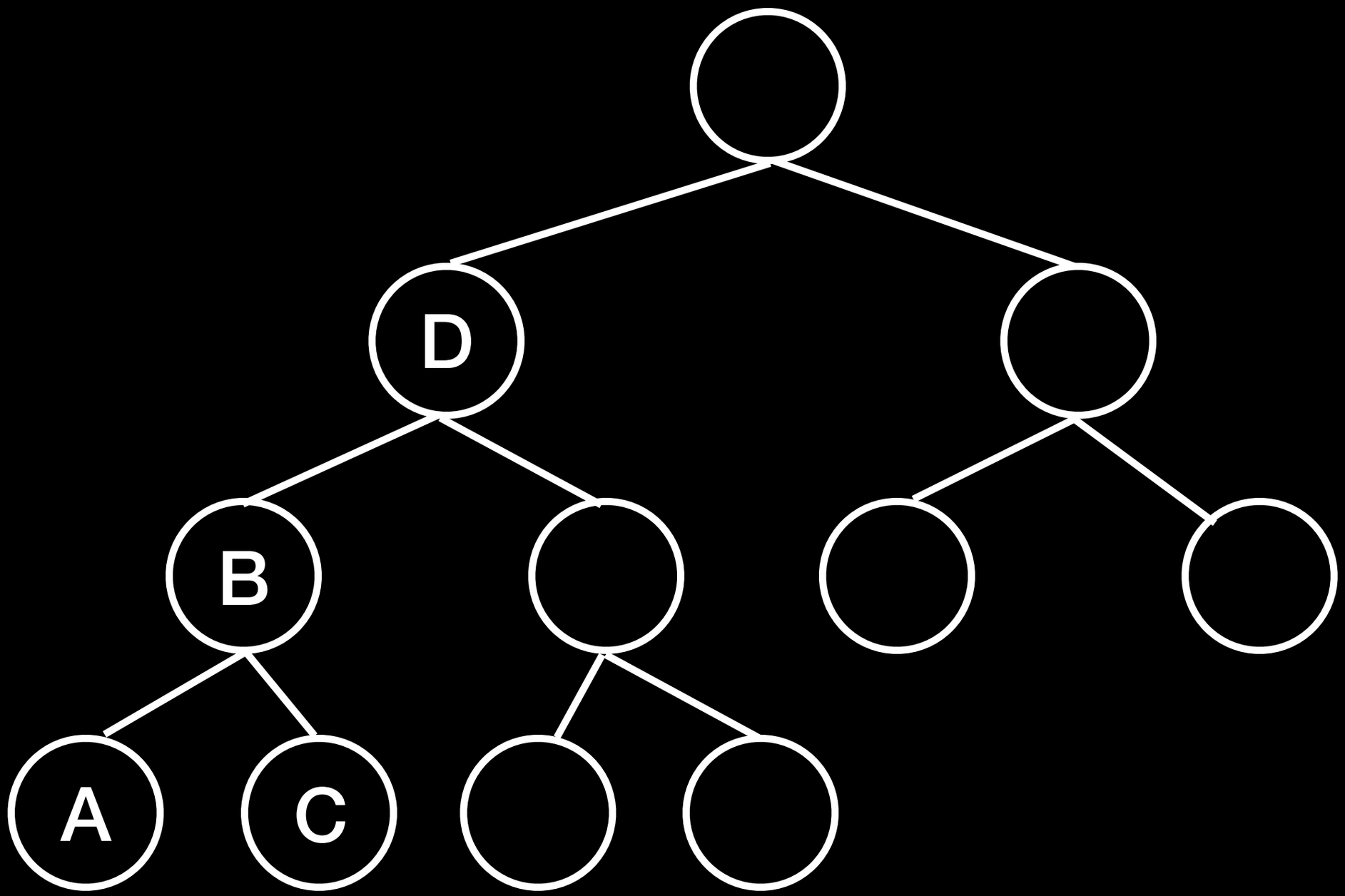

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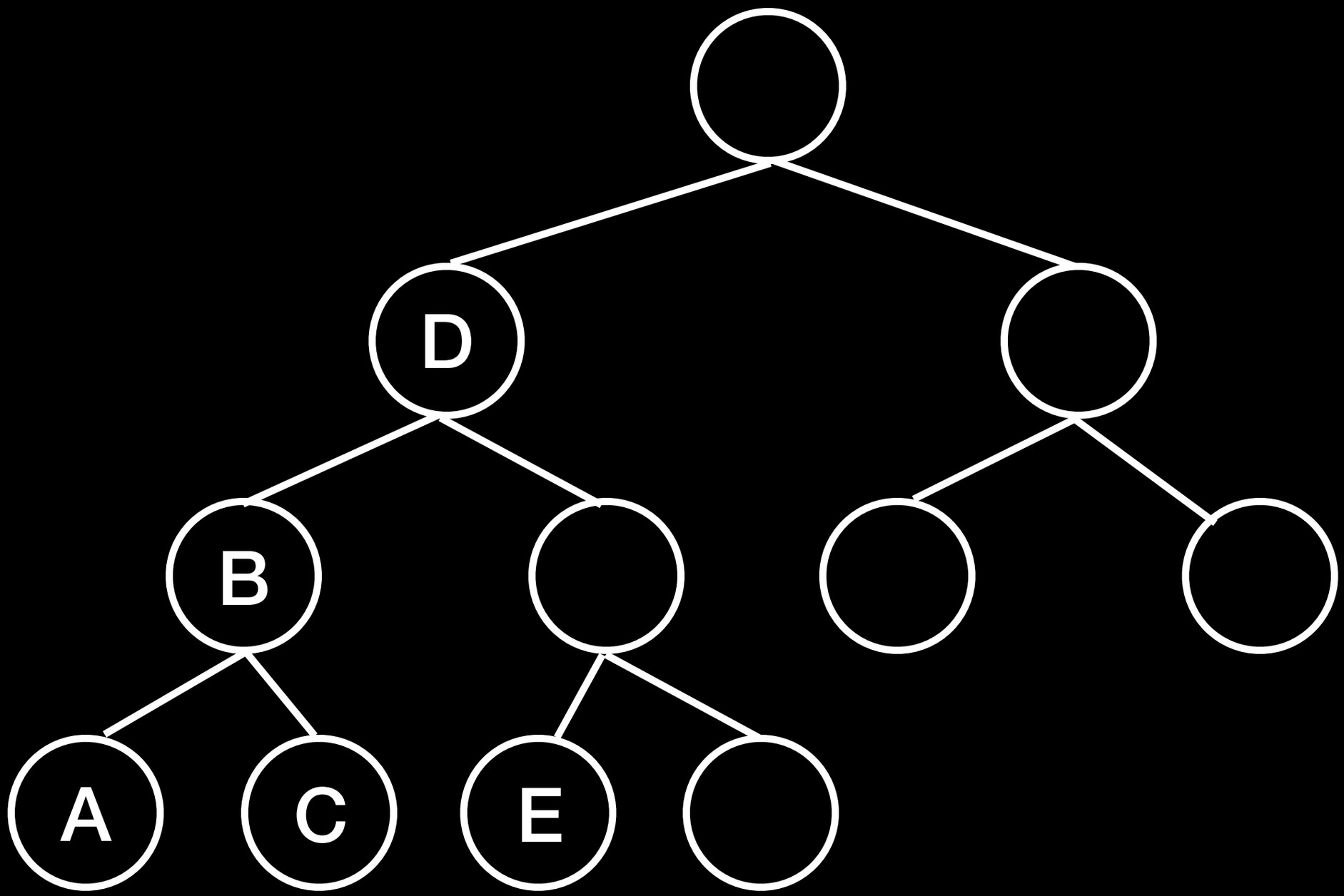

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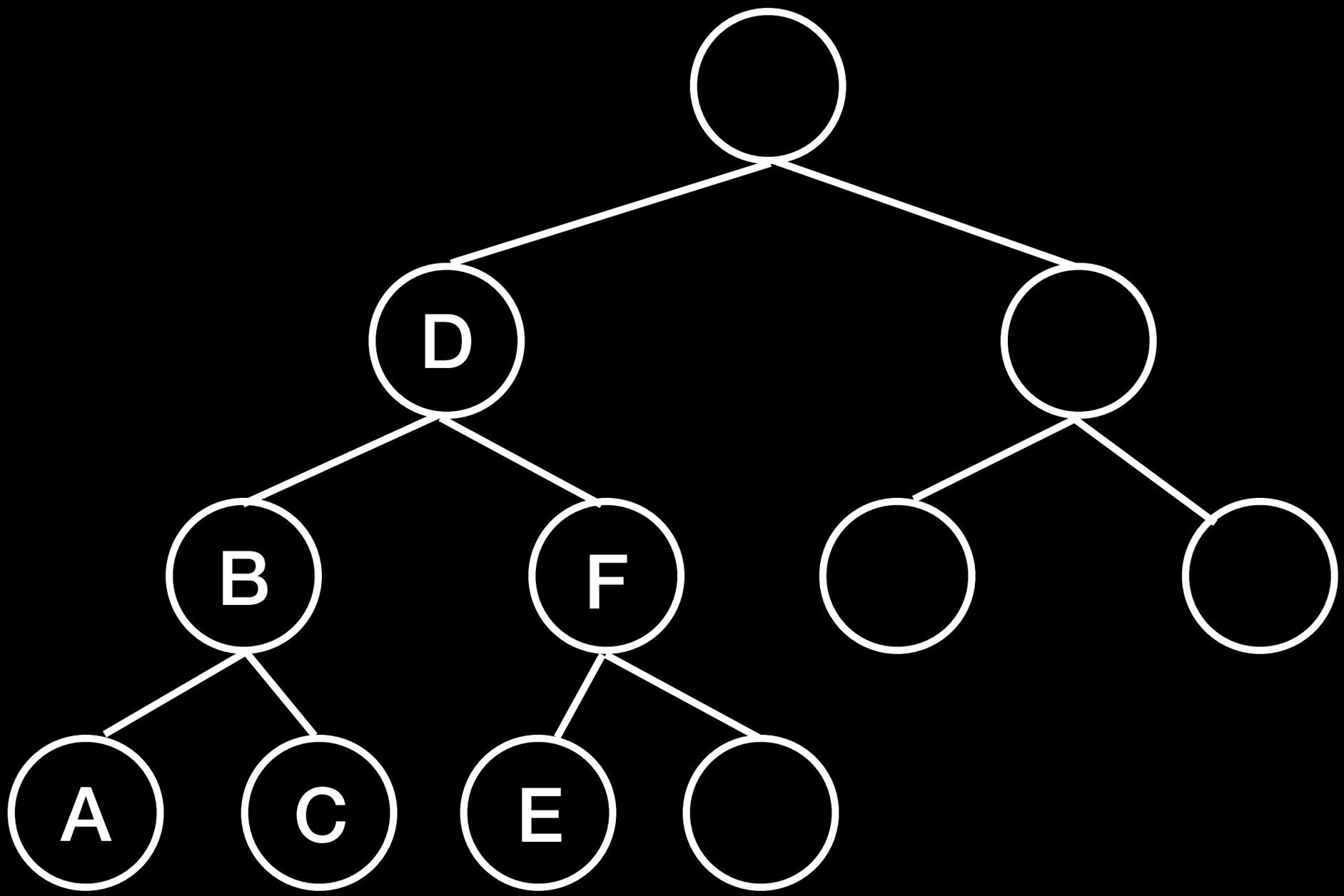

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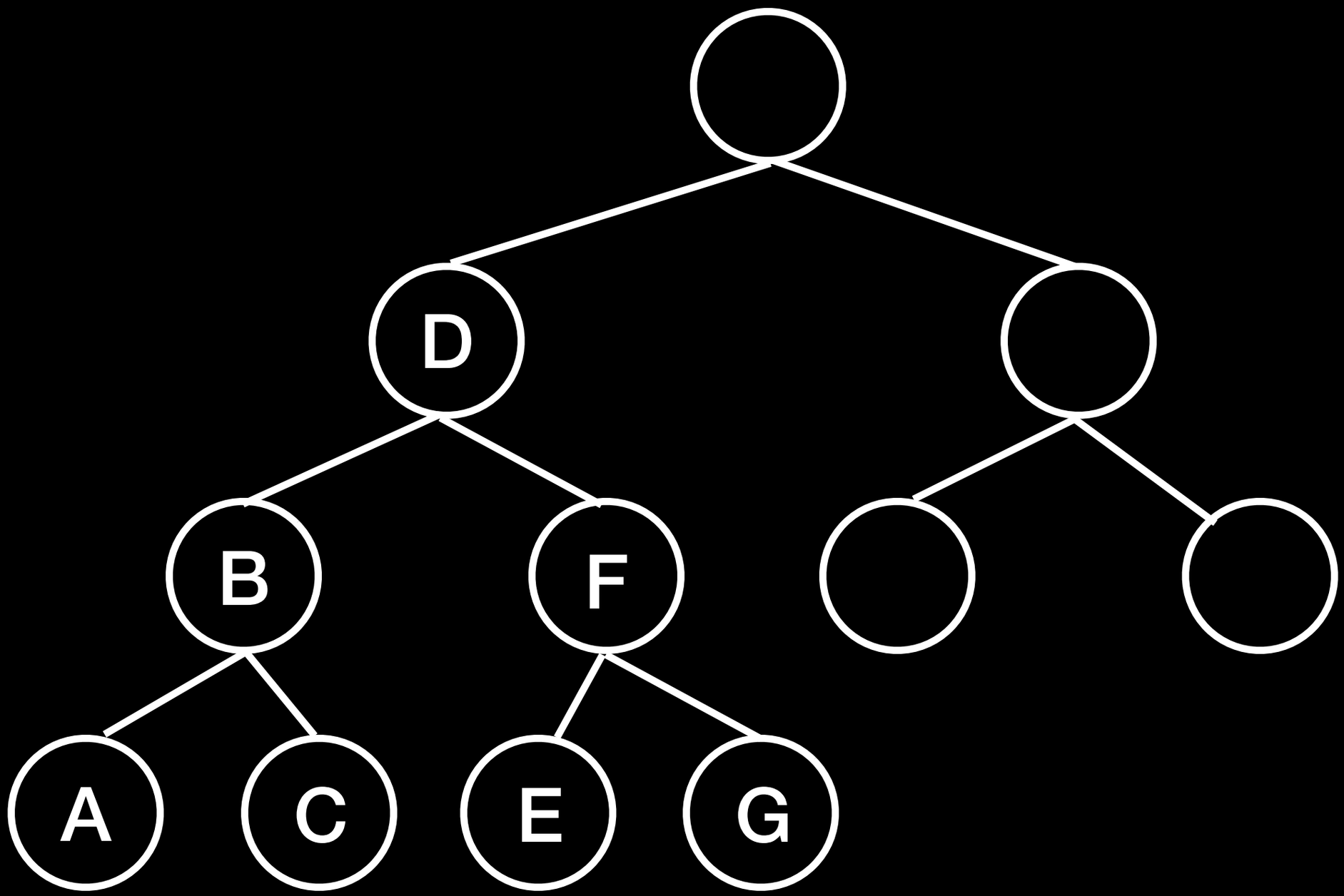

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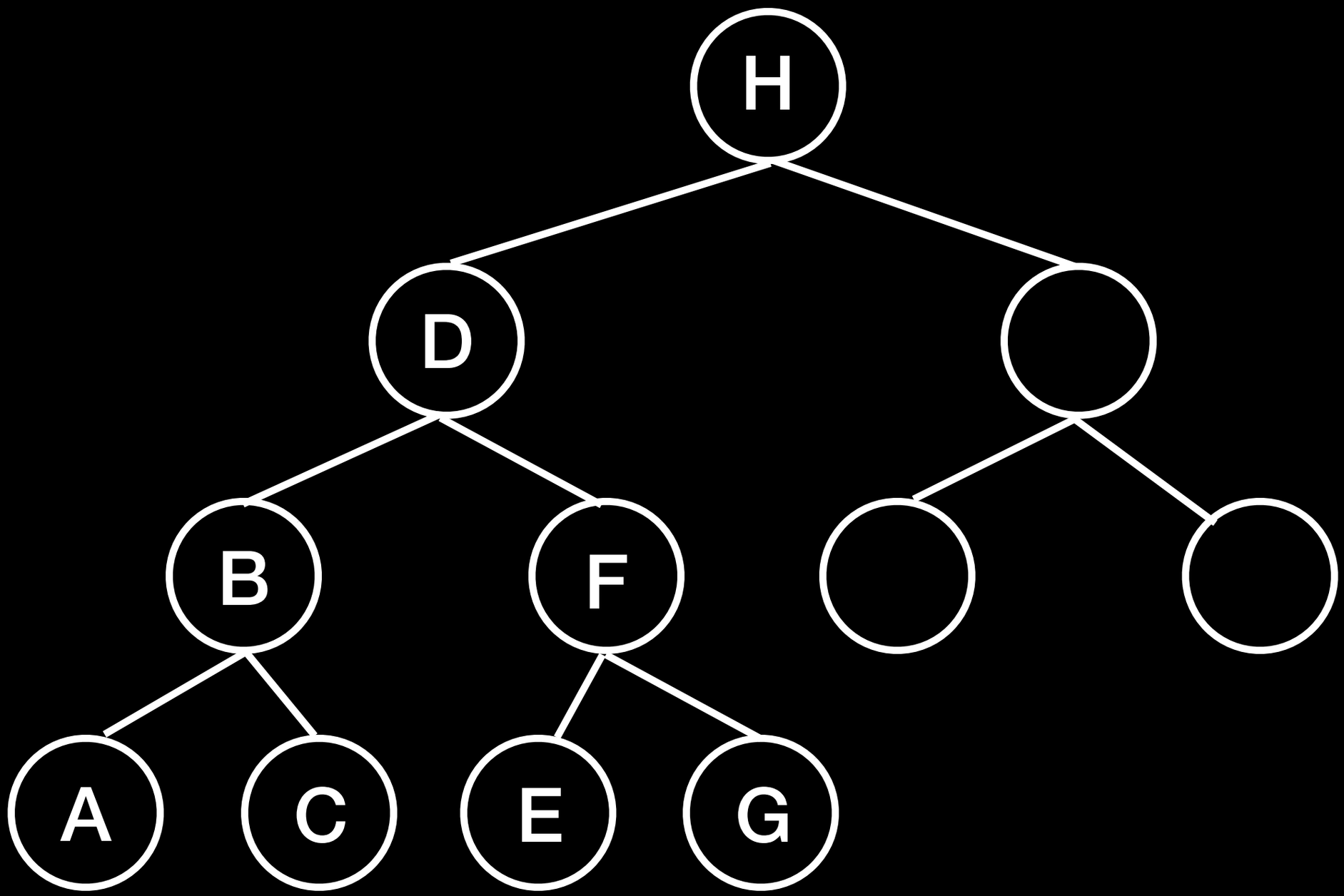

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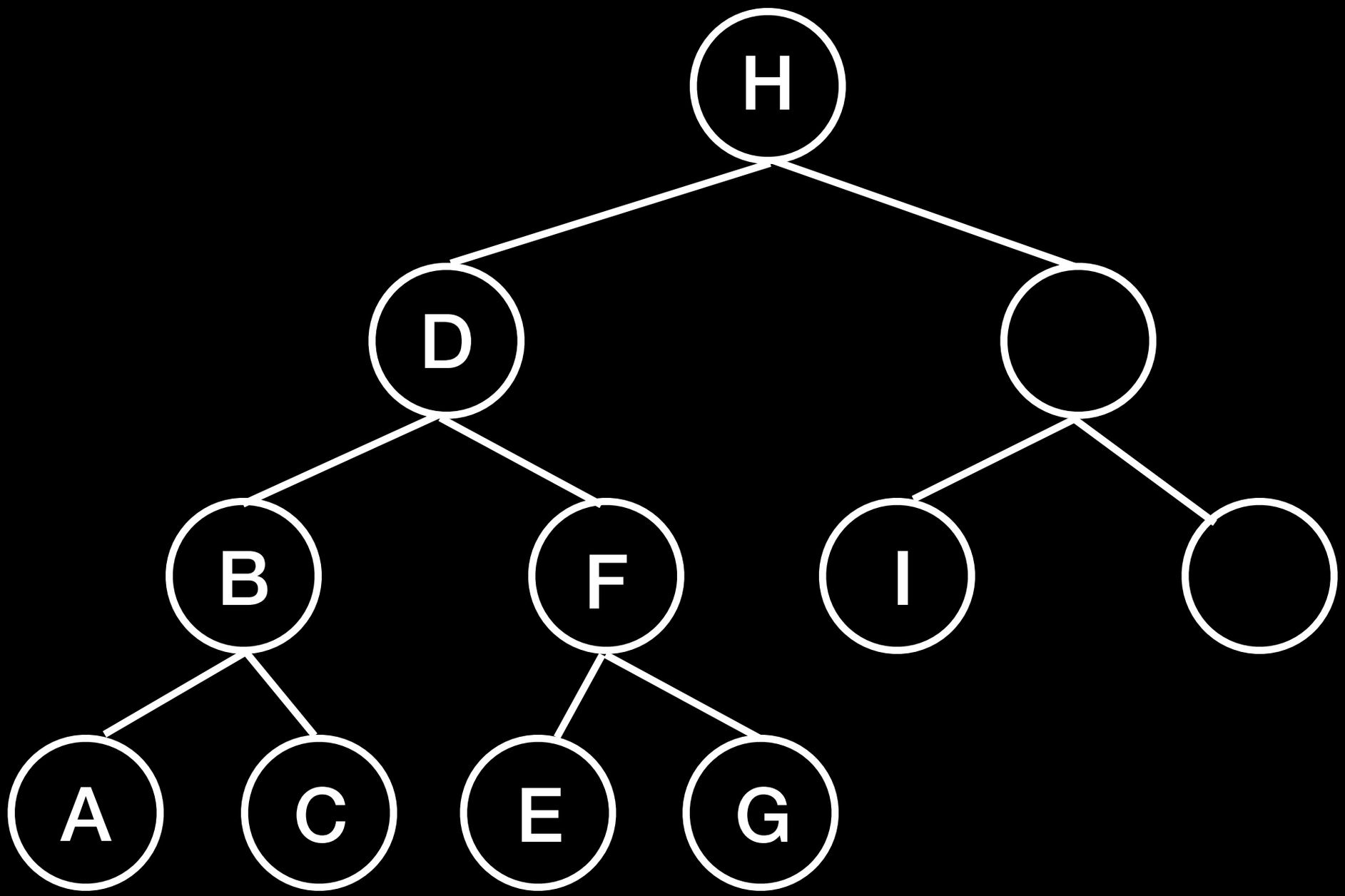

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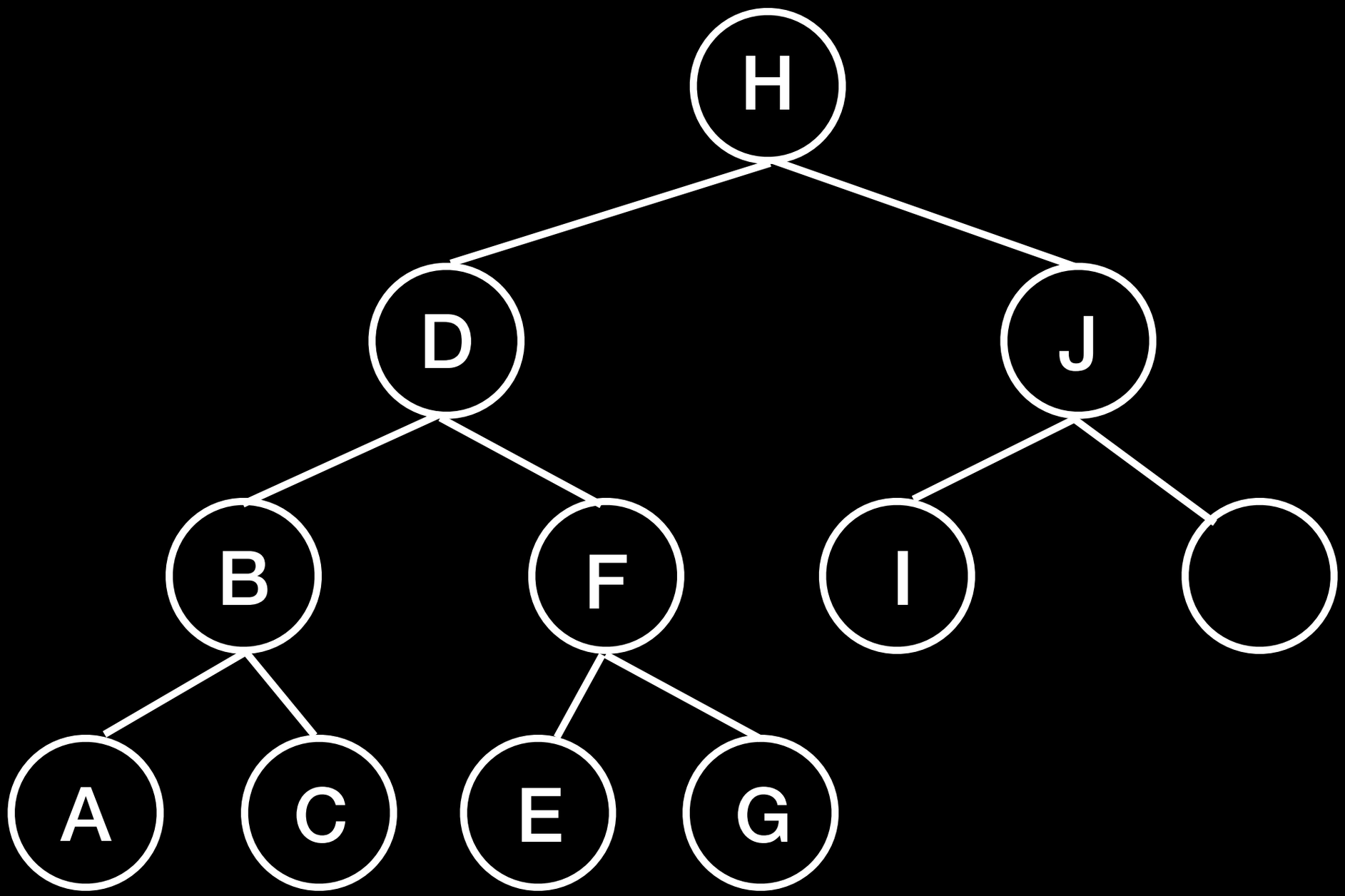

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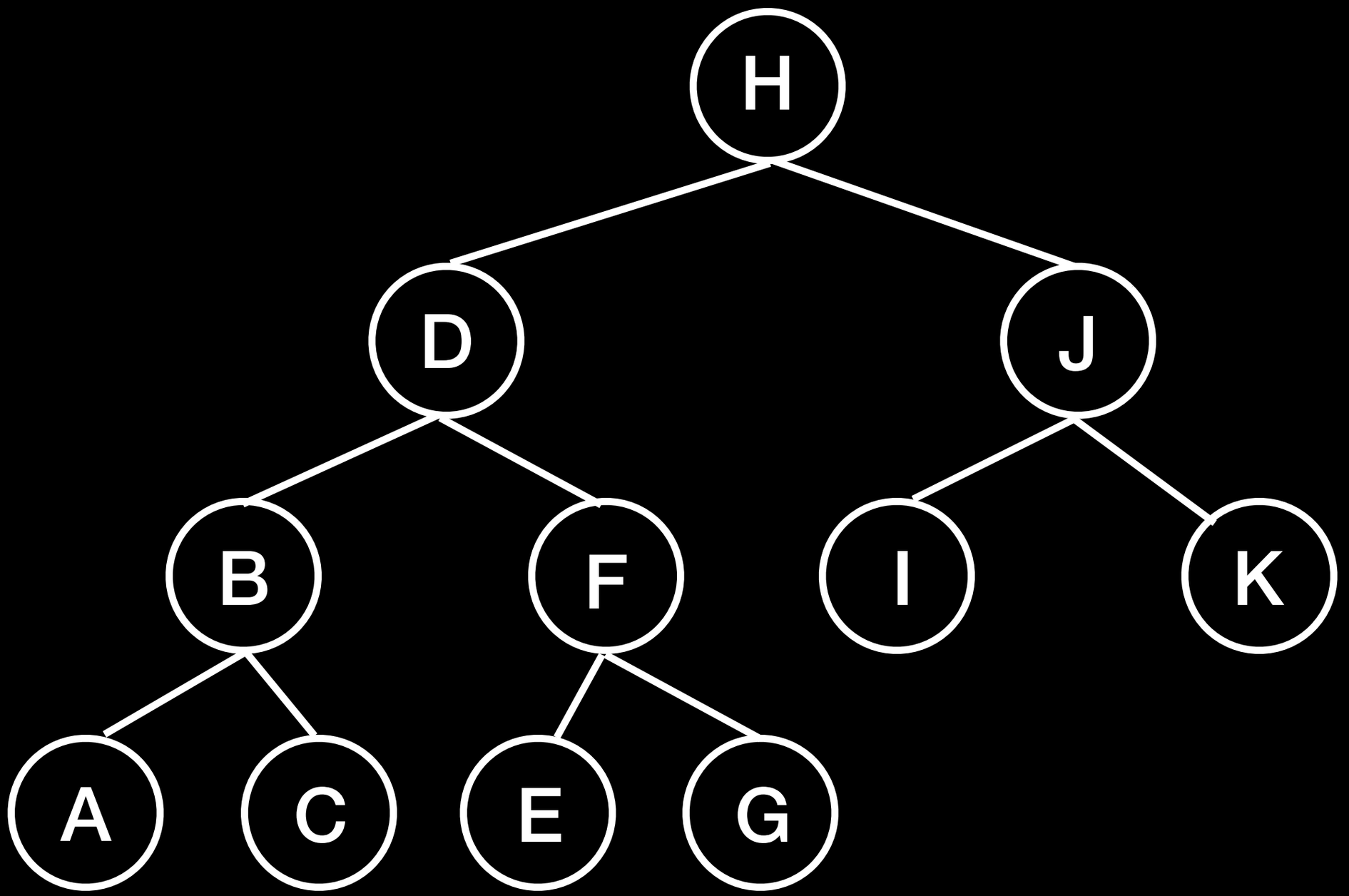
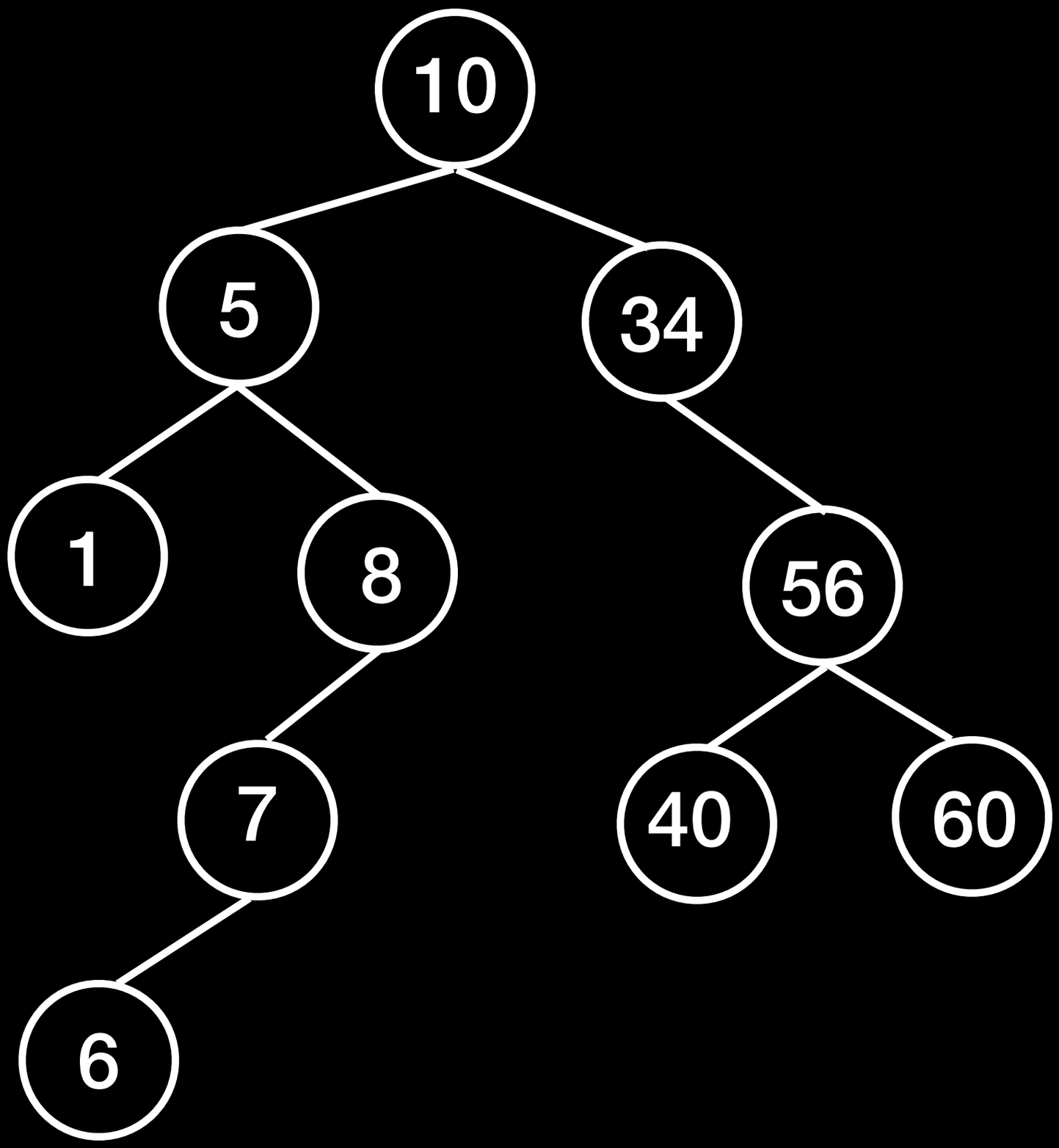


Tree traversals



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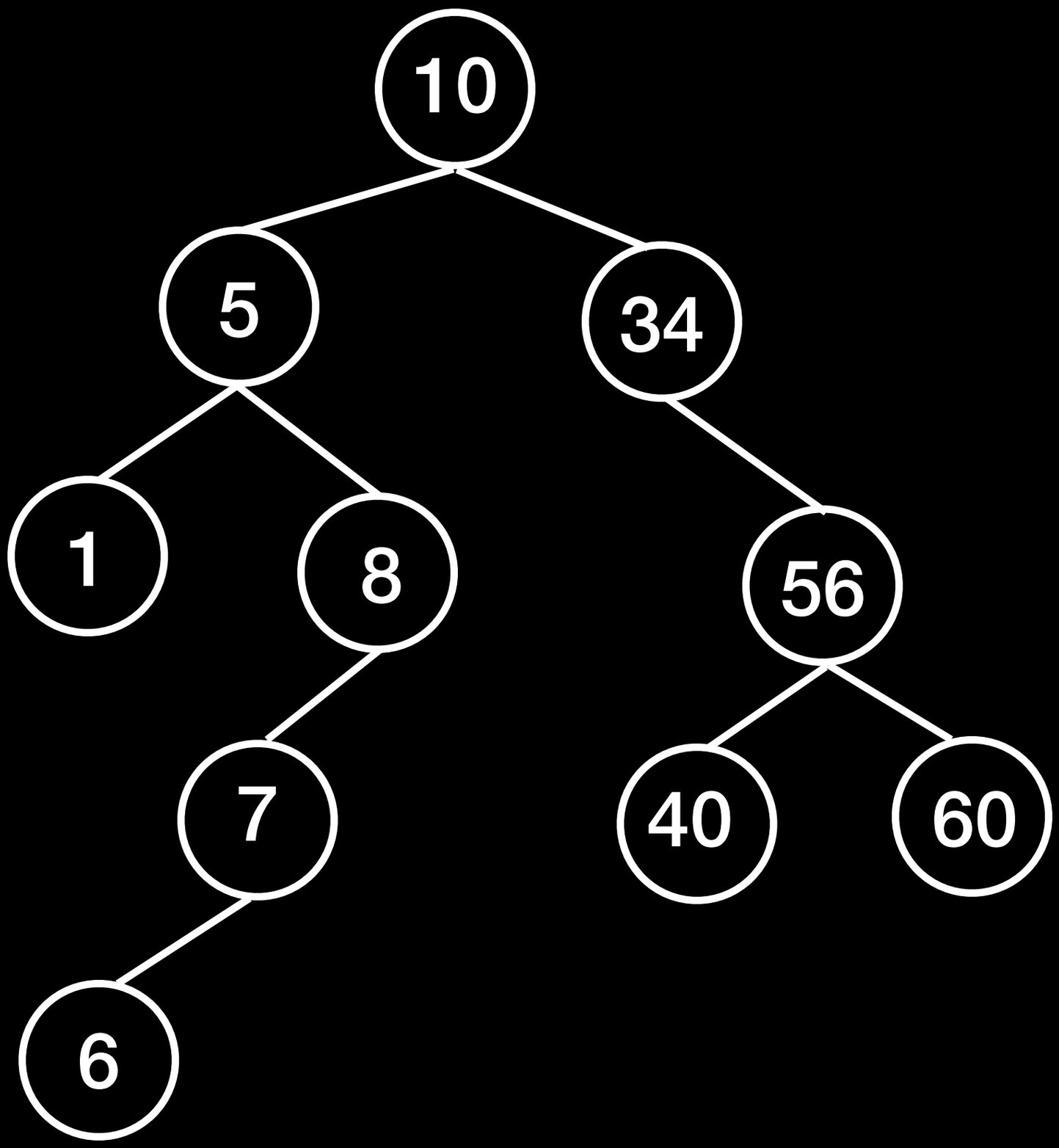
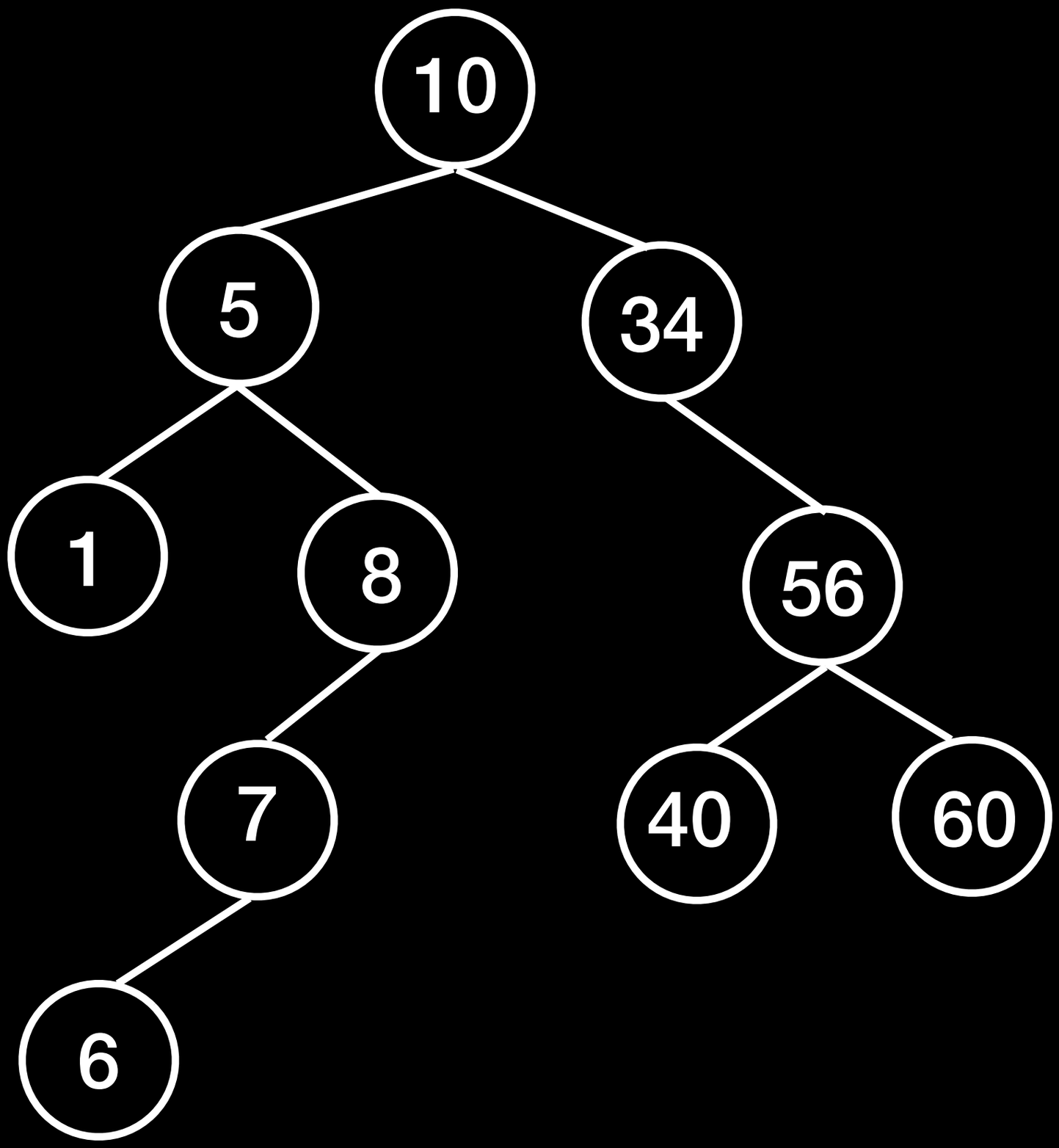


Pre-order

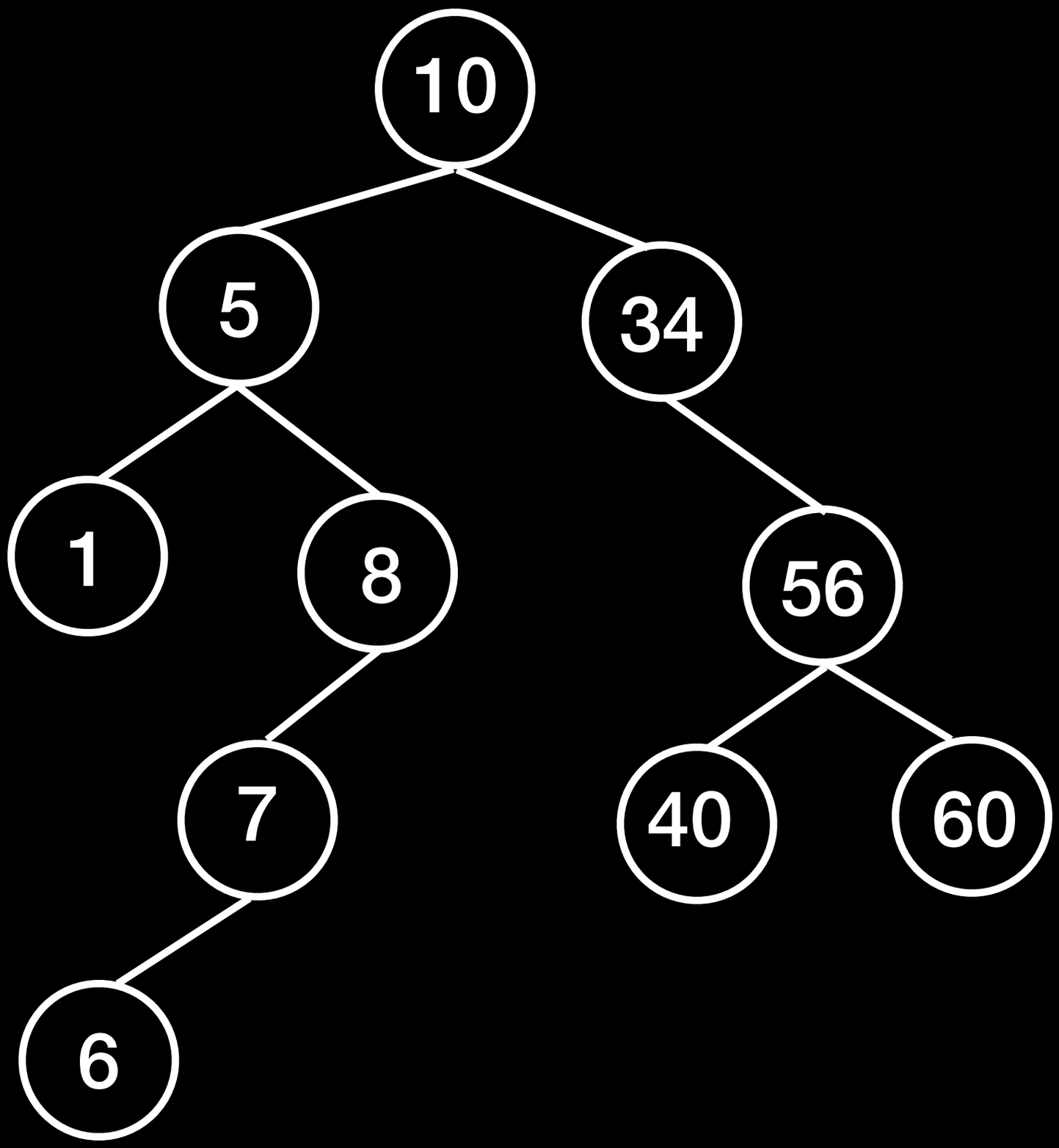
Tree traversals



Pre-order

10, 5, 1, 8, 7, 6, 34, 56, 40, 60

Tree traversals



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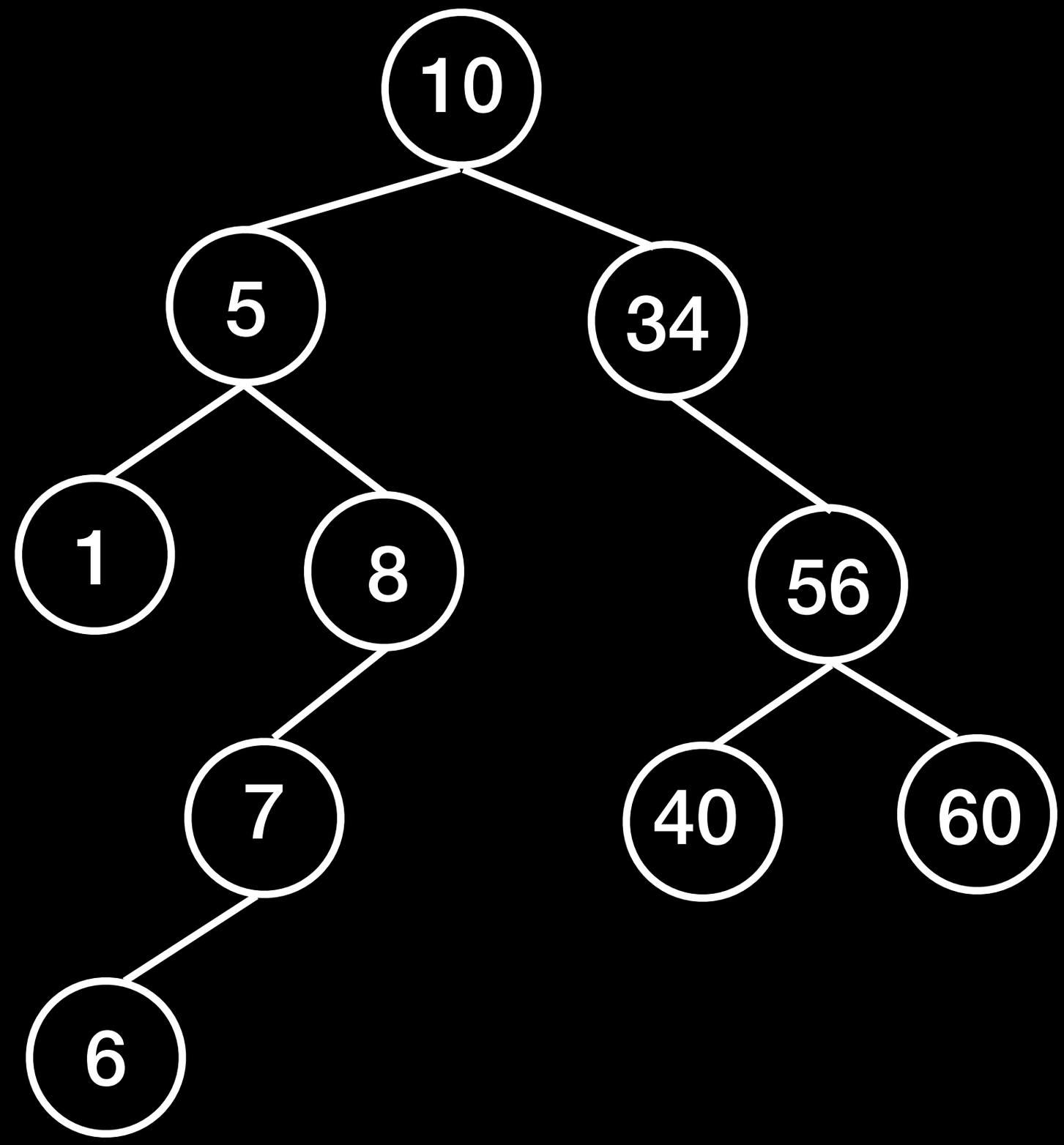
In-order

Tree traversals



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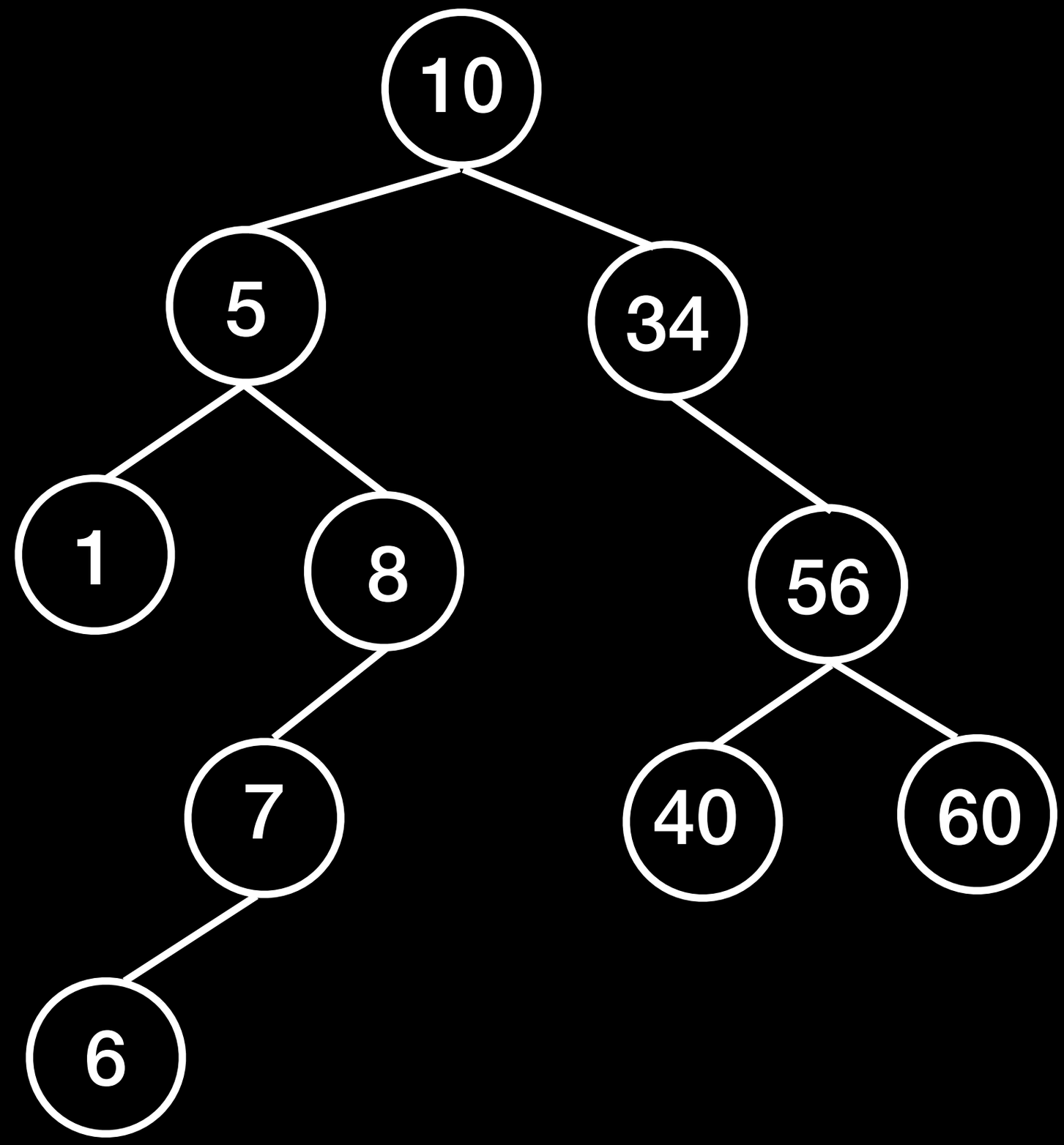

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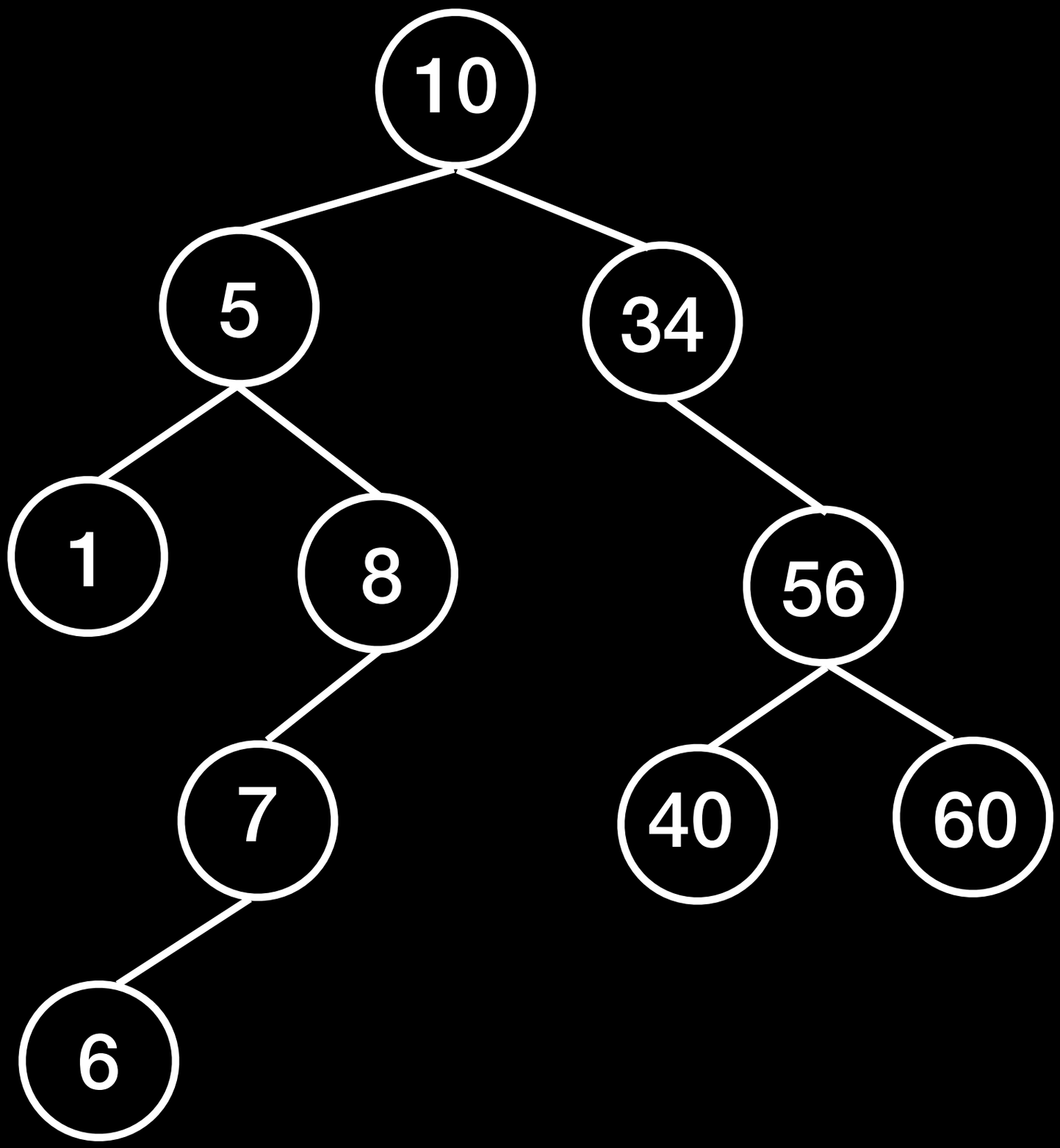


Pre-order

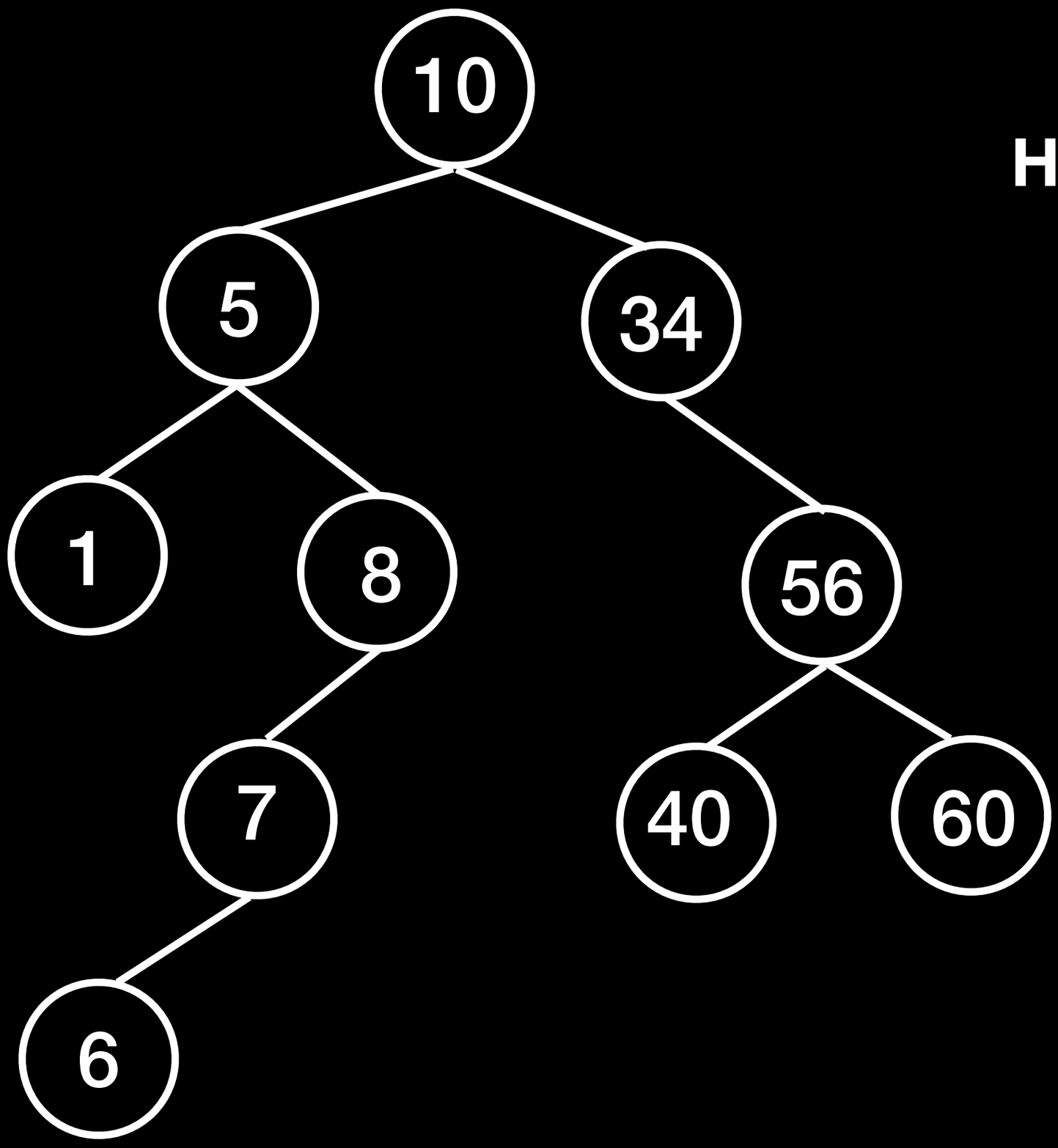
10, 5, 1, 8, 7, 6, 34, 56, 40, 60

In-order

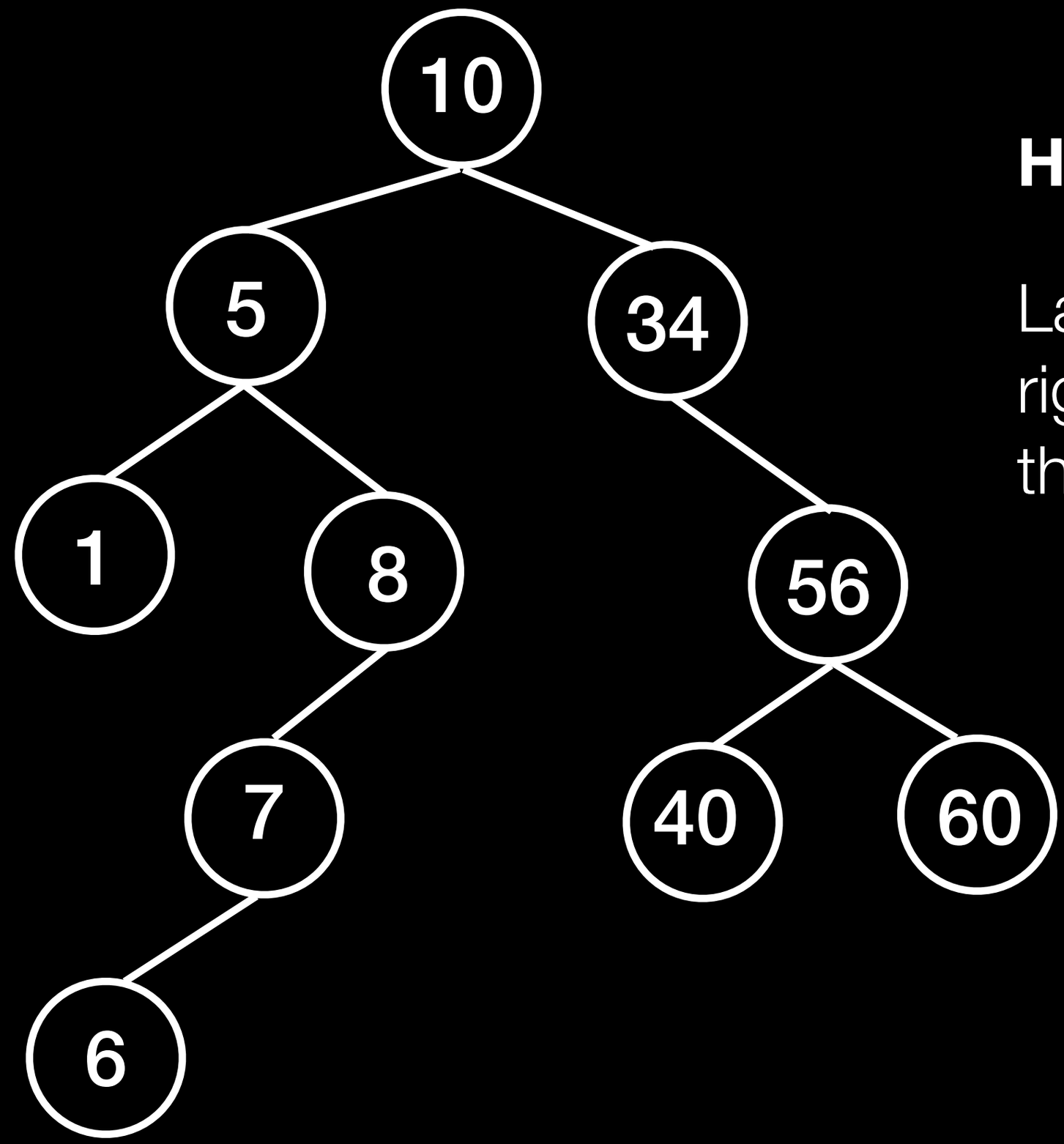
1, 5, 6, 7, 8, 10, 34, 40, 56, 60

Post-order

1, 6, 7, 8, 5, 40, 60, 56, 34, 10

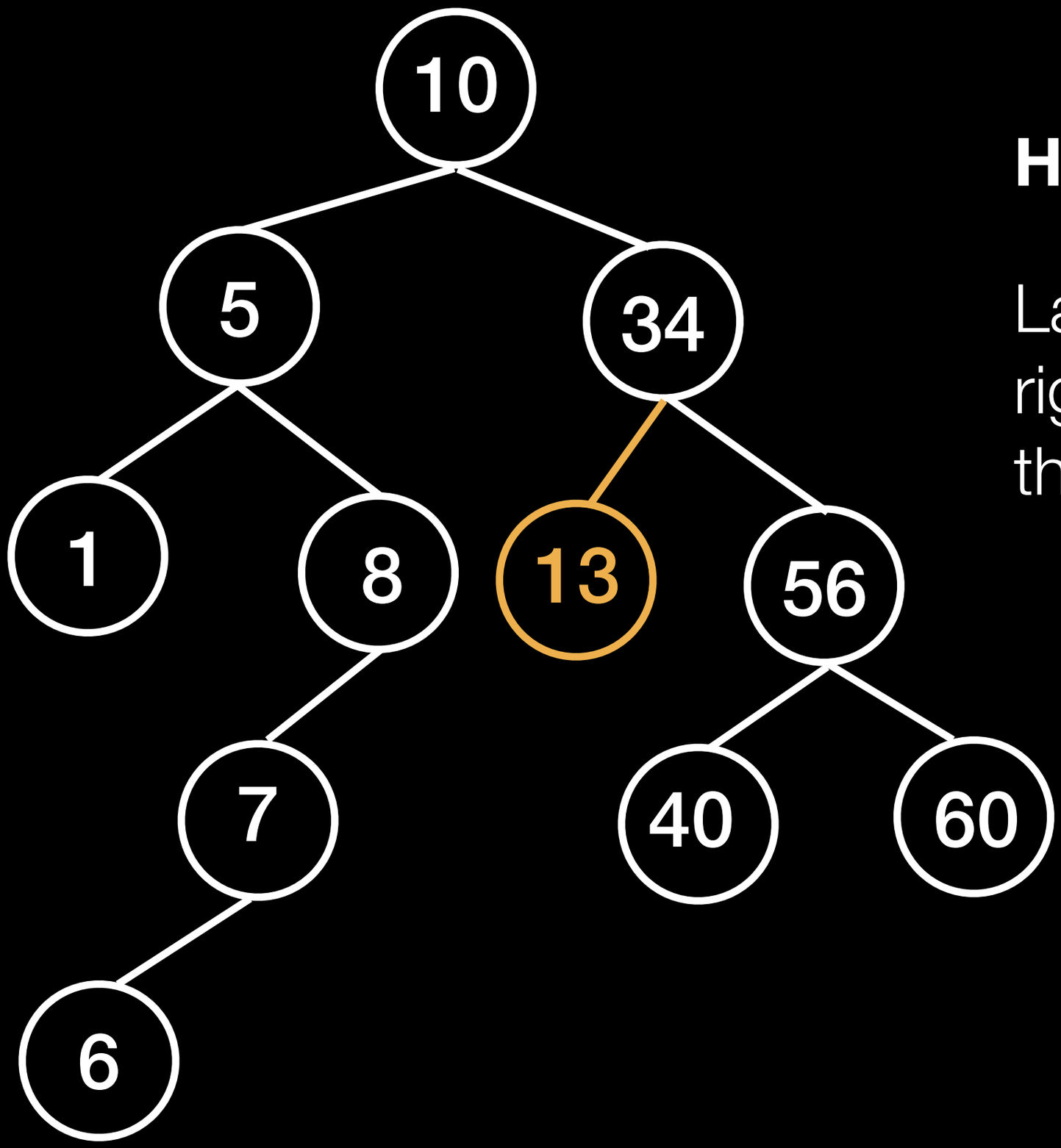


How would we add 13?



How would we add 13?

Larger values go to the right, smaller values go to the left



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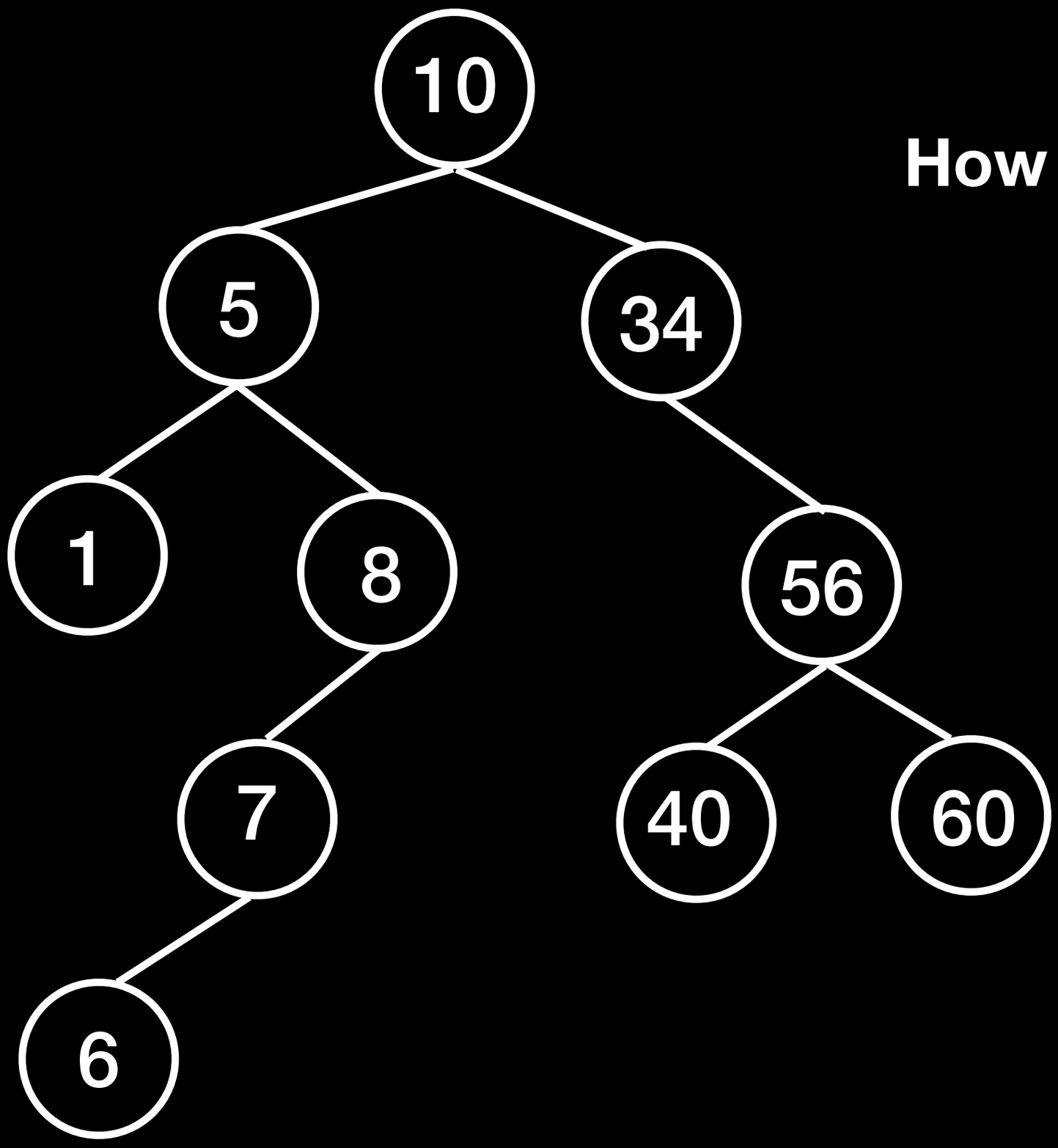
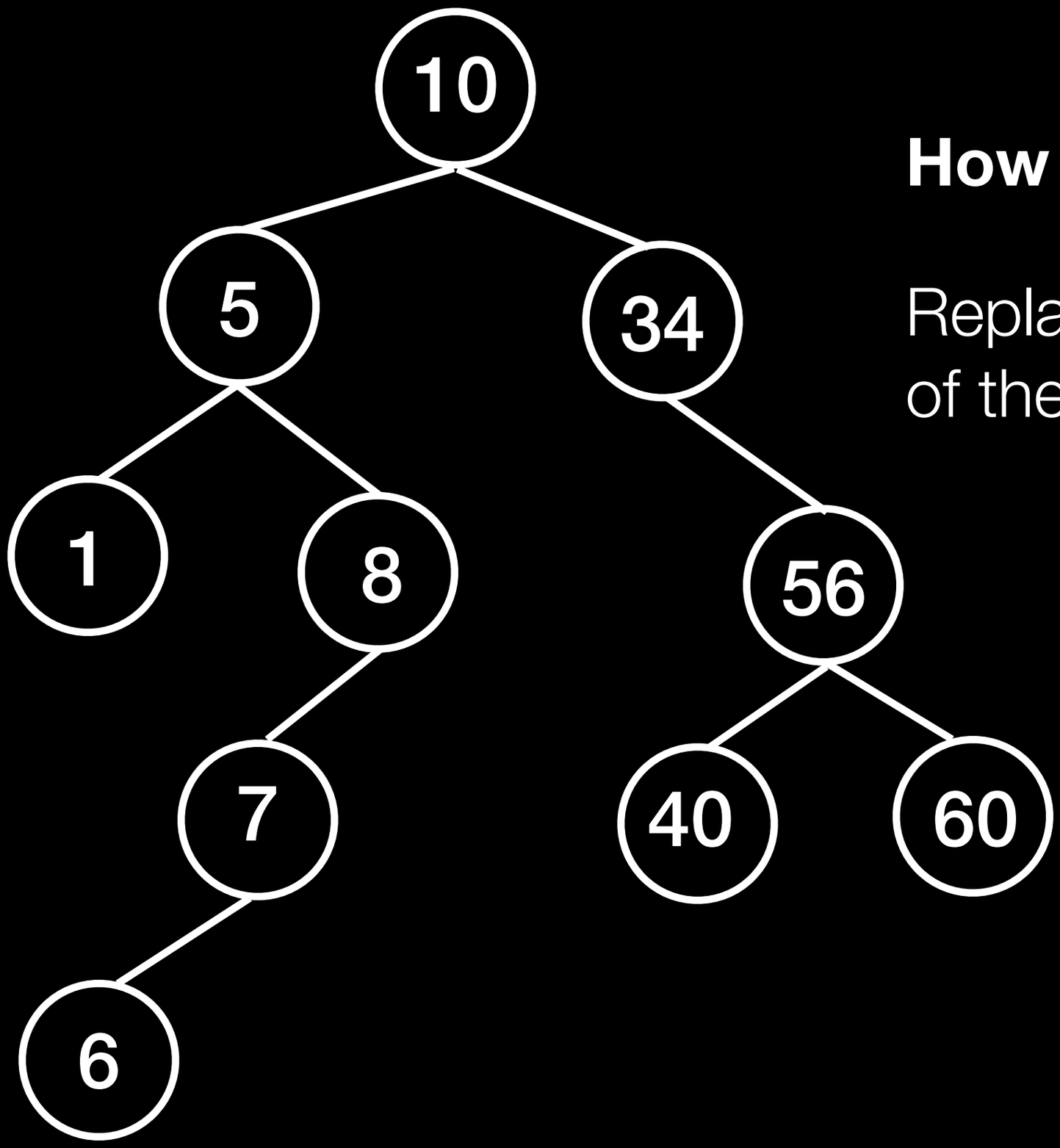
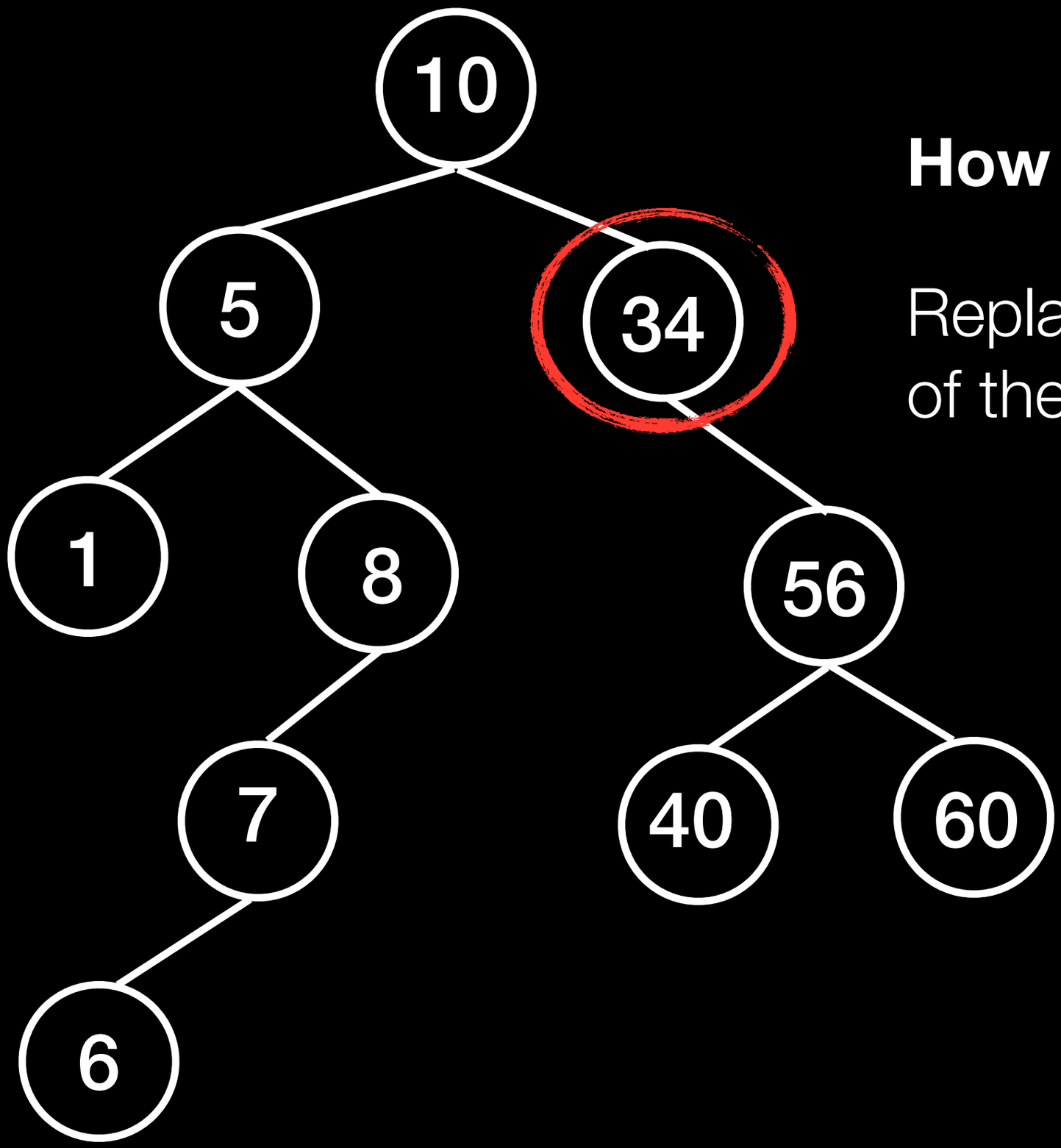


How would we remove 10?



How would we remove 10?

Replace with the left-most item of the right-subtree!



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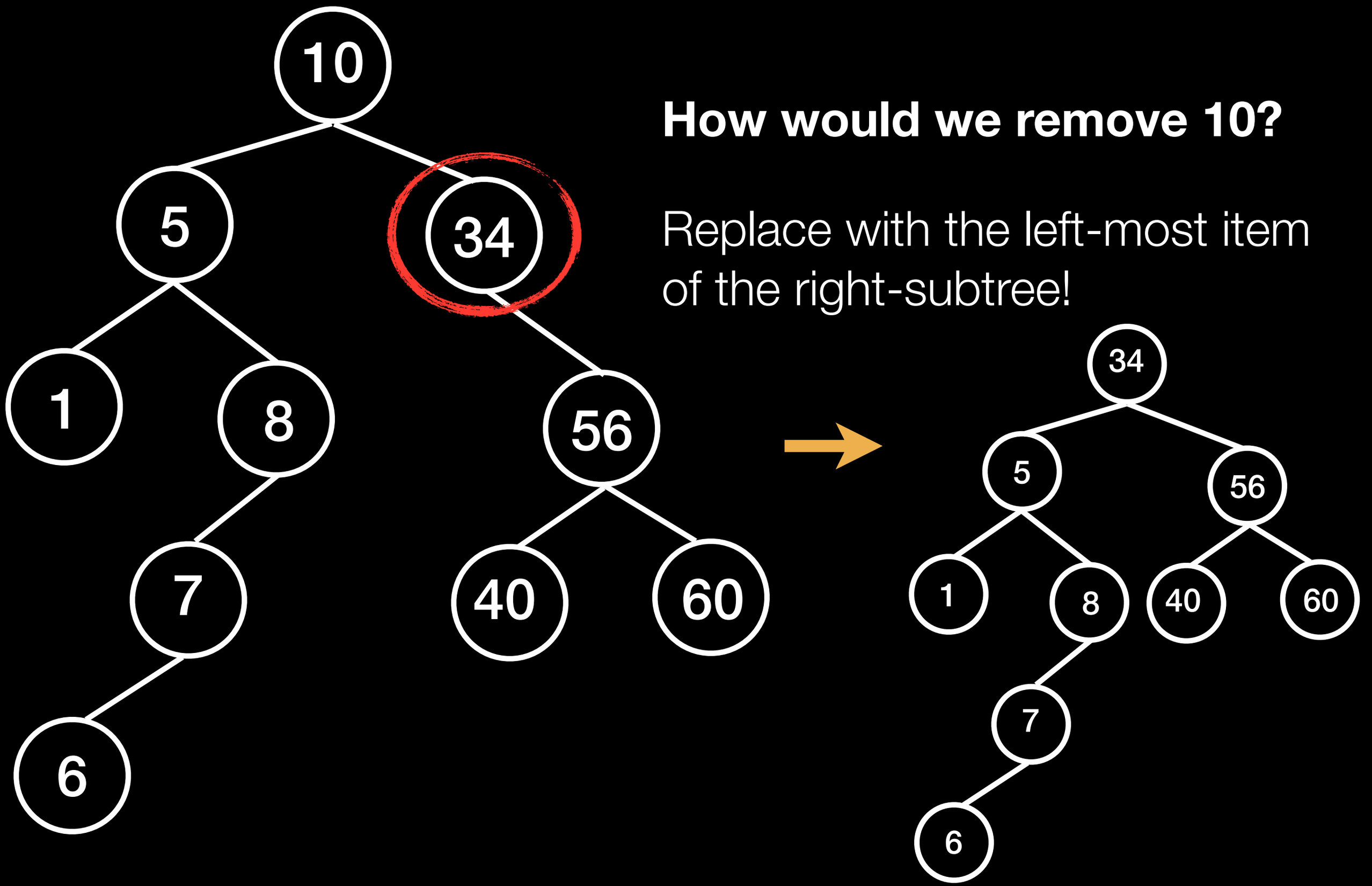

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Write a **treeSort** function that takes an array of elements and returns those elements in sorted order. Assume you do not have an iterator (your approach **must be recursive**). You will need a helper function.

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```
struct AVLTree* newAVLTree();
void addAVLTree(struct AVLTree *tree, TYPE val);

void treeSort (TYPE data[], int n) {
  // WRITE ME
}

void _treeSortHelper(AVLNode *cur, TYPE *data,
int *count) {
  // WRITE ME
}
```

```
void treeSort(TYPE data[], int size){
    int i;
    int sortIdx = 0;



}
```

```
void treeSort(TYPE data[], int size){
    int i;
    int sortIdx = 0;

    /* declare an AVL tree */
    struct AVLTree *tree = newAVLtree();
    assert(data != NULL && size > 0);

}
```

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void treeSort(TYPE data[], int size){
    int i;
    int sortIdx = 0;

    /* declare an AVL tree */
    struct AVLTree *tree = newAVLtree();
    assert(data != NULL && size > 0);

    /* add elements to the tree */
    for (i = 0; i < size; i++)
        addAVLTree(tree, data[i]);



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     assert(data != NULL && size > 0);

     /* add elements to the tree */
     for (i = 0; i < size; i++)
          addAVLTree(tree, data[i]);

    /* call the helper function on the root */
     _treeSortHelper(tree->root, data, &sortIdx);
}
```

```
/* *index goes from 0 to size-1 */

void _treeSortHelper(AVLNode *cur, TYPE *data,
                     int *index){

}
```

```
/* *index goes from 0 to size-1 */

void _treeSortHelper(AVLNode *cur, TYPE *data,
                     int *index){
    /* In-order traversal: get the left subtree,
       then this node, then the right subtree */
    if (cur != NULL) {
        _treeSortHelper(cur->left, data, index);
        data[*index] = cur->val;
        (*index)++;
        _treeSortHelper(cur->right, data, index);
    }
}
```

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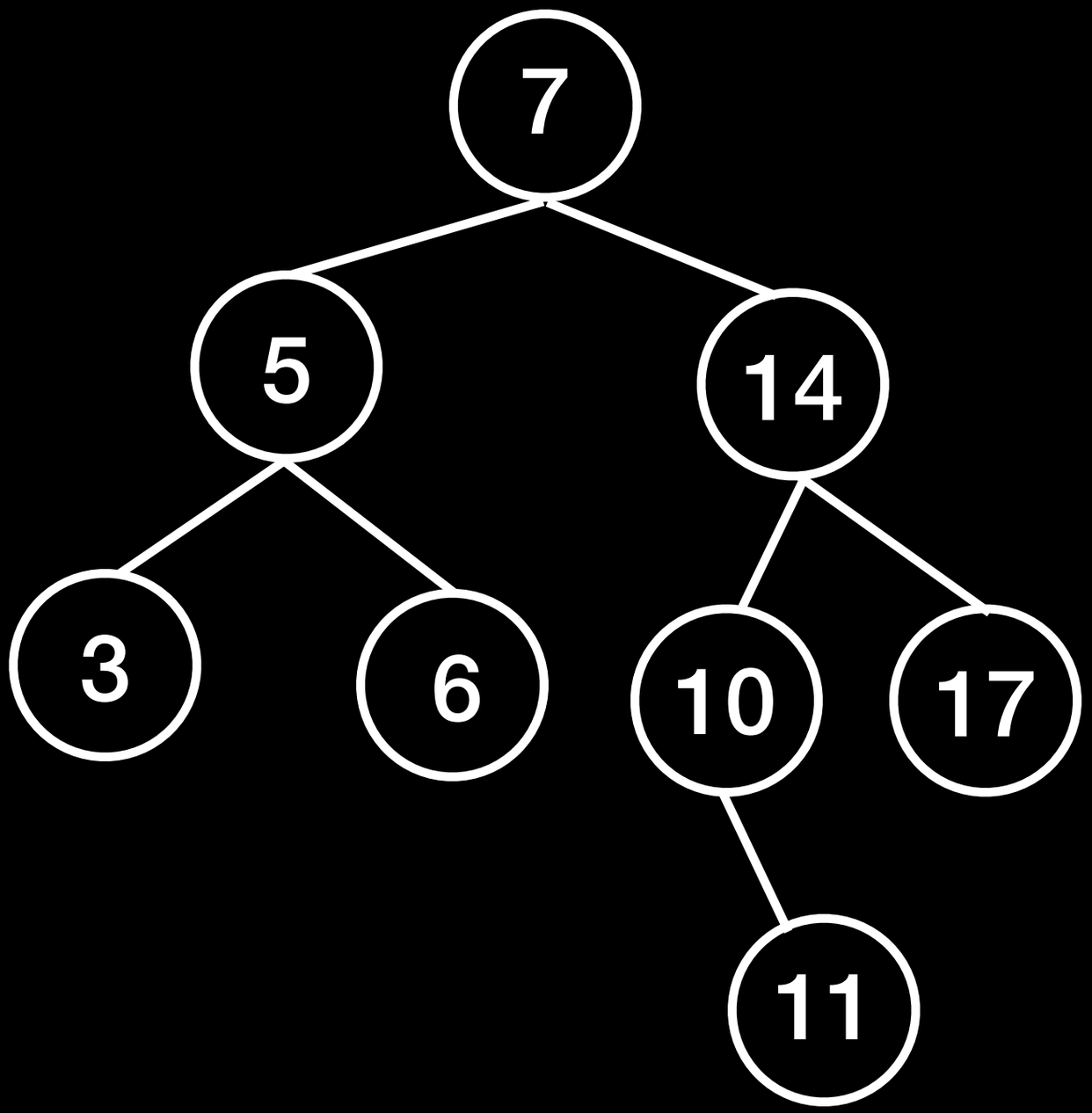
Does inserting into an AVL tree with n nodes require $O(\log n)$ rotations?

No, we need at most 2 rotations

Add 12 to this AVL tree



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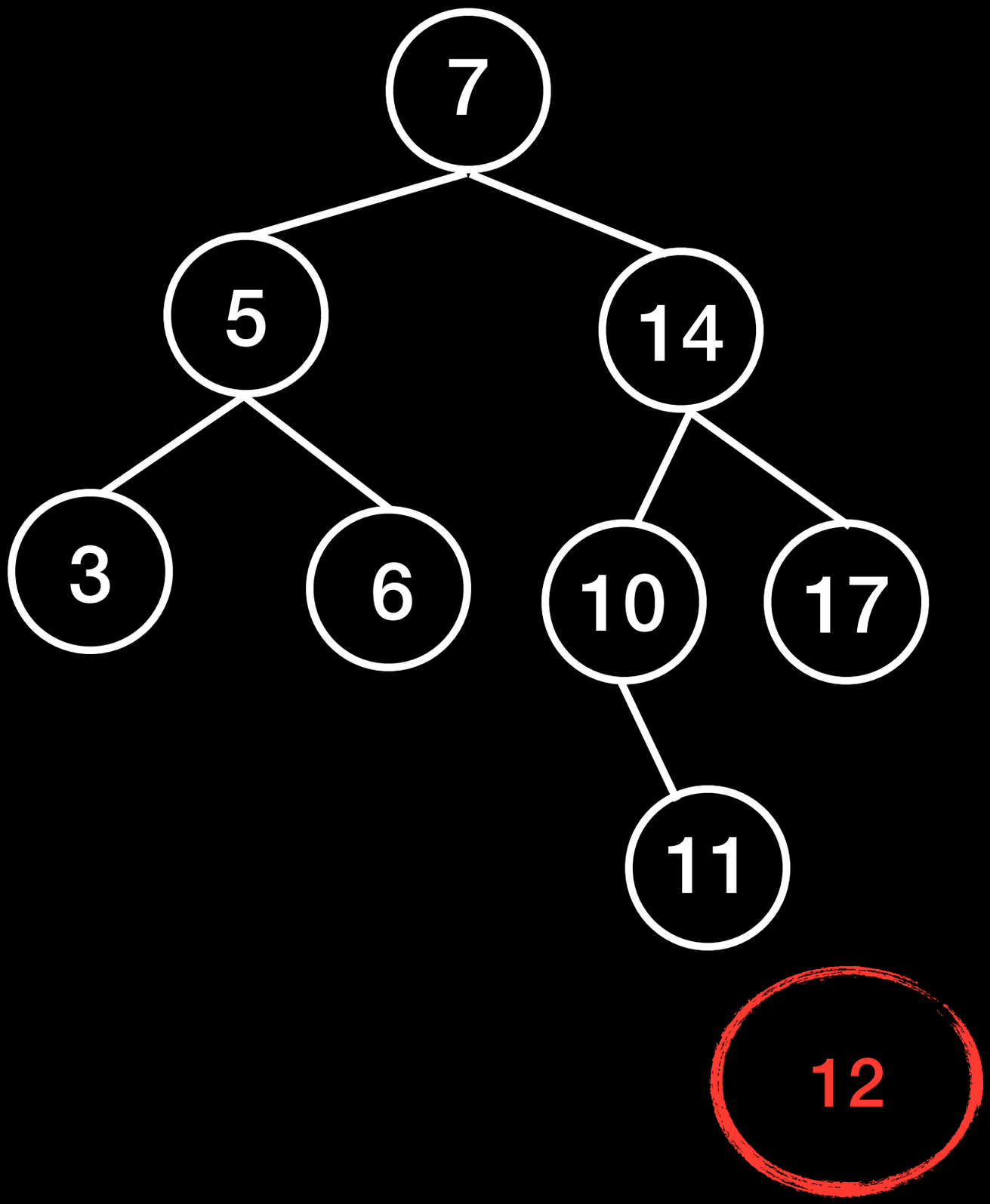

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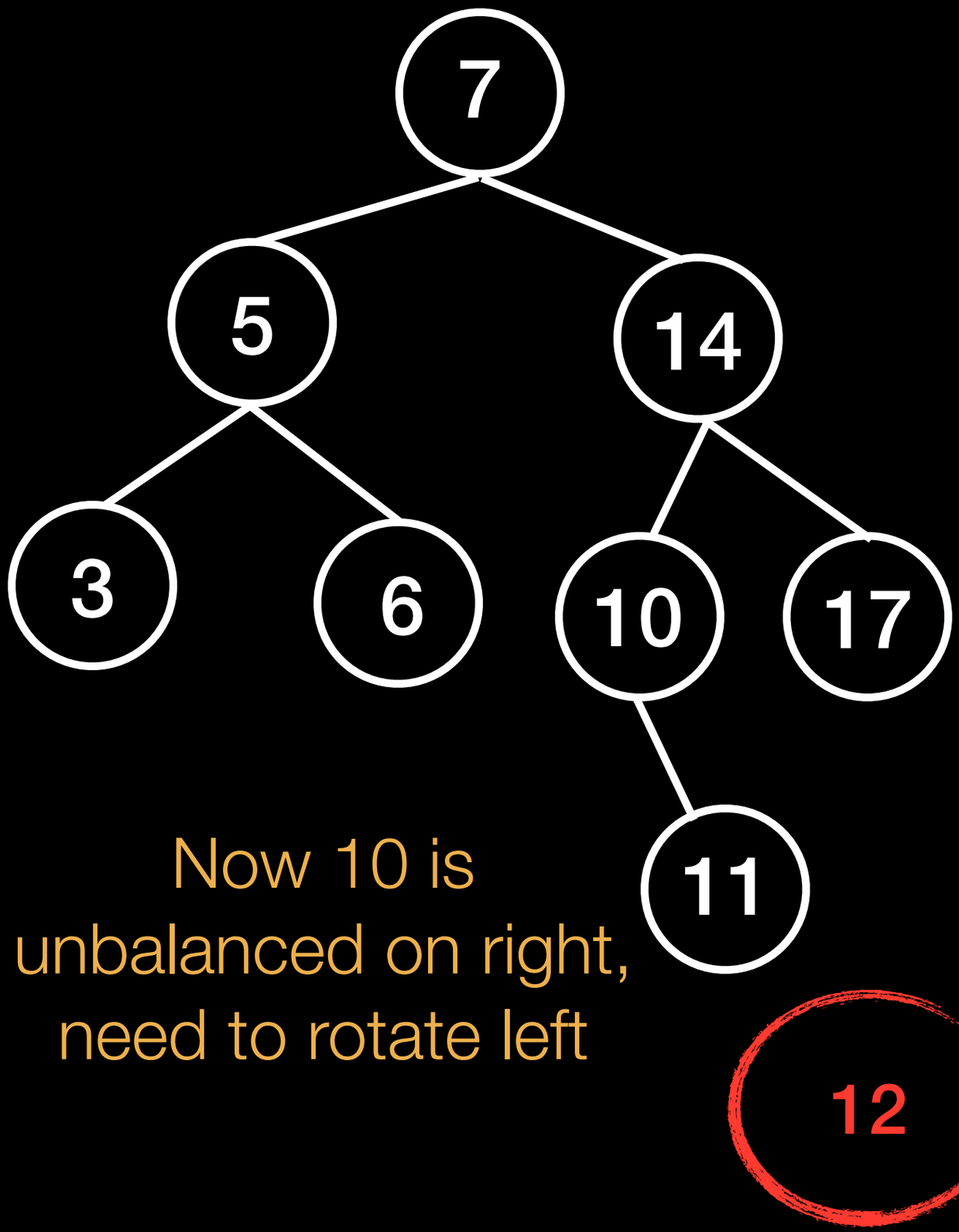

Now 10 is unbalanced on right, need to rotate left

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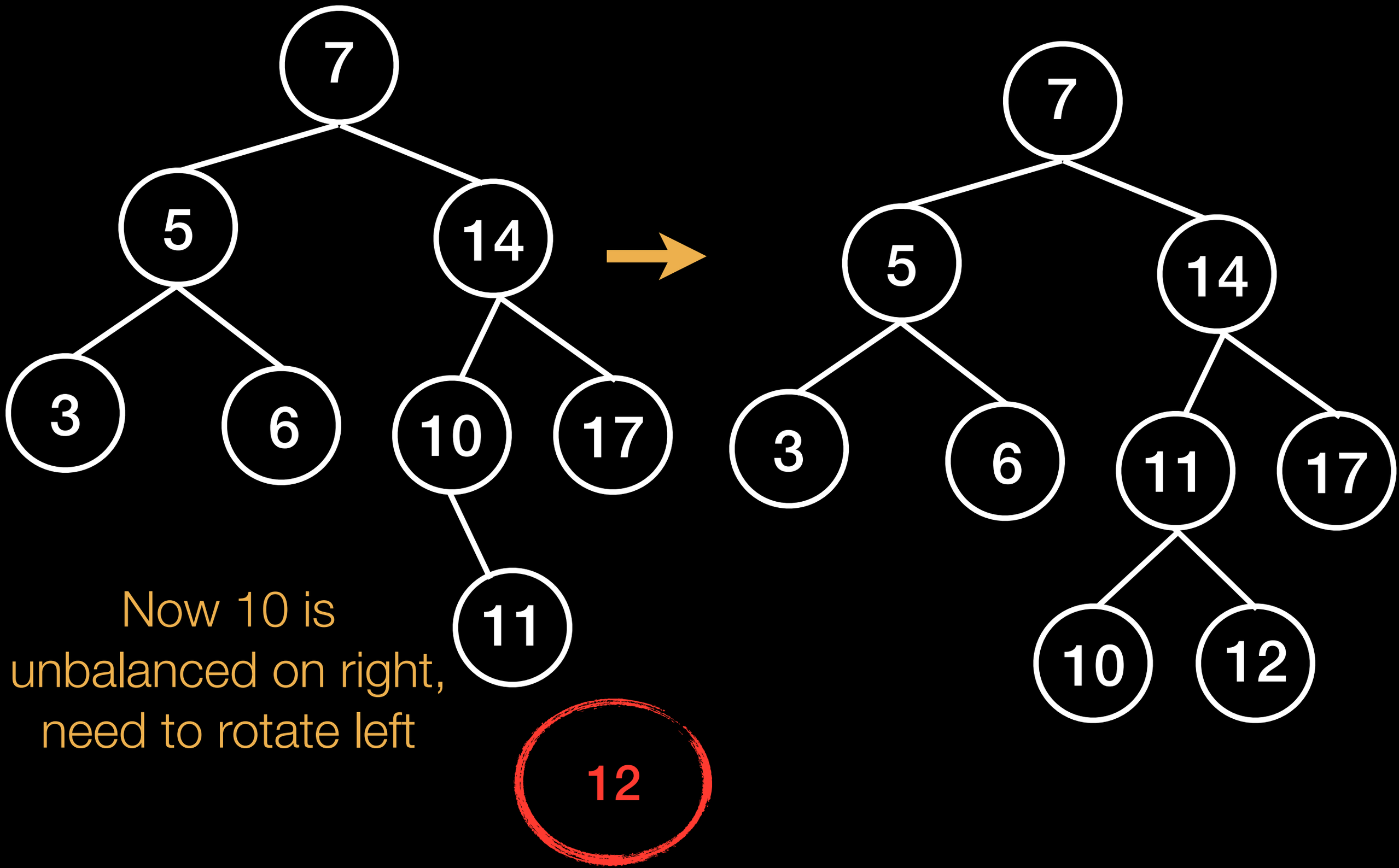

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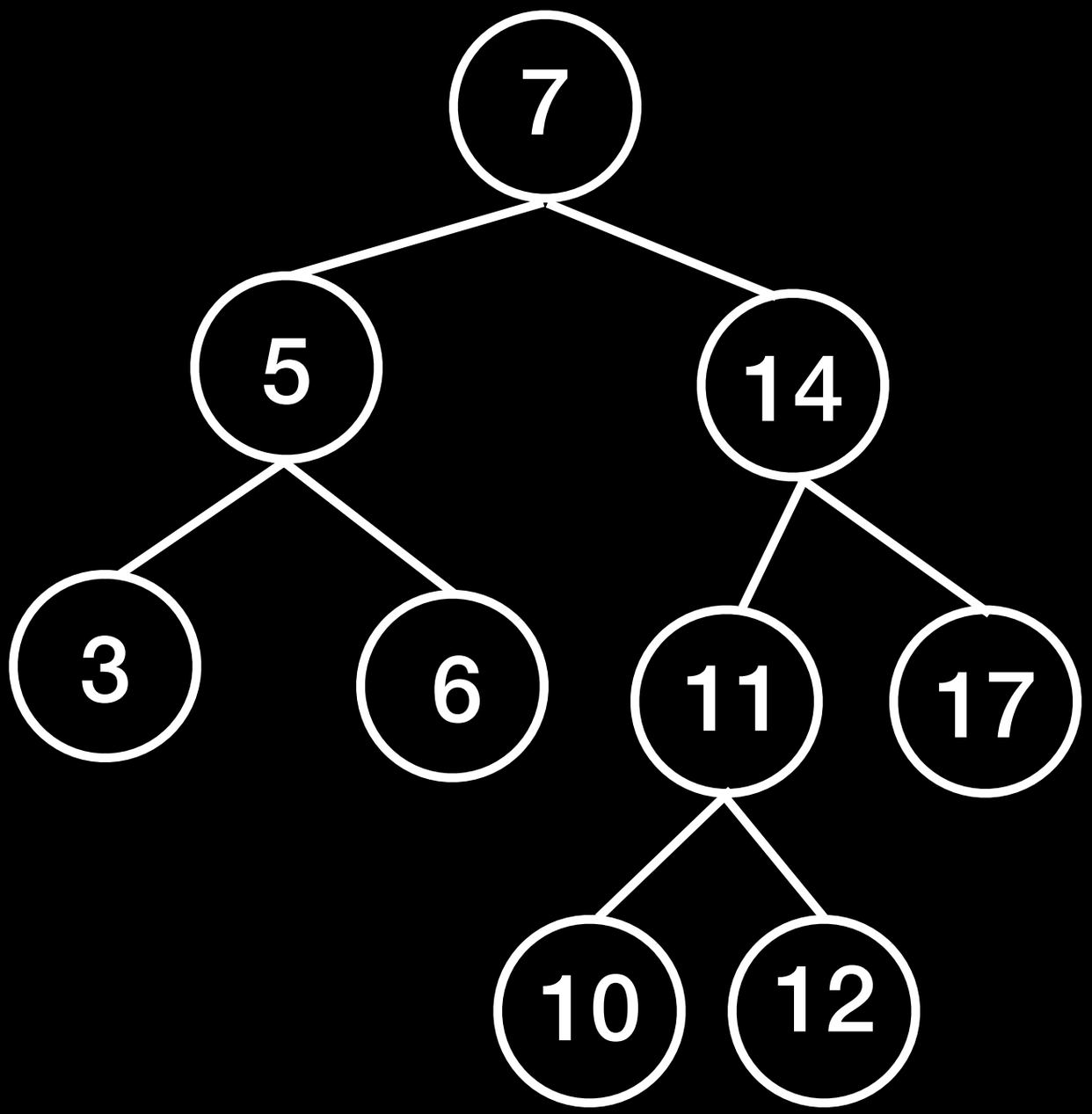
12

Remove 3



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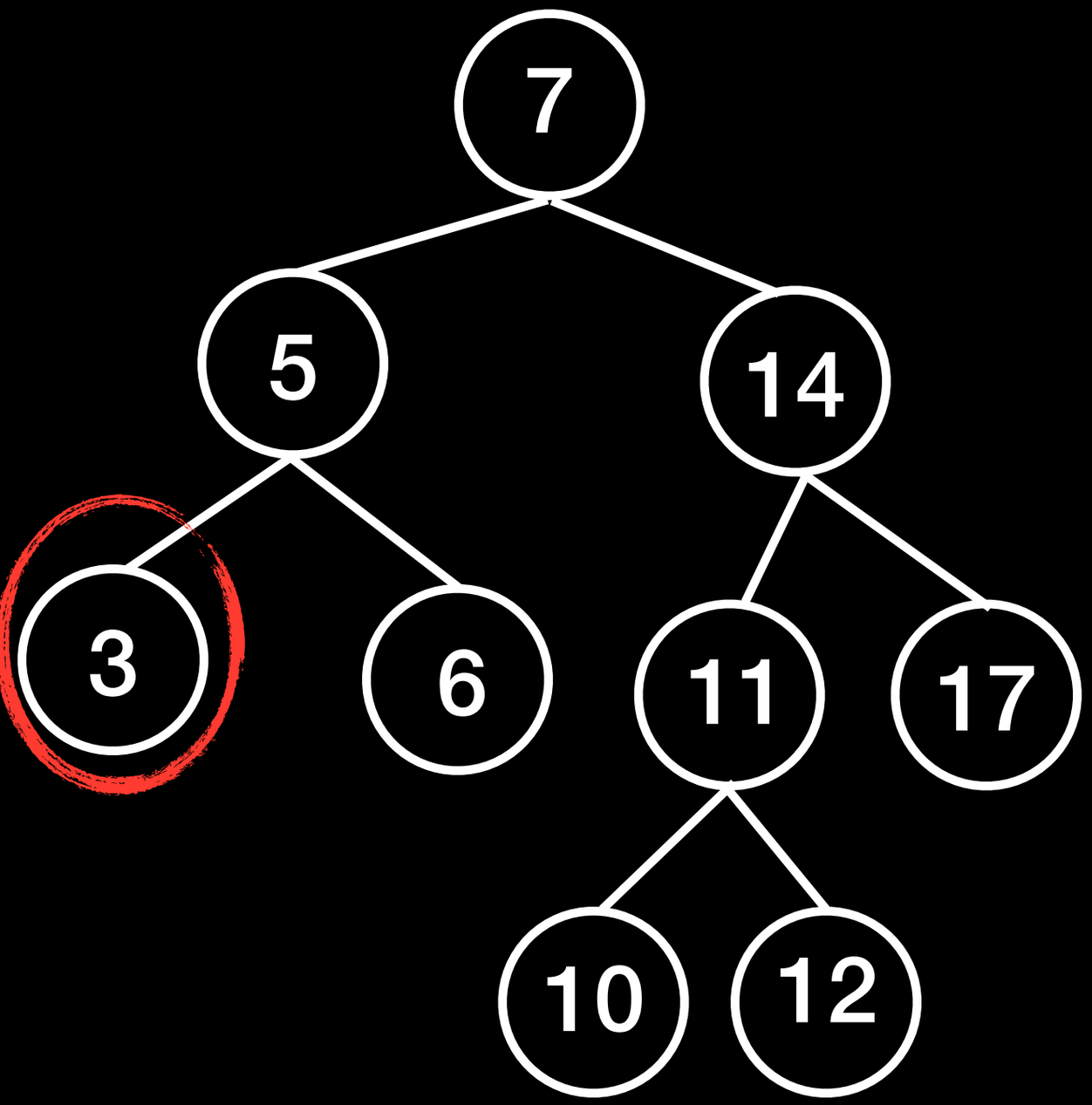

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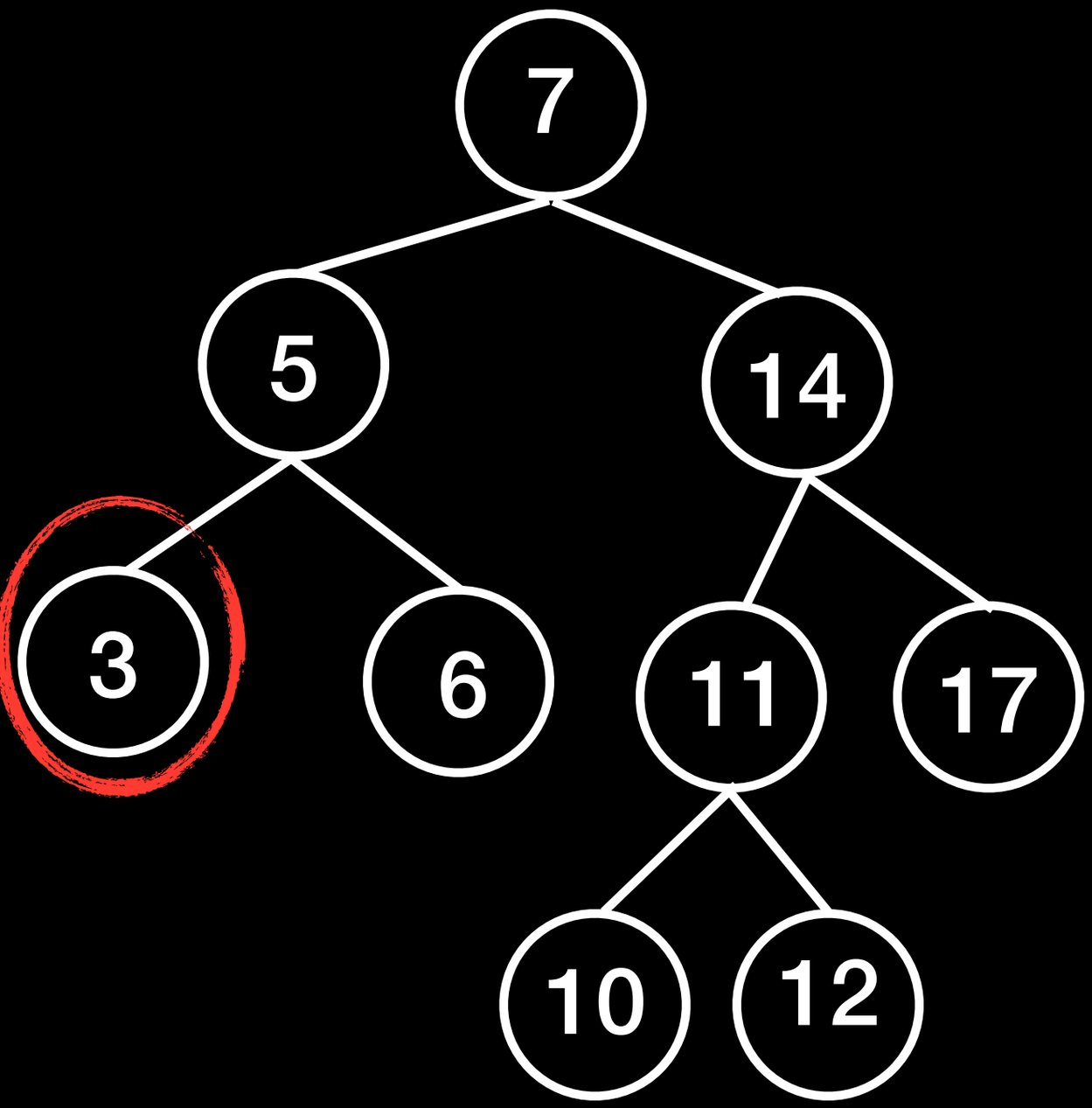

Still balanced, no rotations needed

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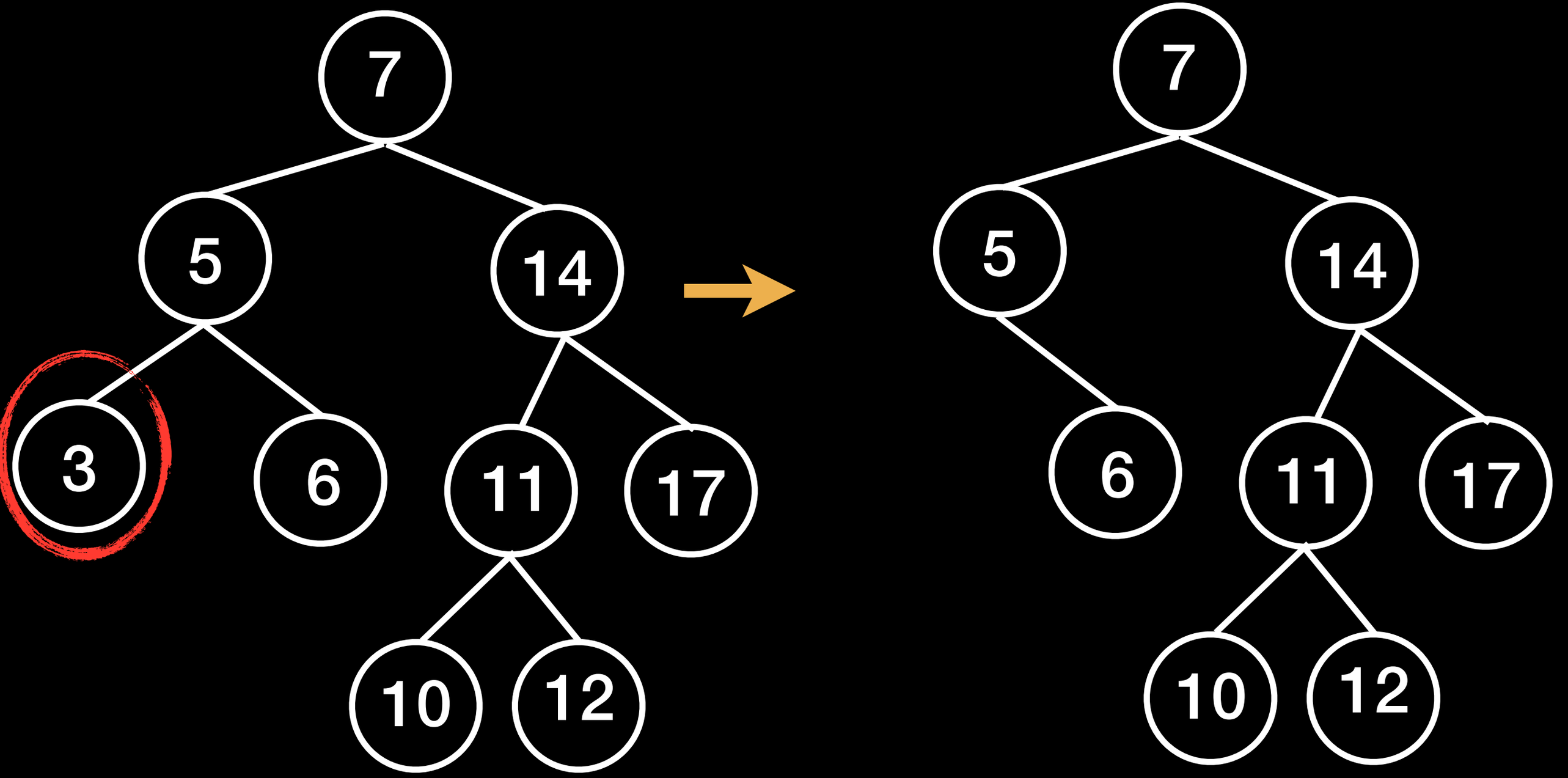

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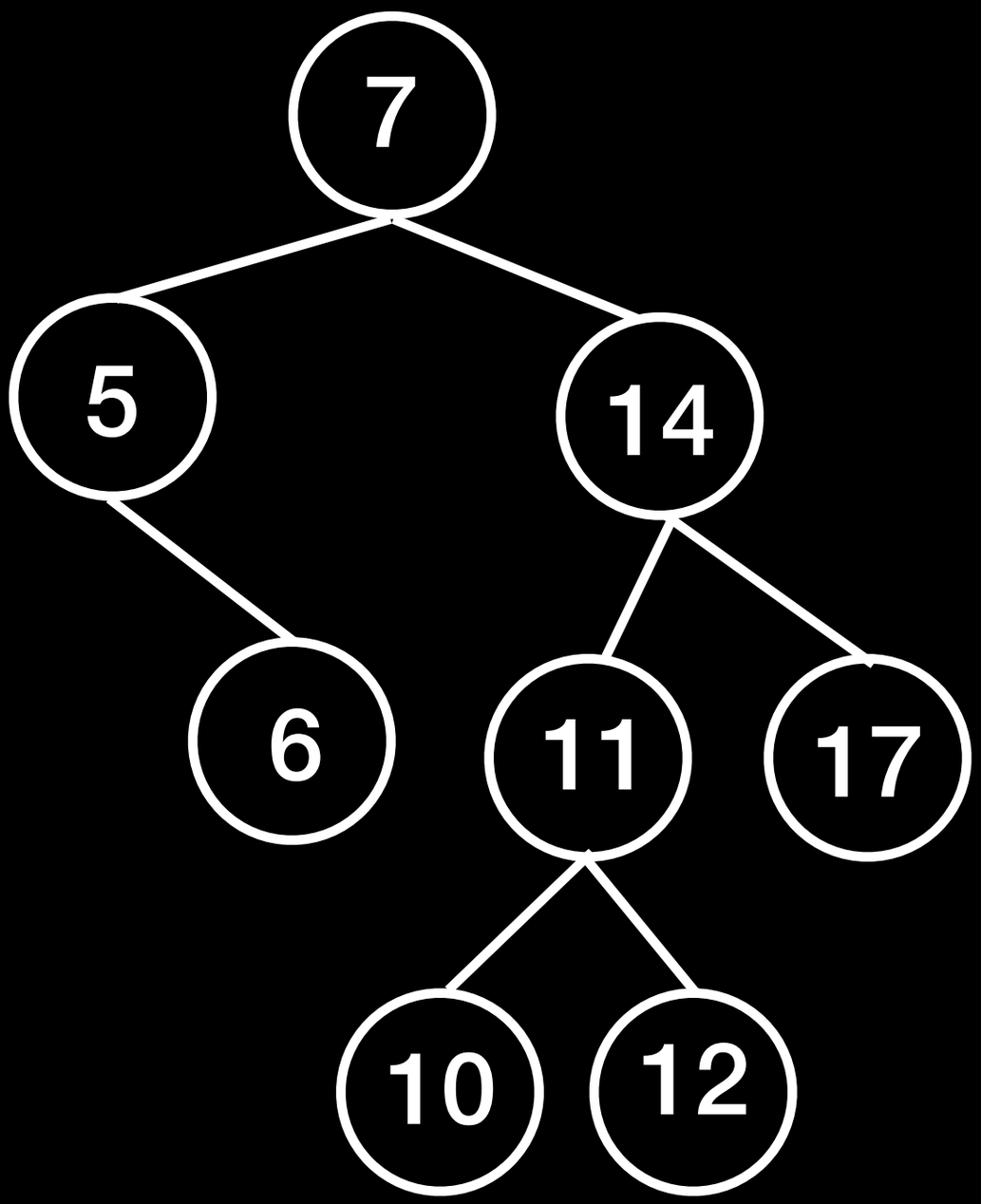
Remove 5



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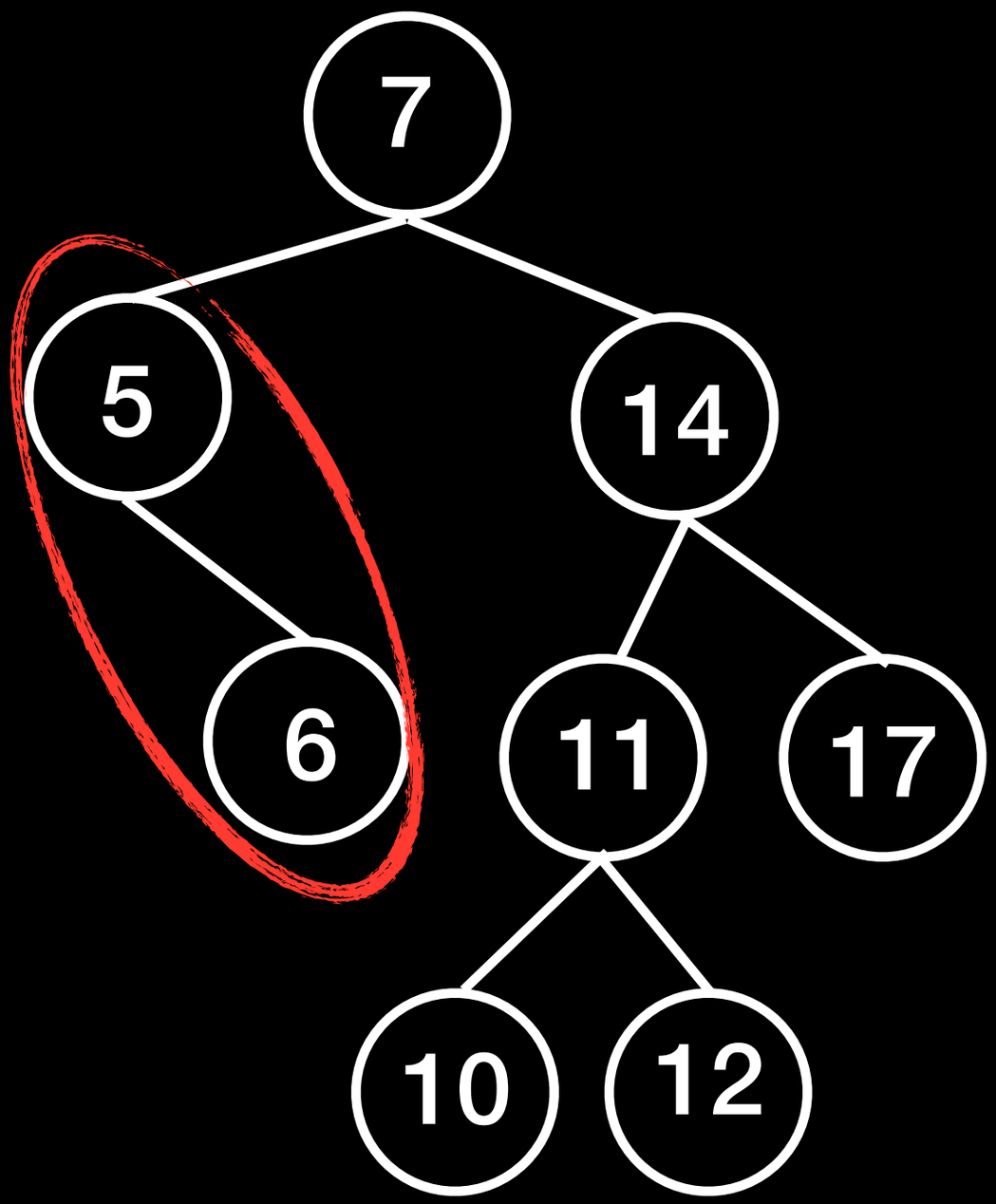

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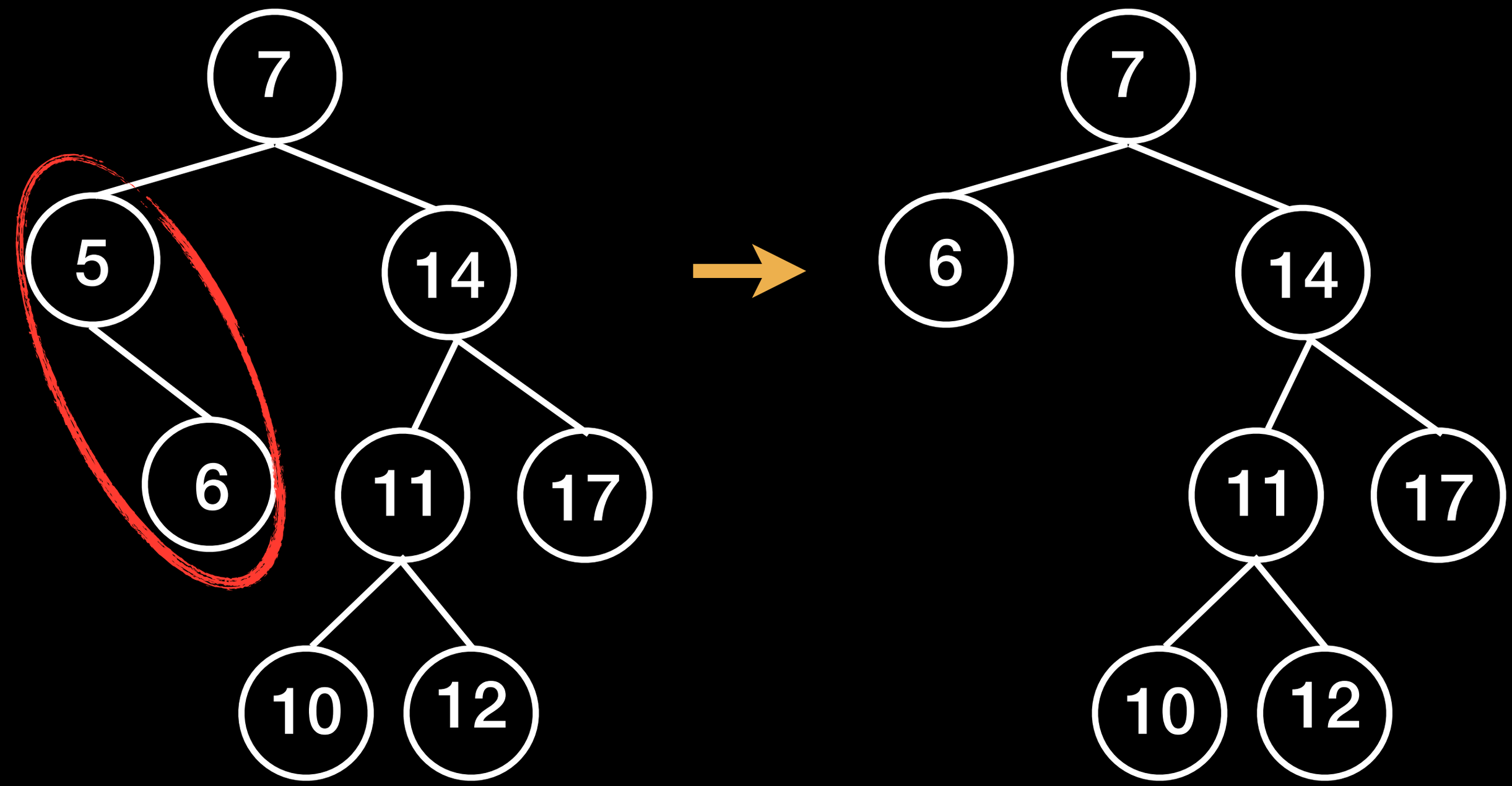

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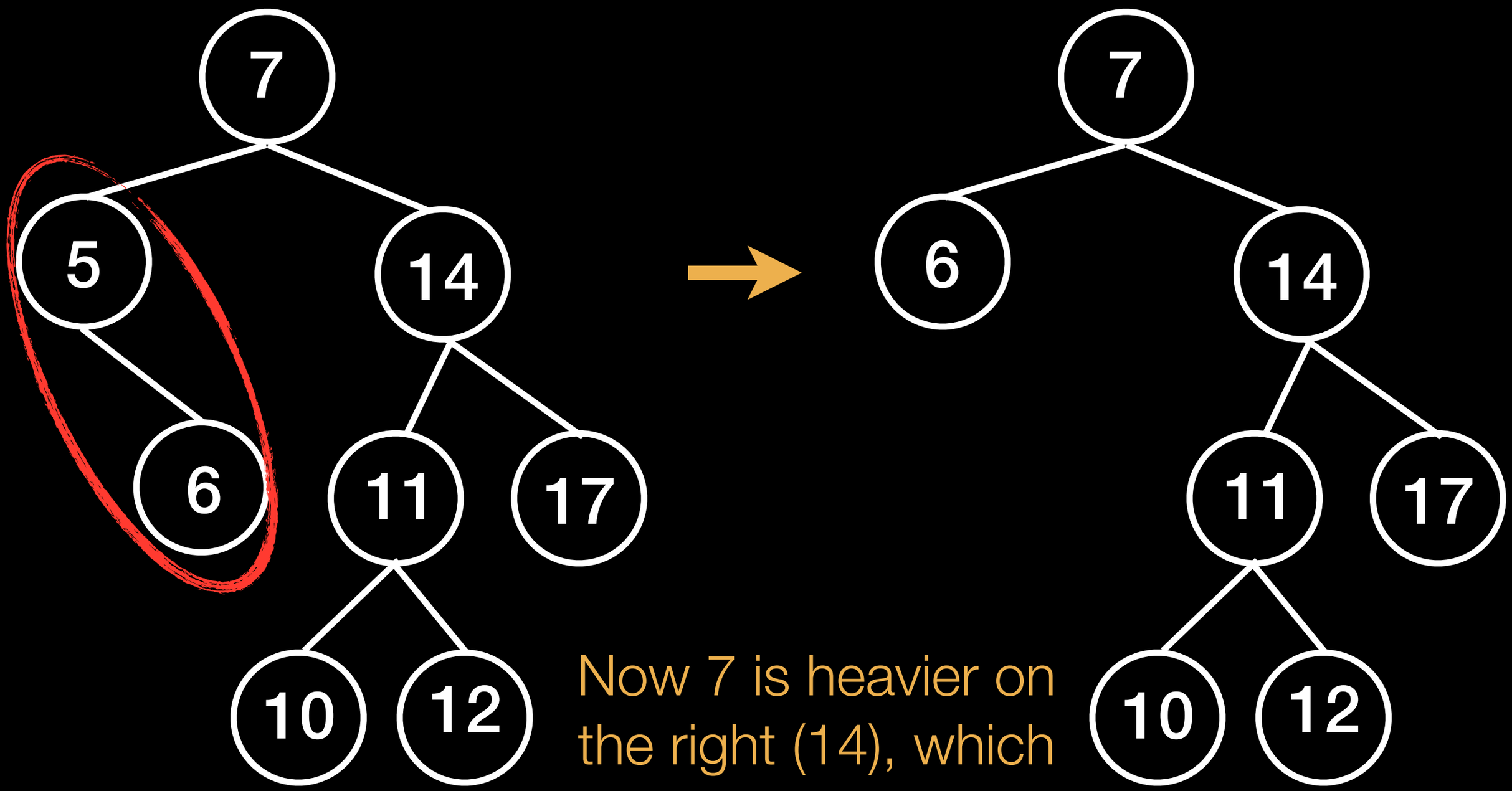
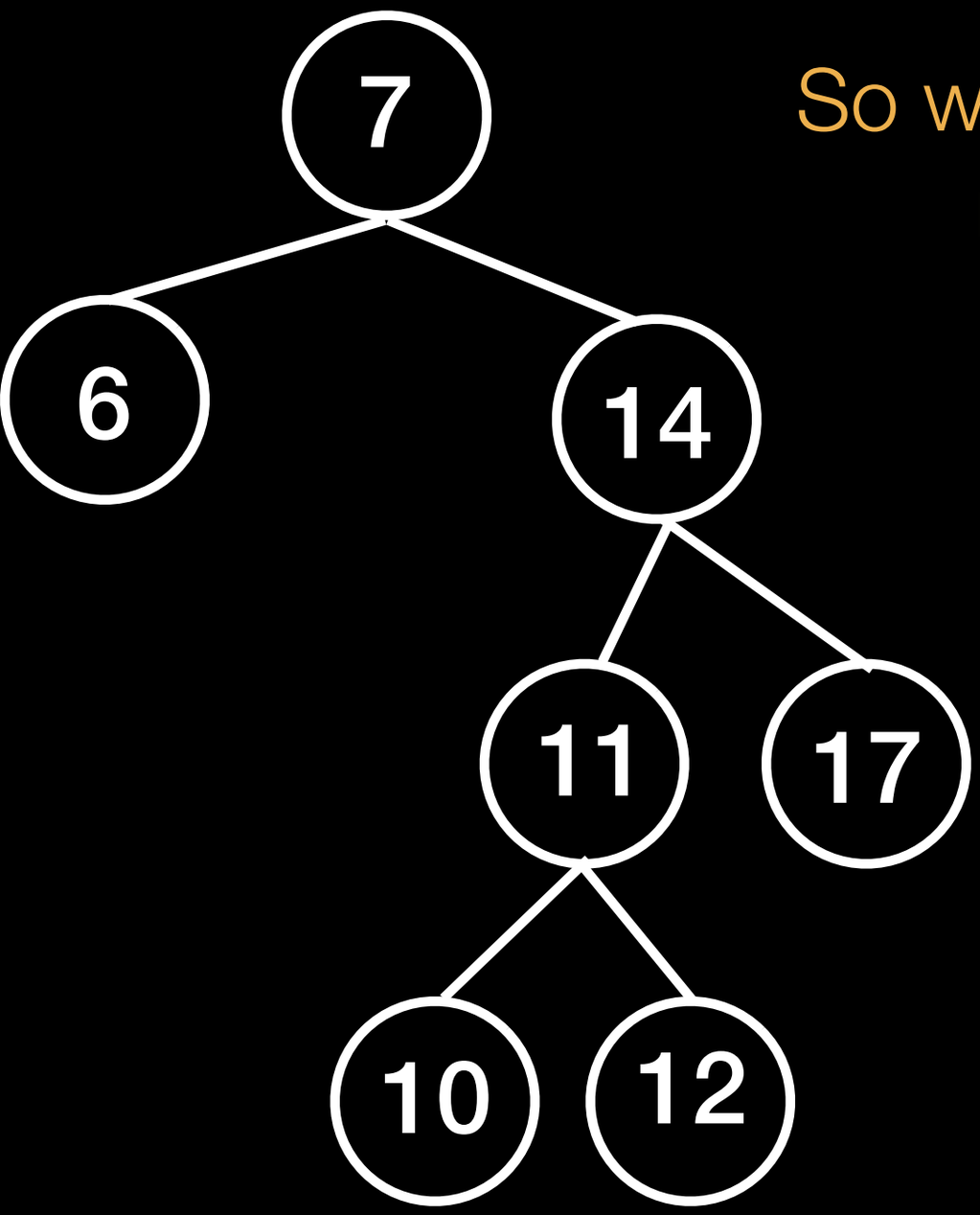


Now 7 is heavier on the right (14), which is heavier on the left. Need a **double rotation...**

Remove 5 (continued)



So we rotate 14 right...

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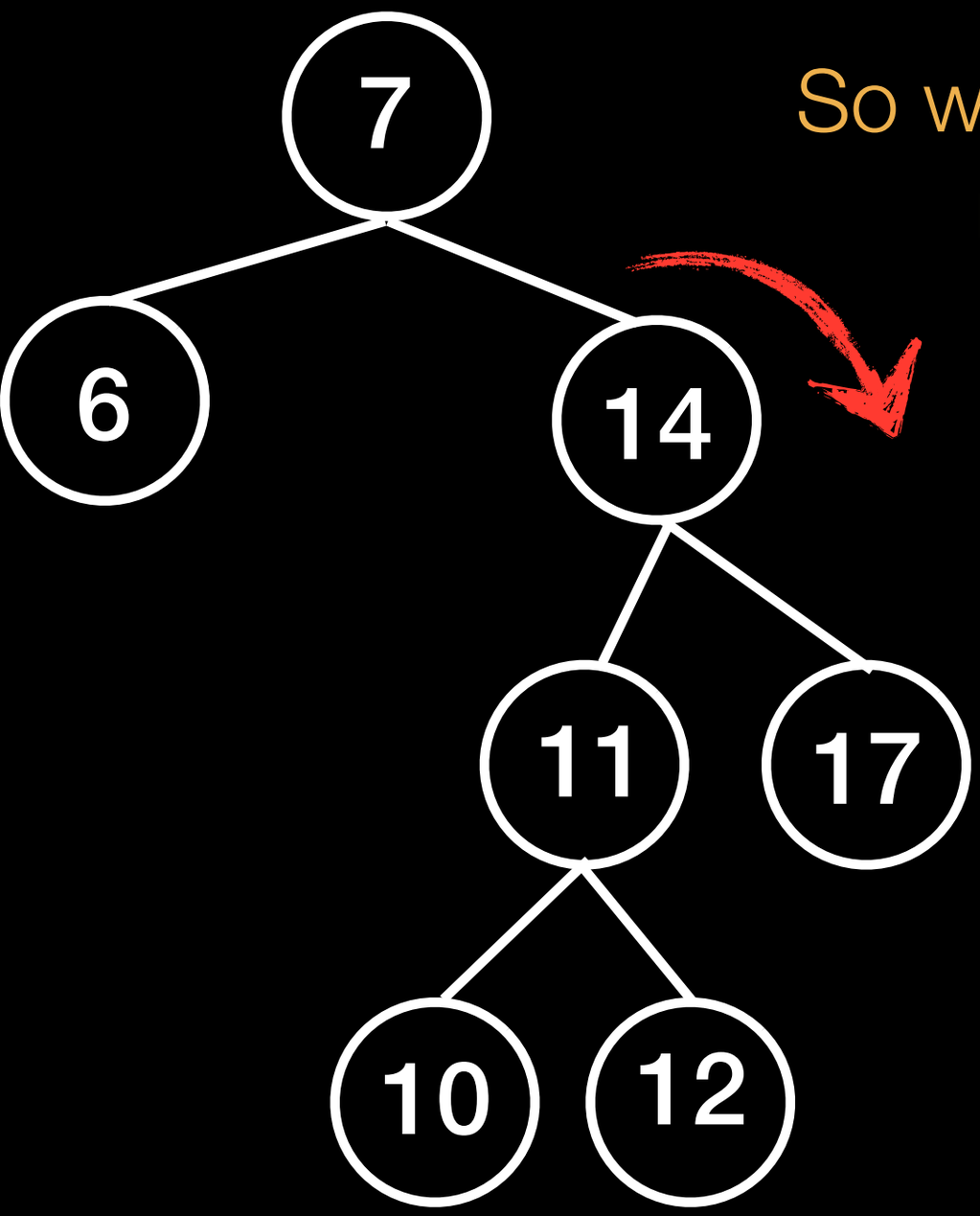

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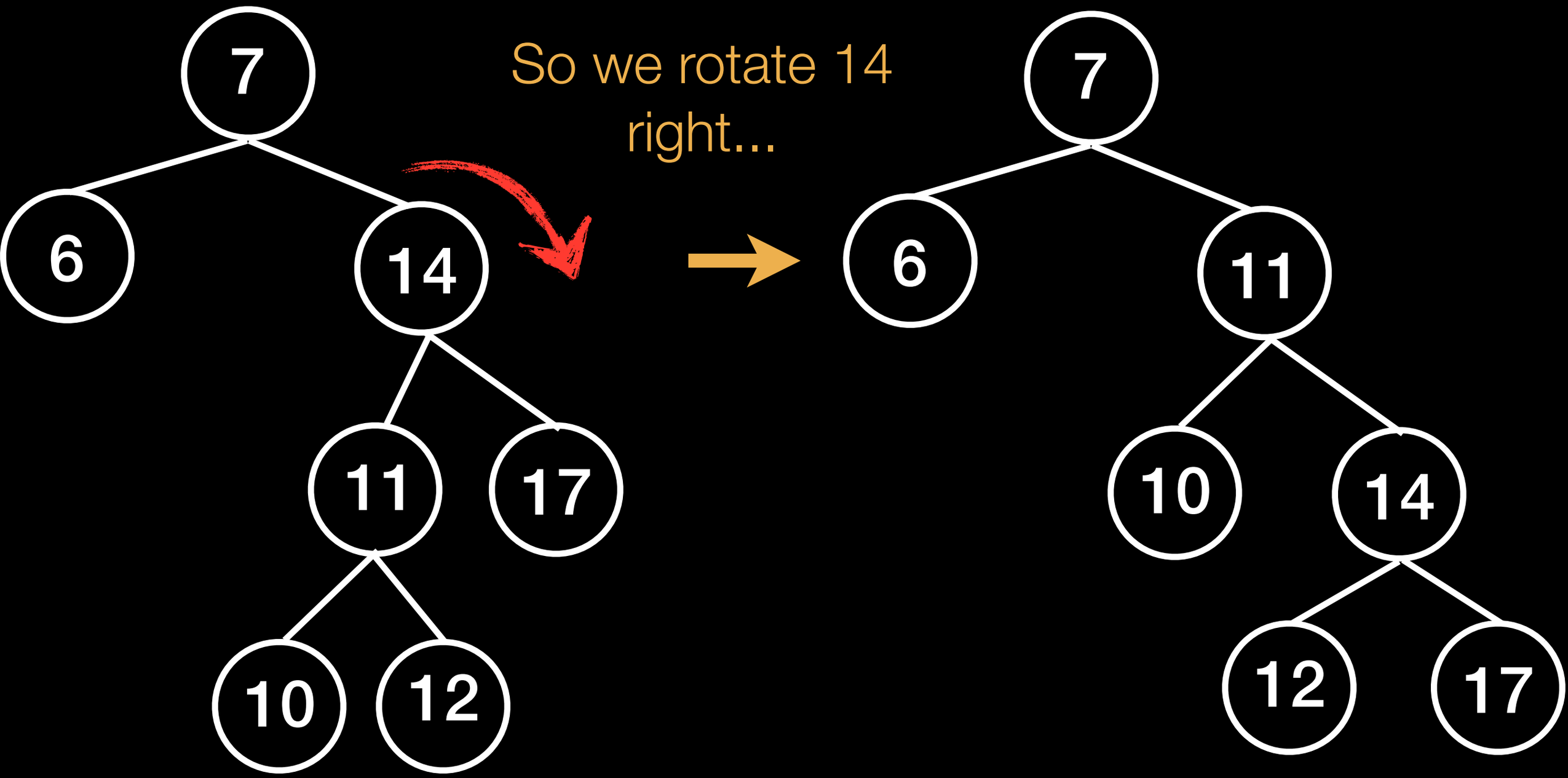

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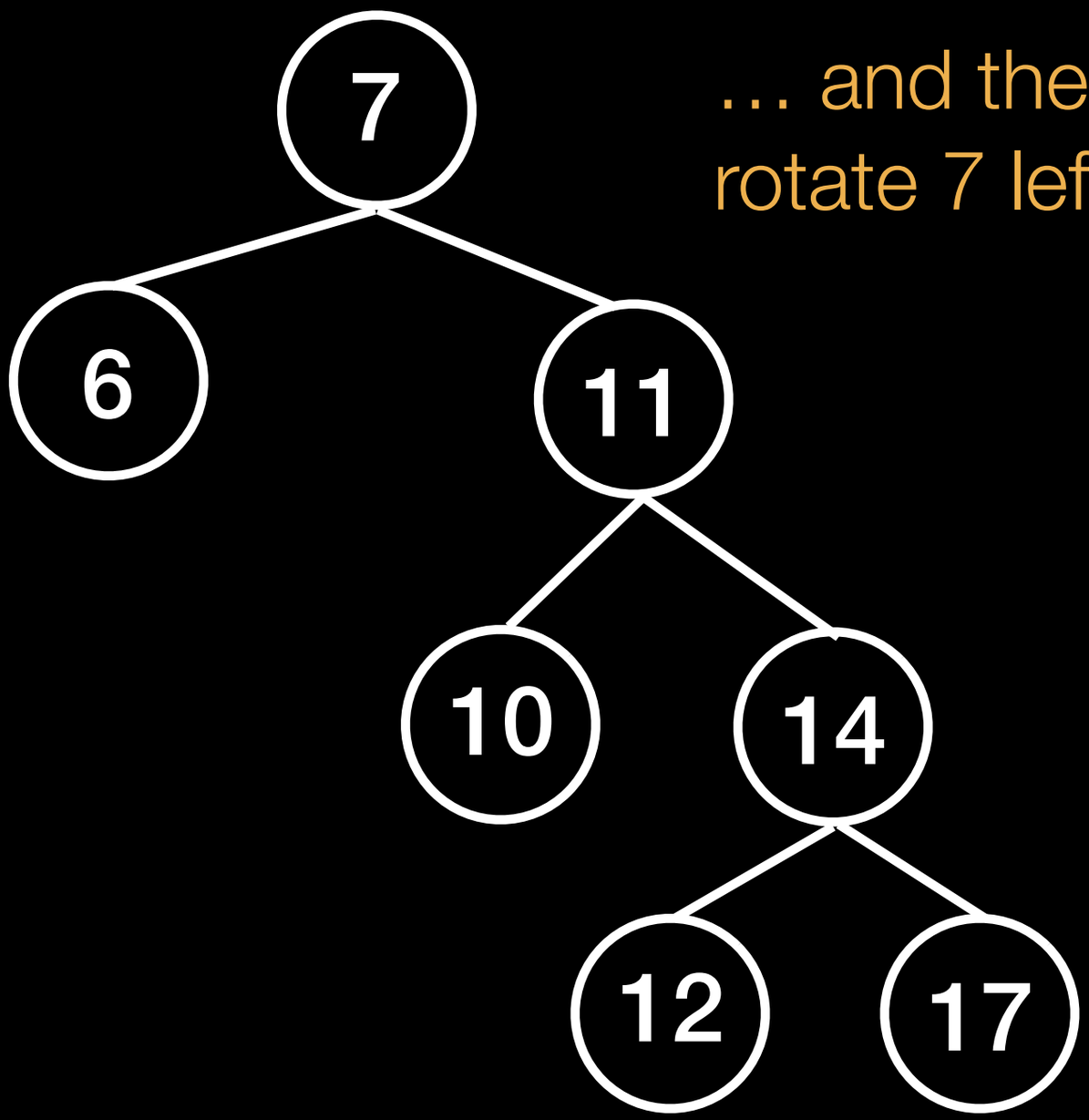
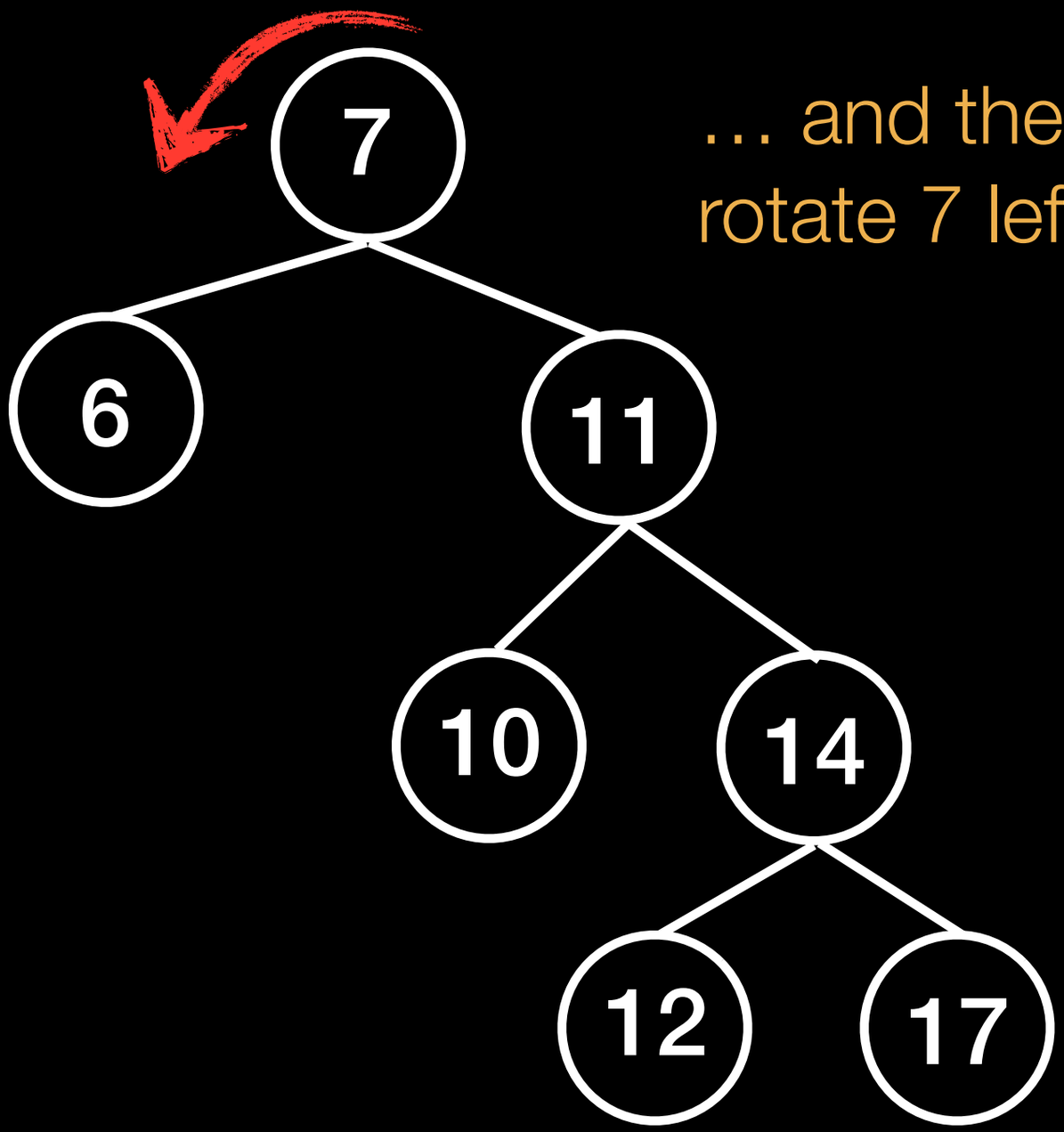


… and then
rotate 7 left!

Remove 5 (continued)



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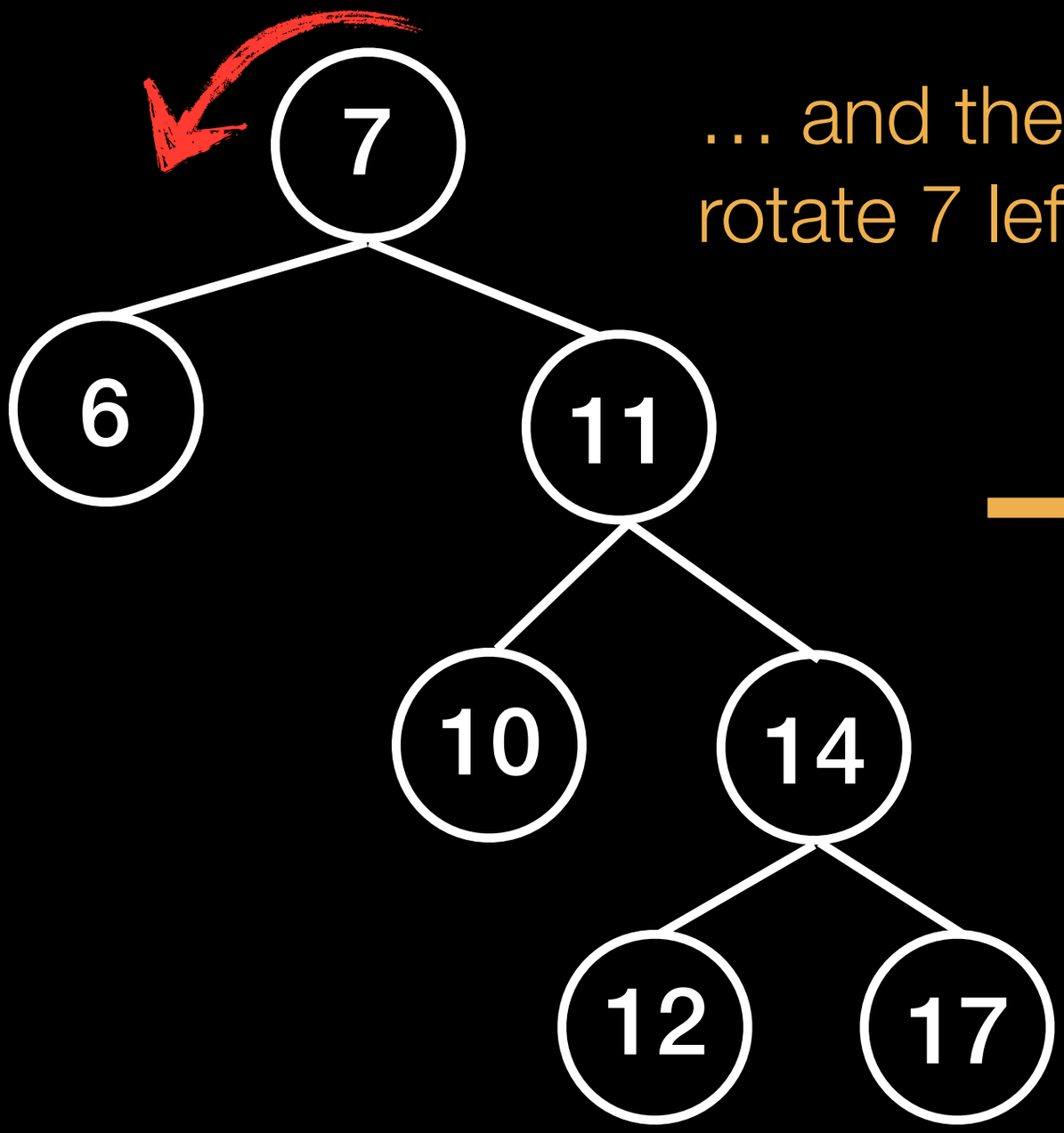

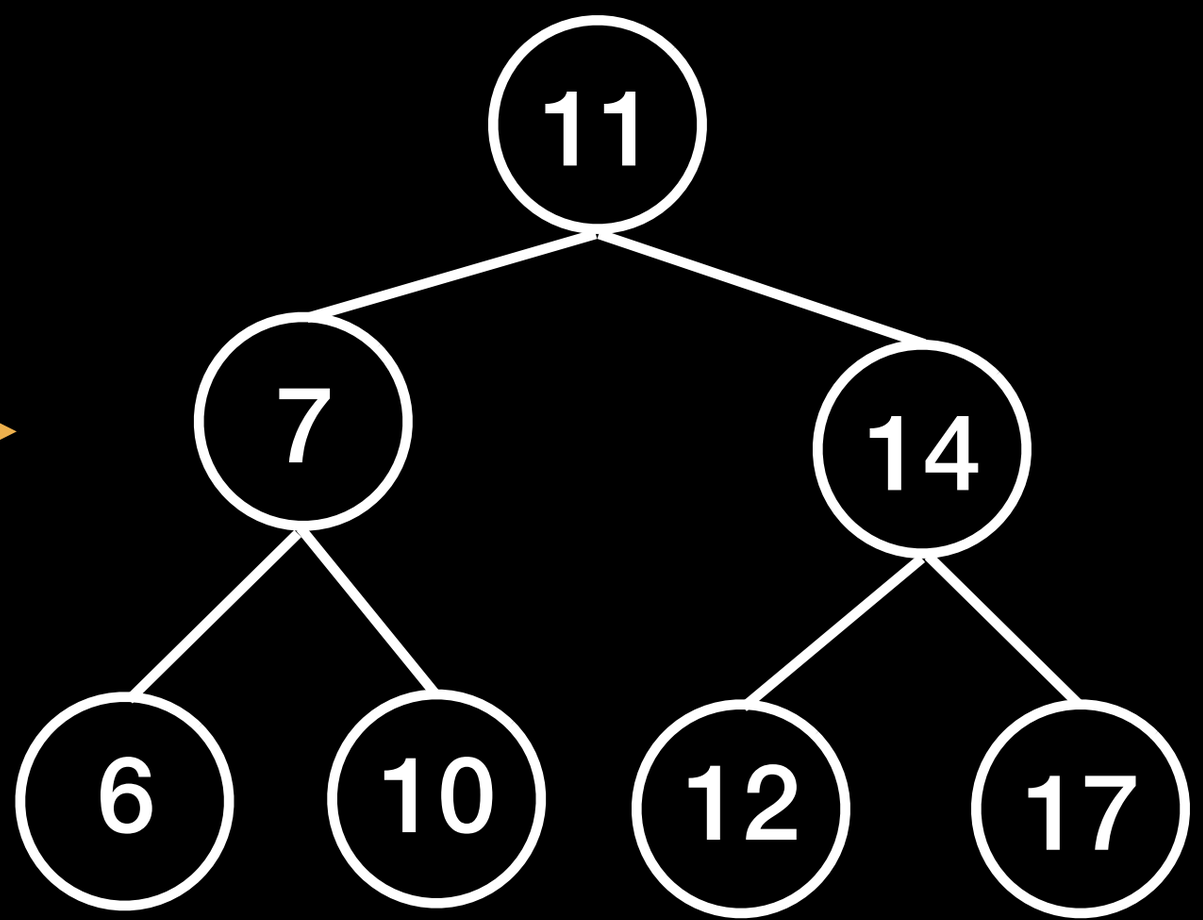

When do we need to do a **double rotation?**

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Balance factor = height(right subtree) - height(left subtree)

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An array

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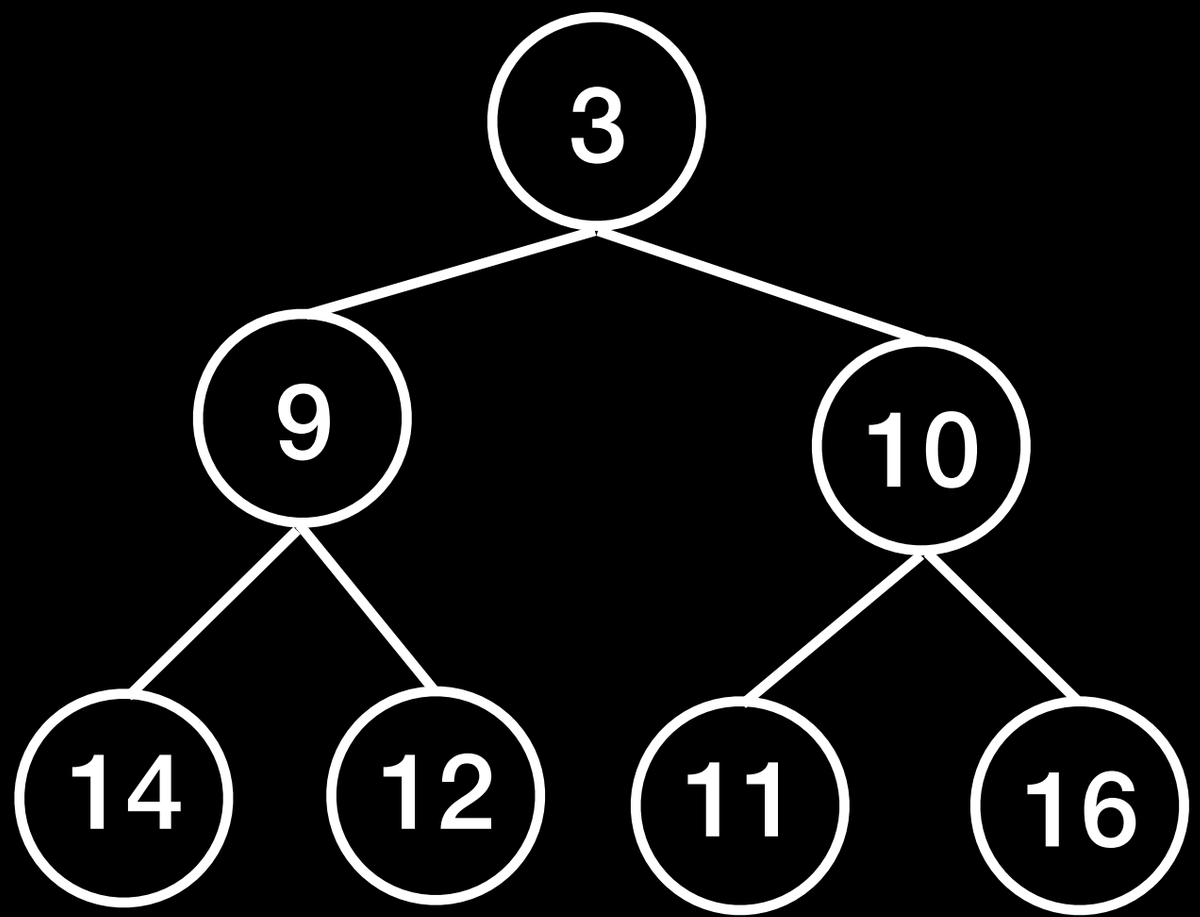
How do we add a node to a heap?

Insert it after the last item, then percolate it up

Simulate **heap sort** on this heap



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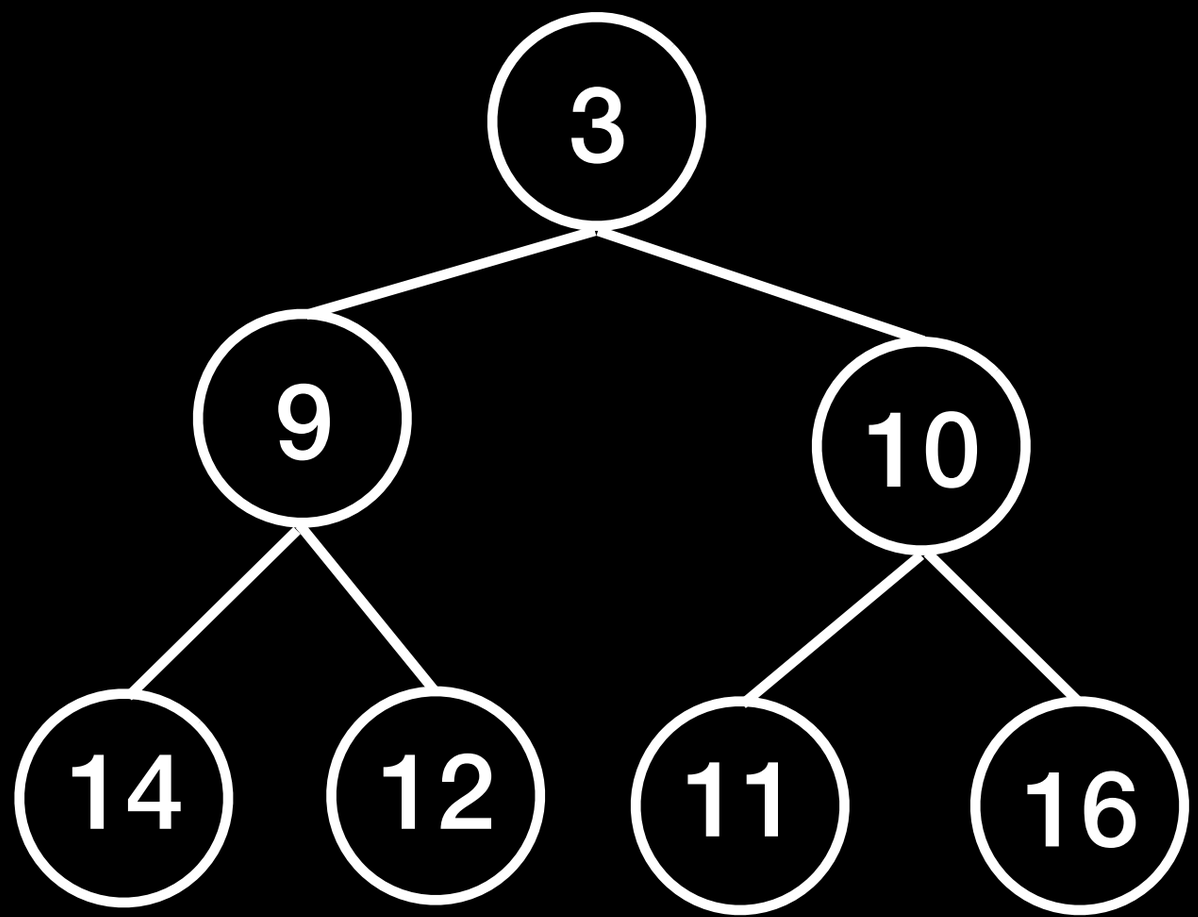

We’ll work this out on the chalk board

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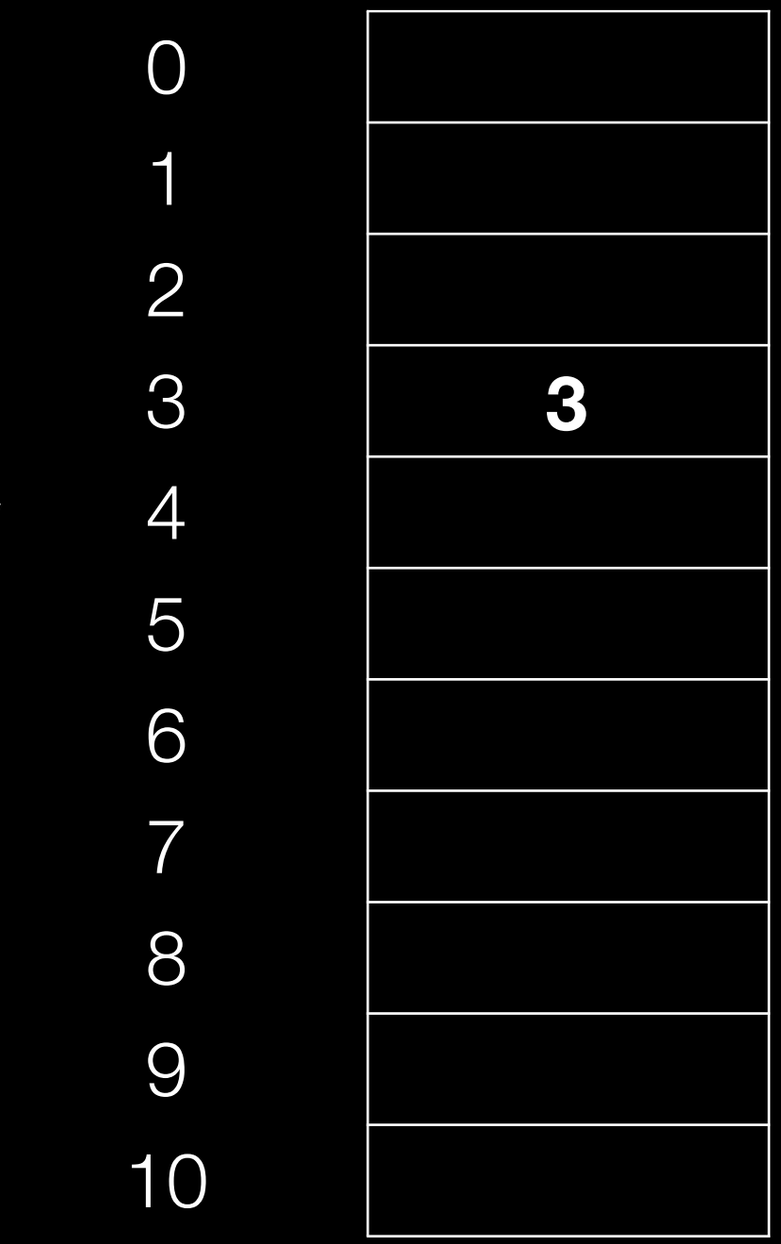

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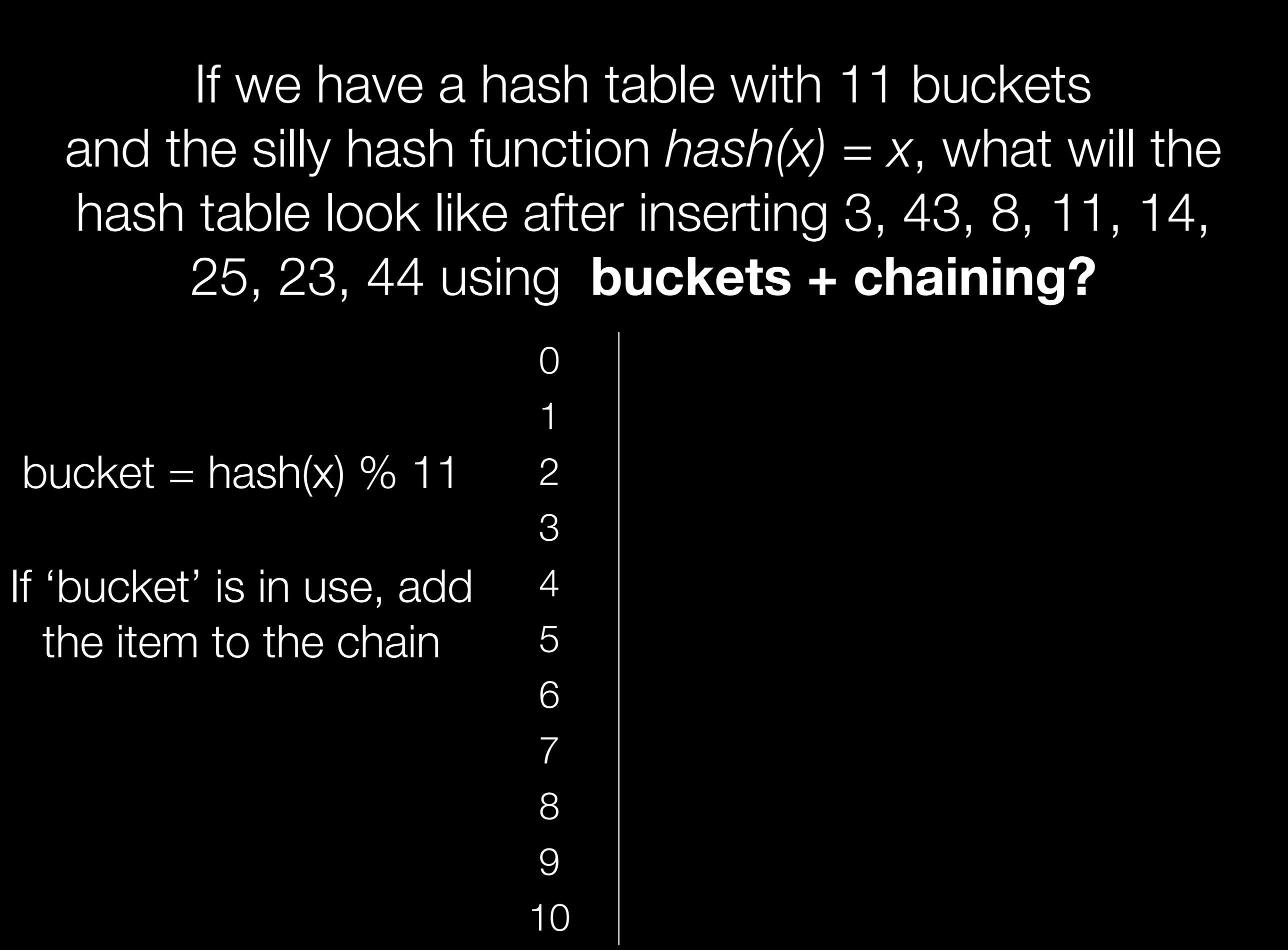

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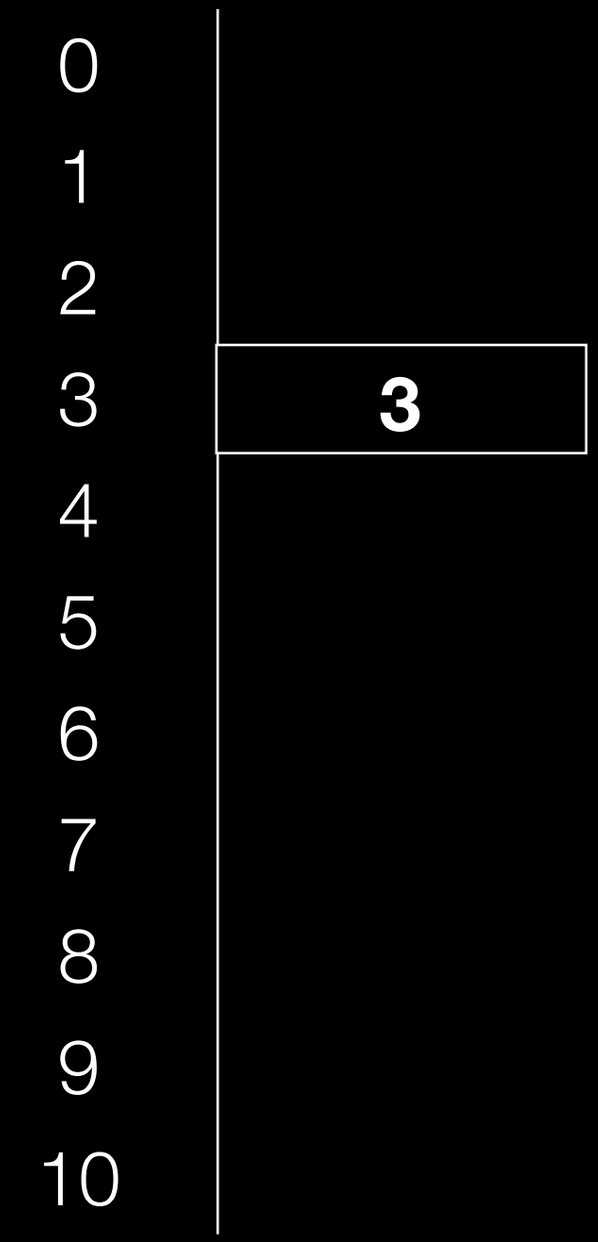

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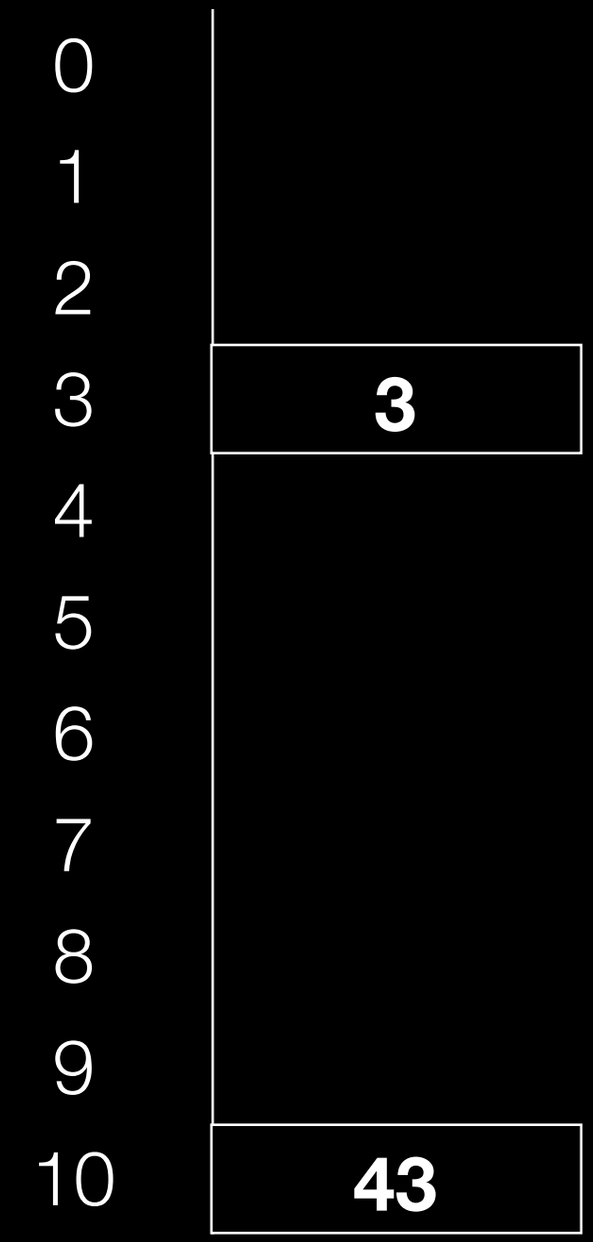

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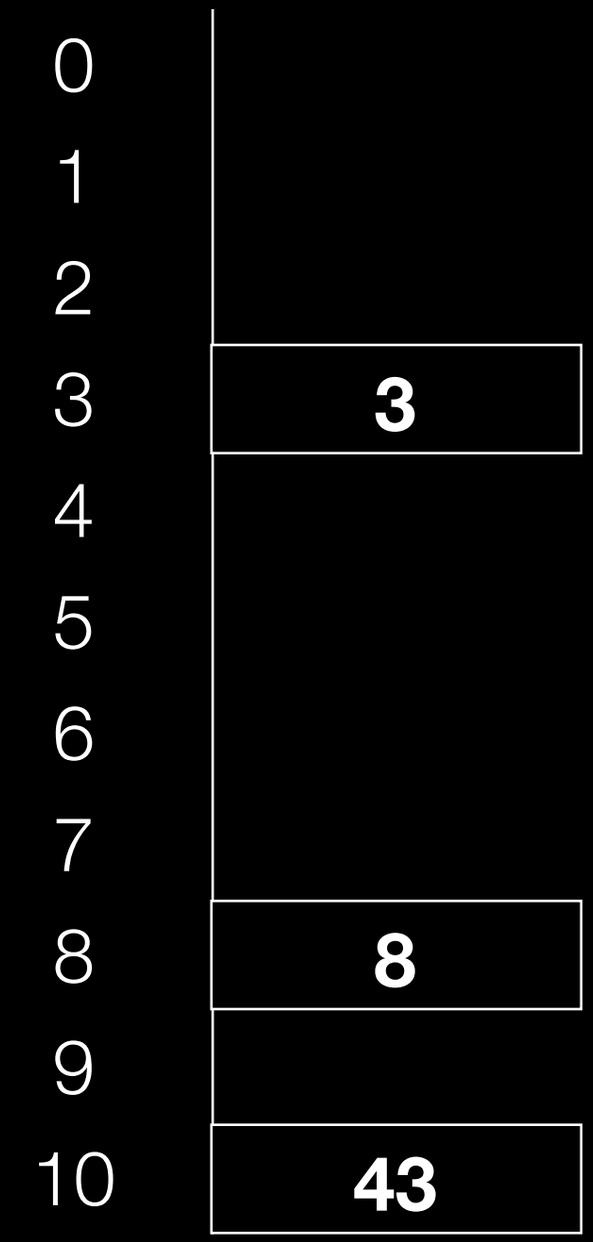

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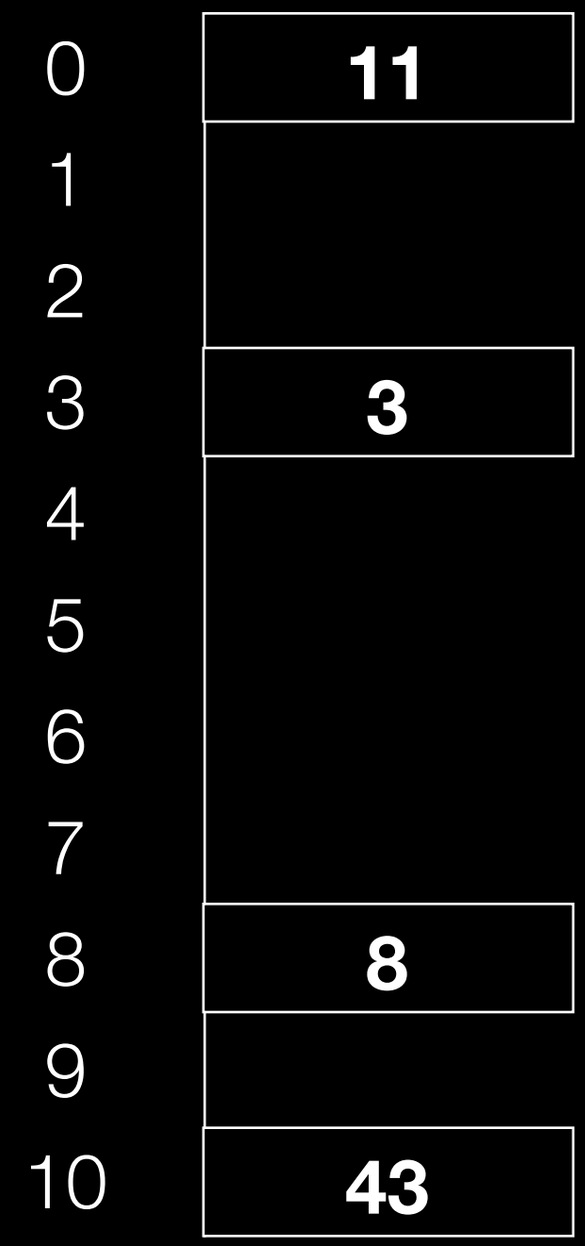

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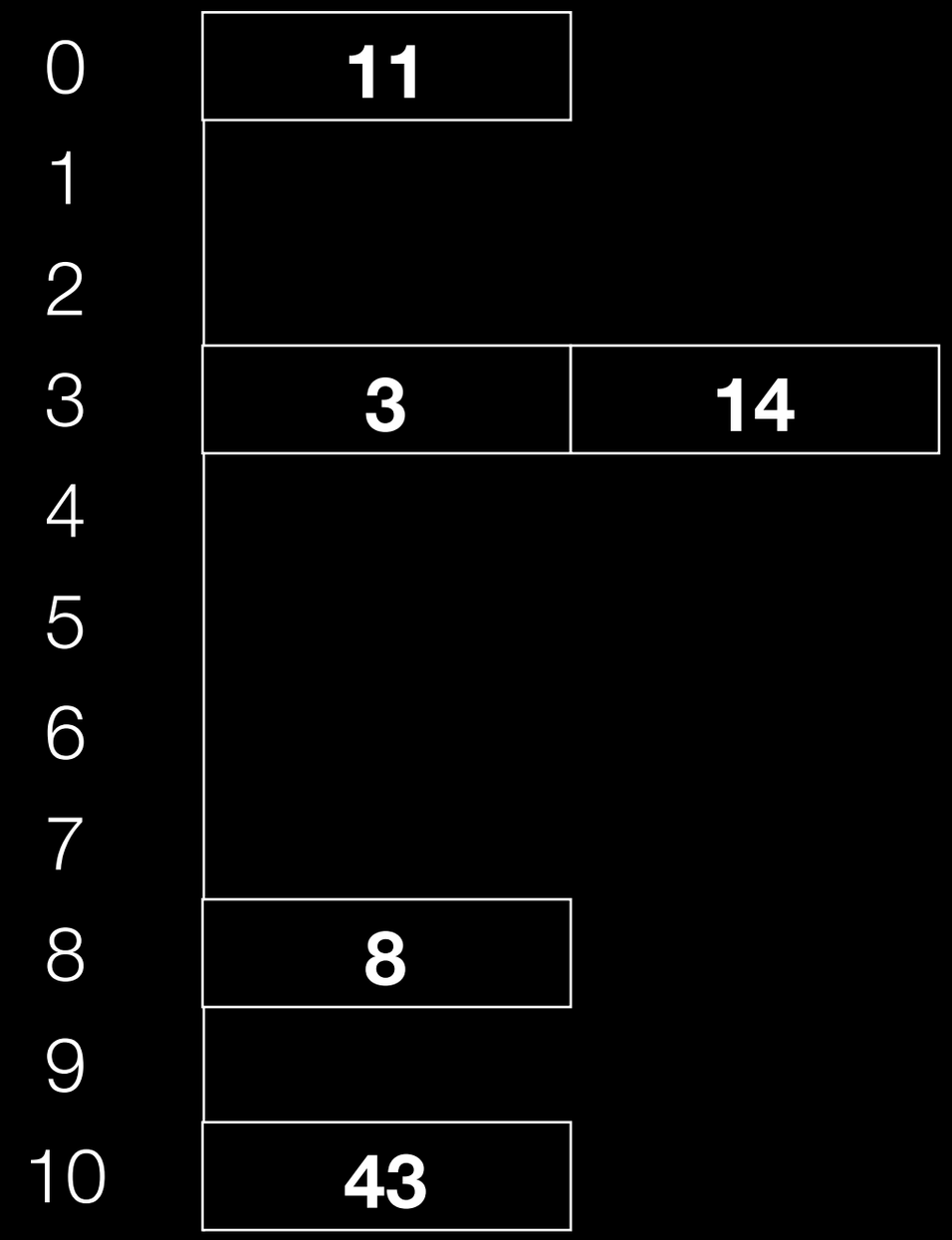

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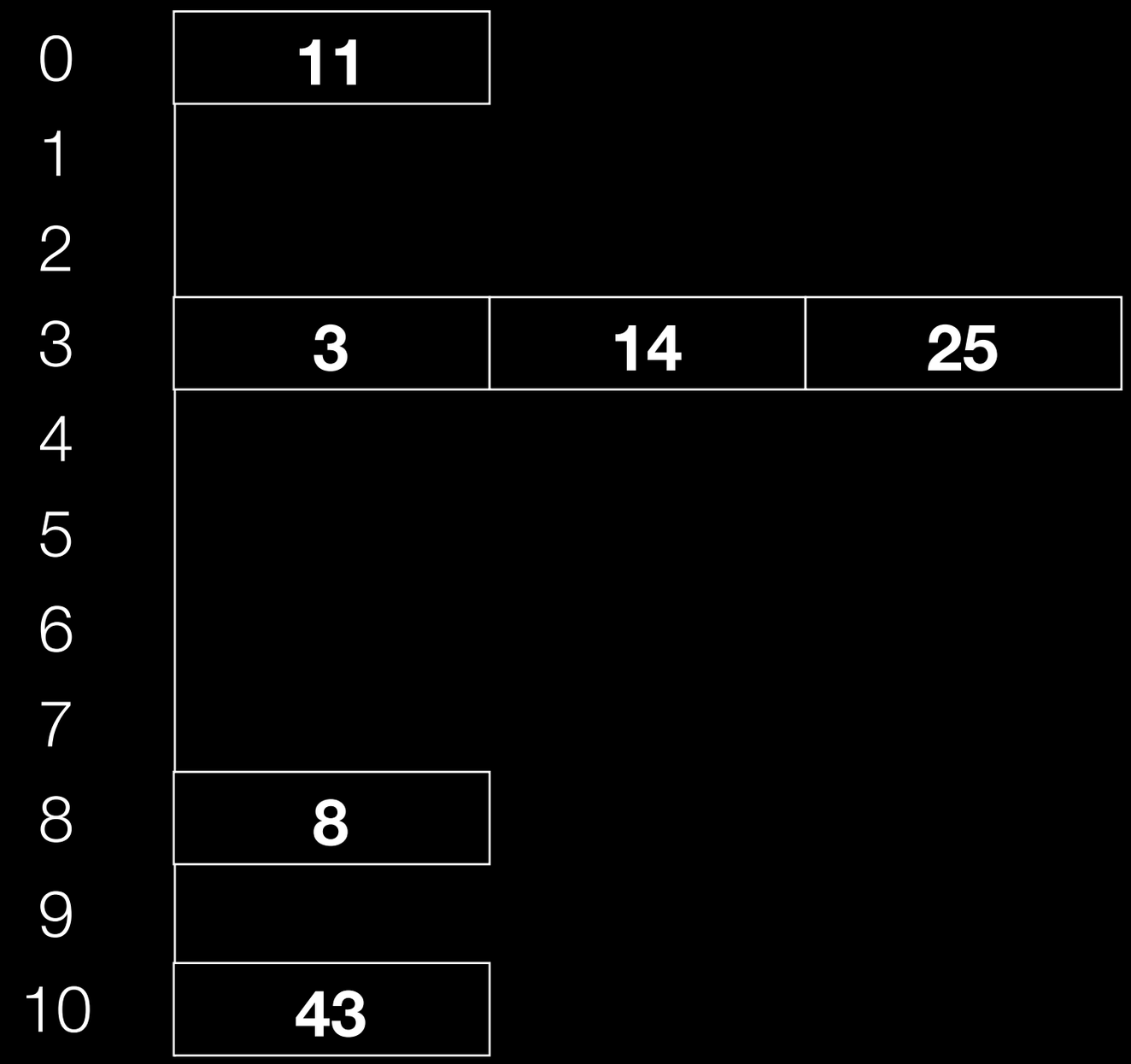

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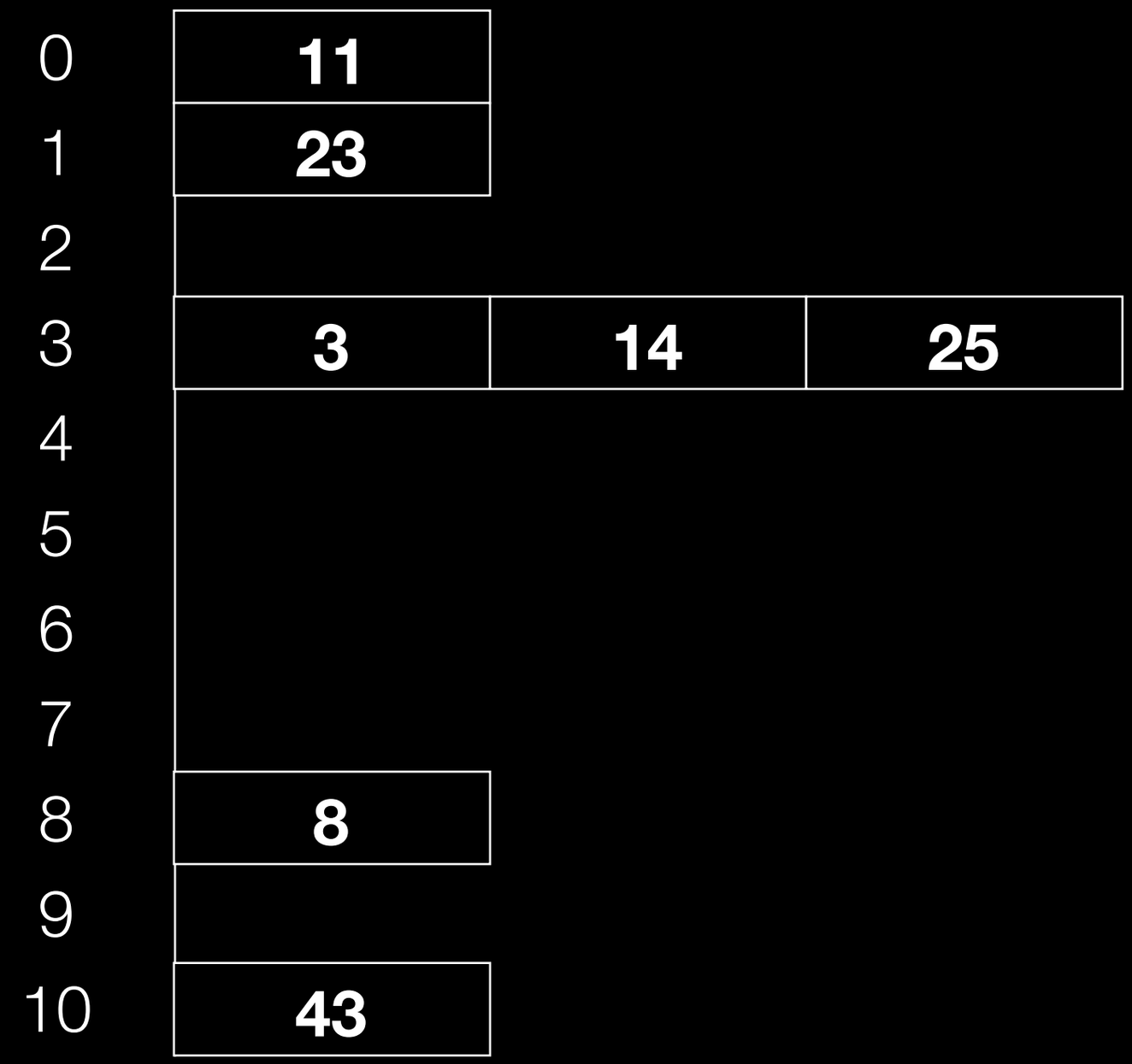

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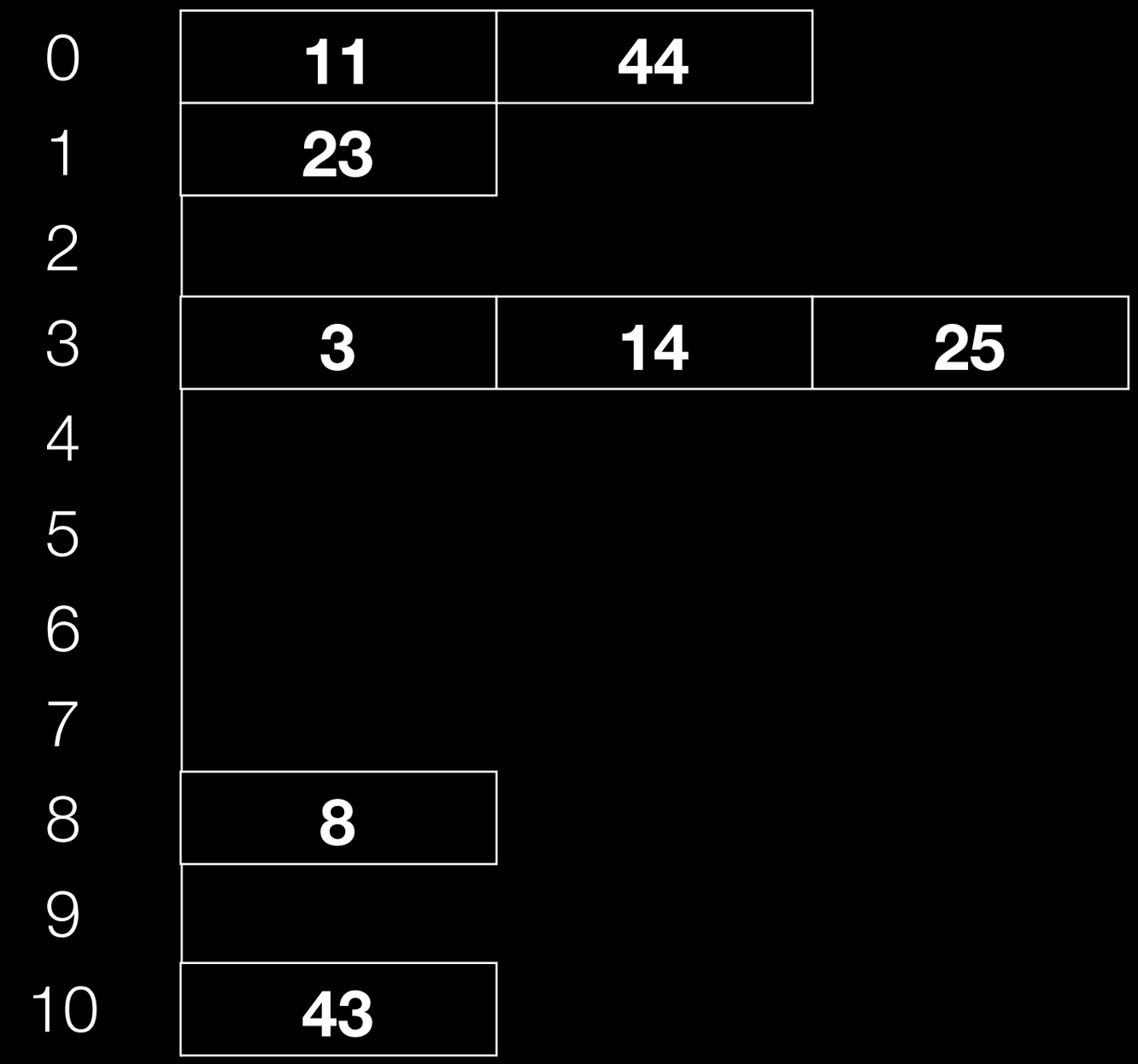

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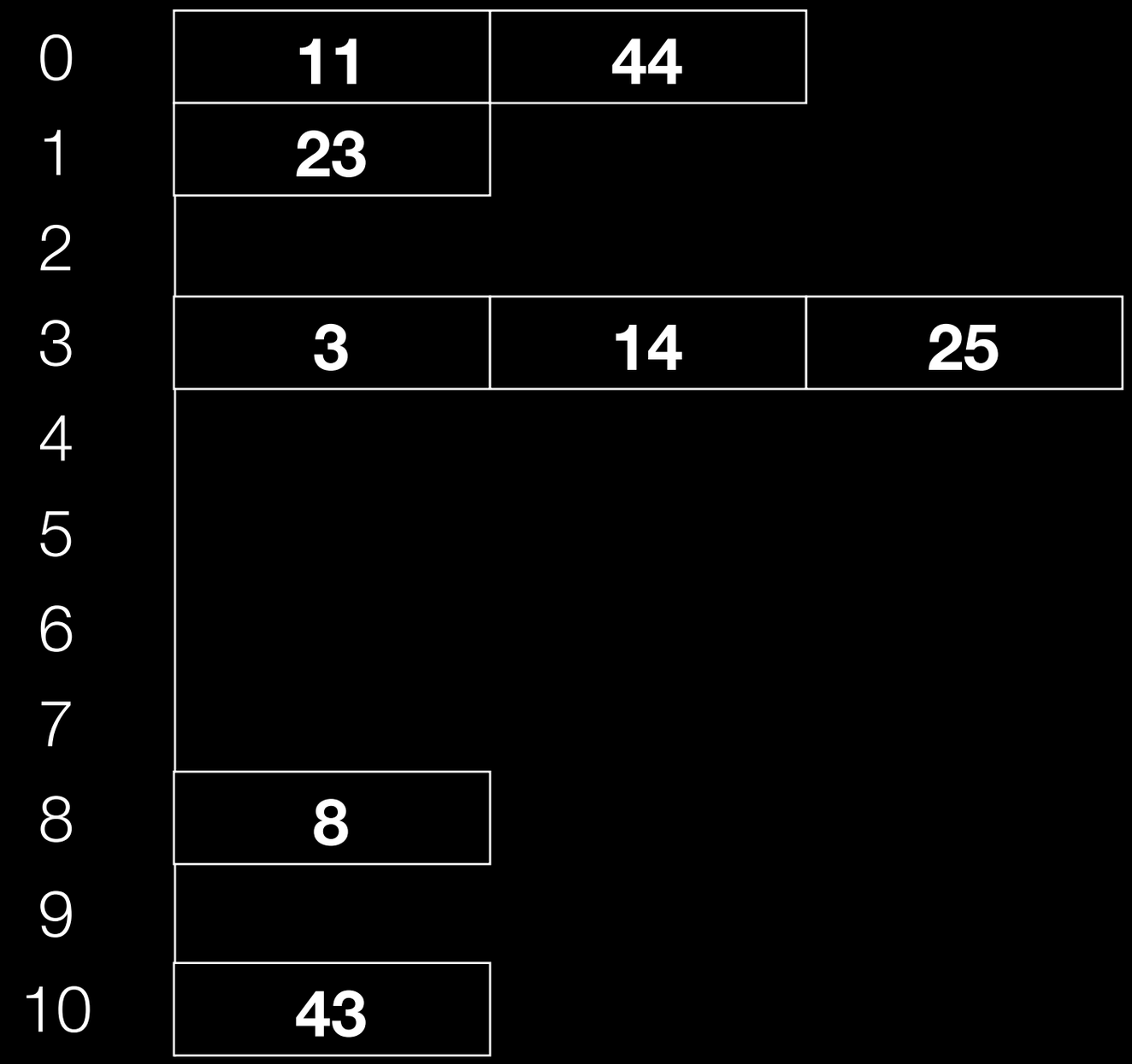

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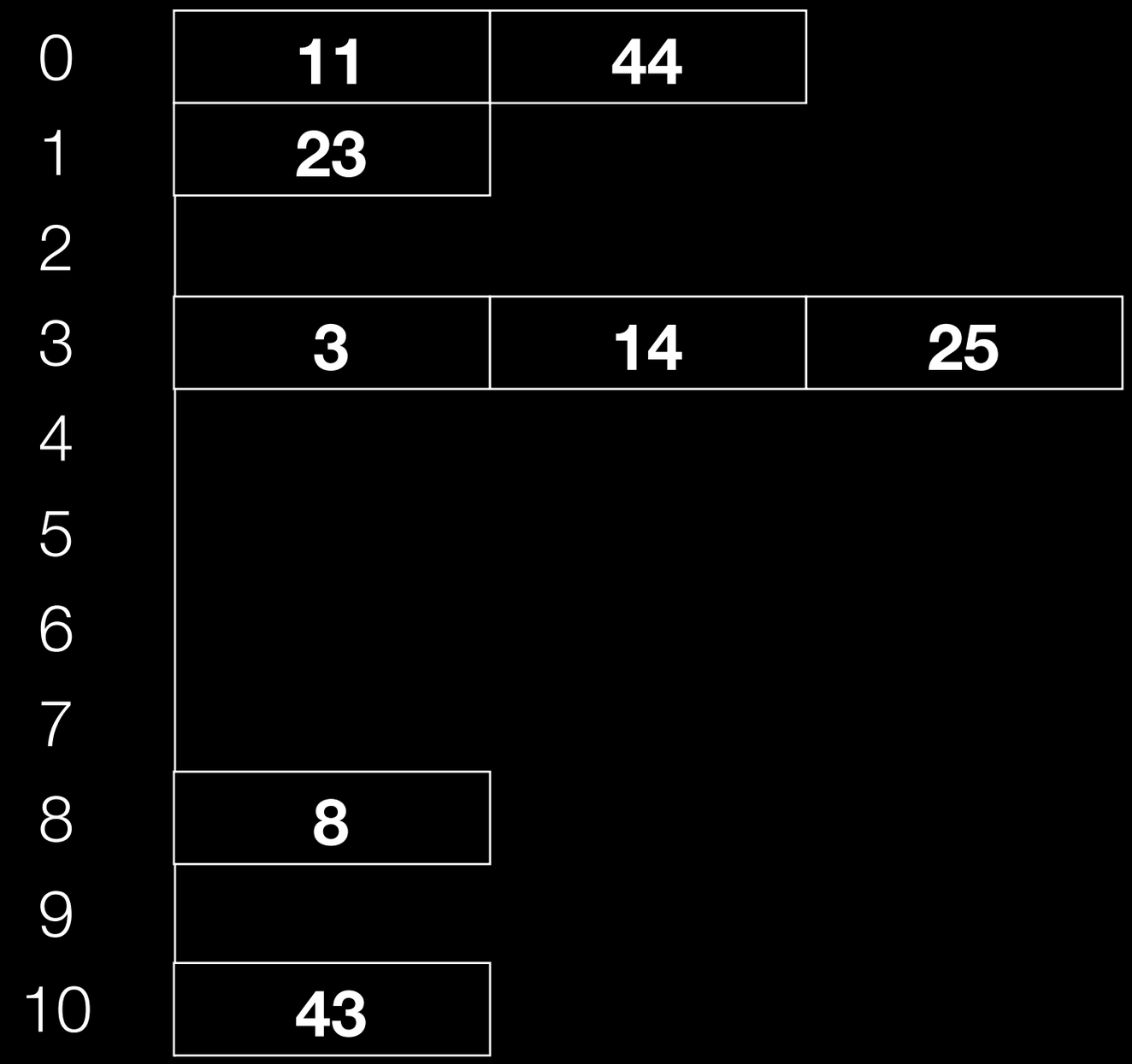
8 items / 11 buckets



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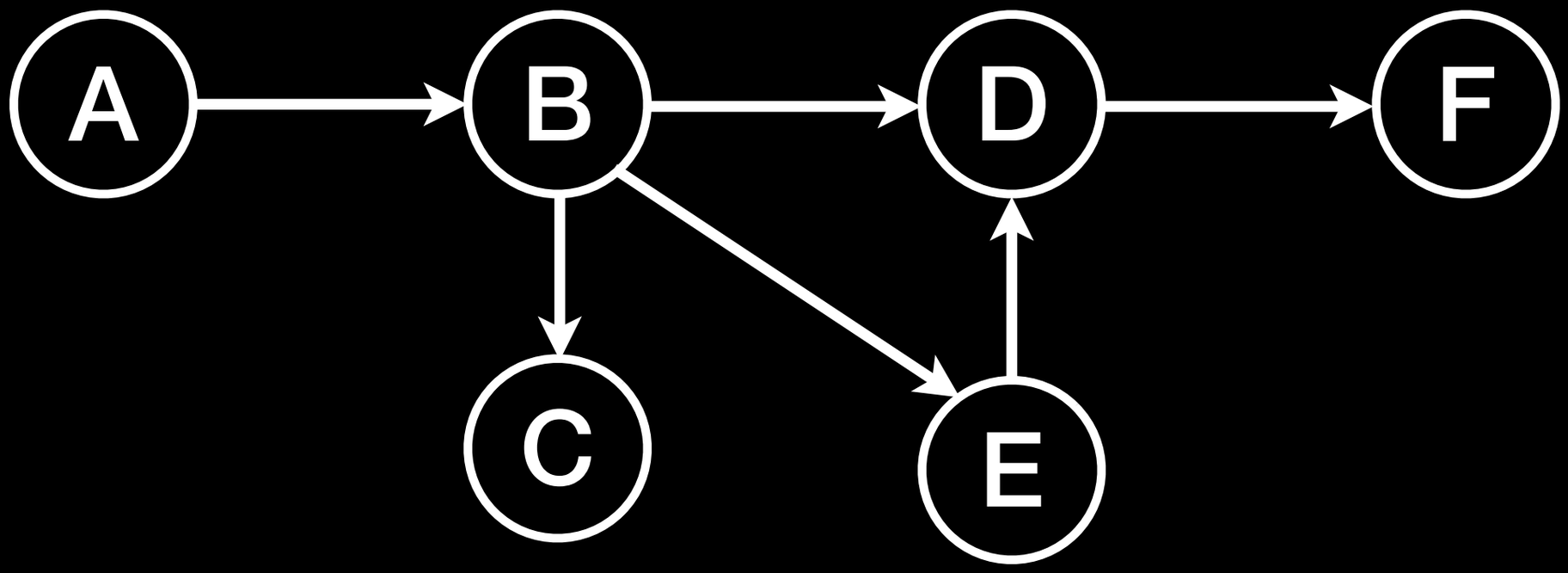
Does hash table performance increase or decrease as the number of buckets increases?

It should increase

Simulate **depth-first search** on this graph



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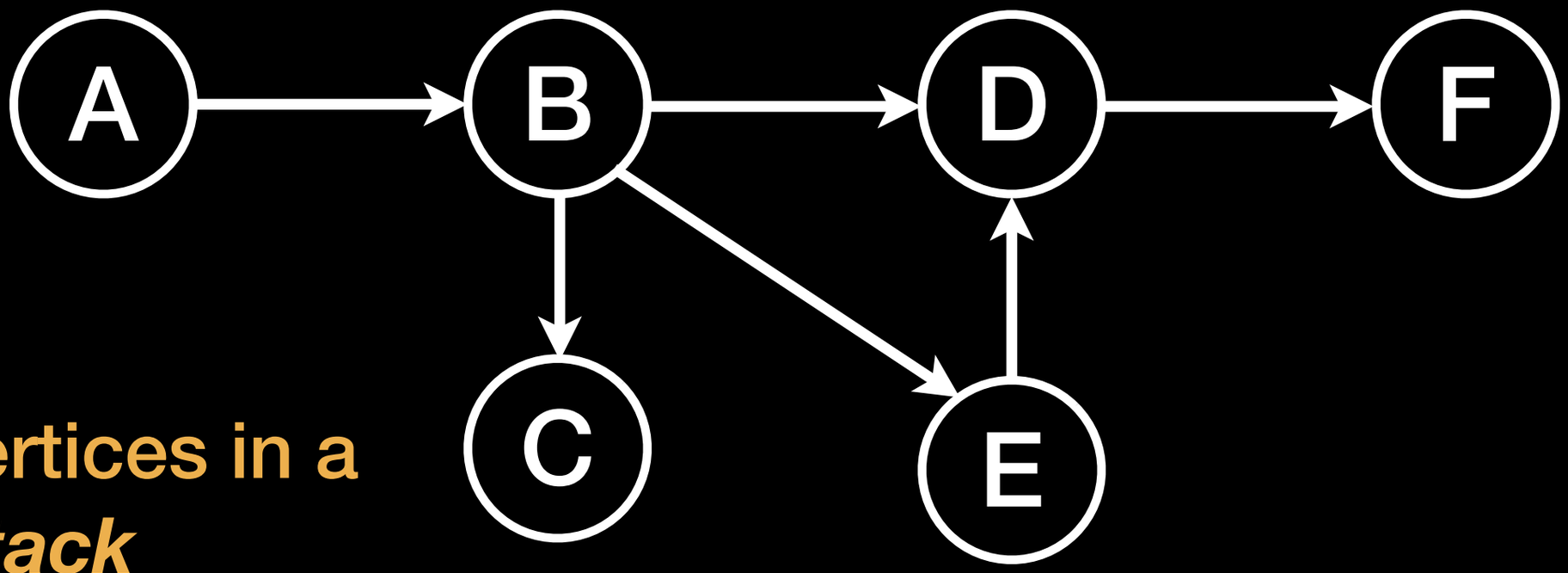

Store vertices in a *stack*
(last in, first out)

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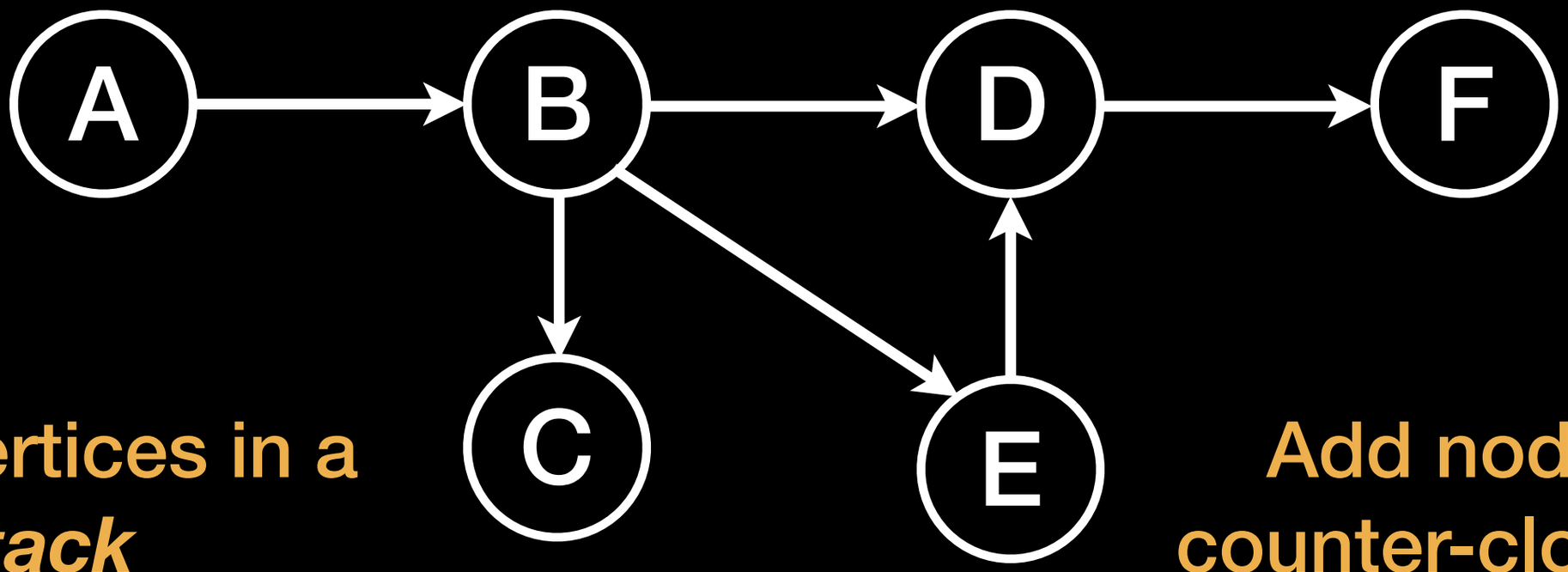

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Add nodes in counter-clockwise order

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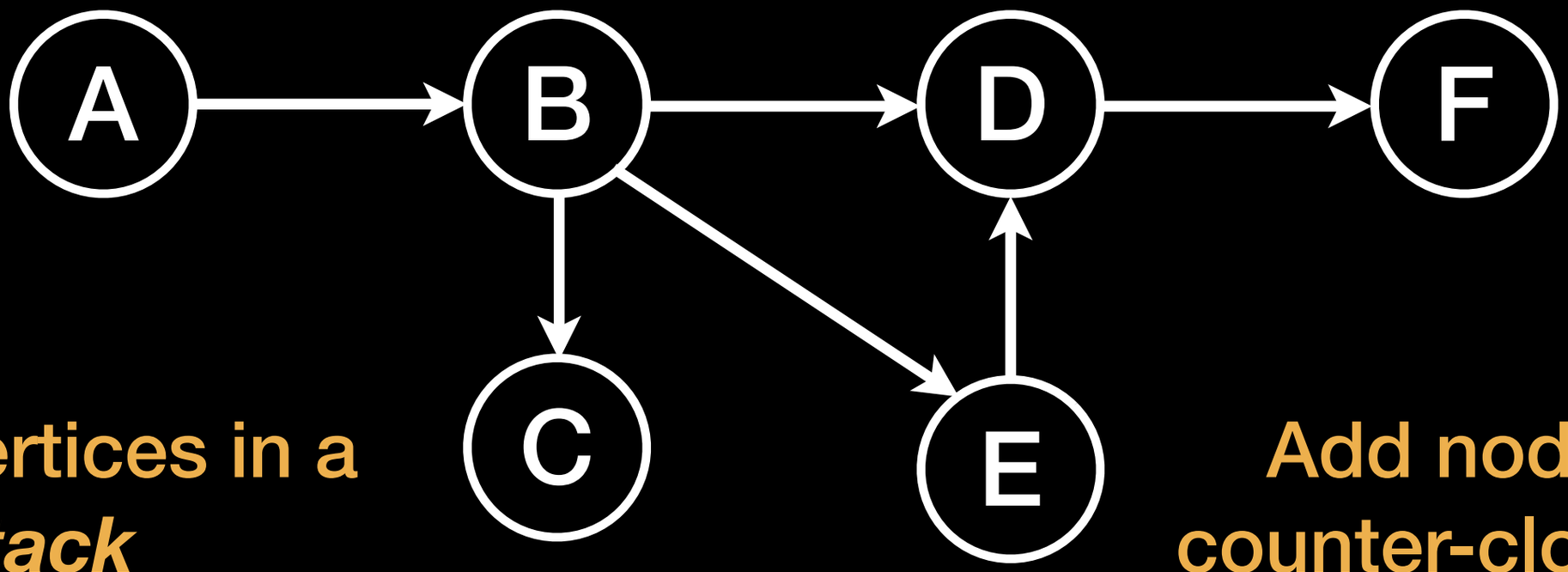

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Reachable:

Known:

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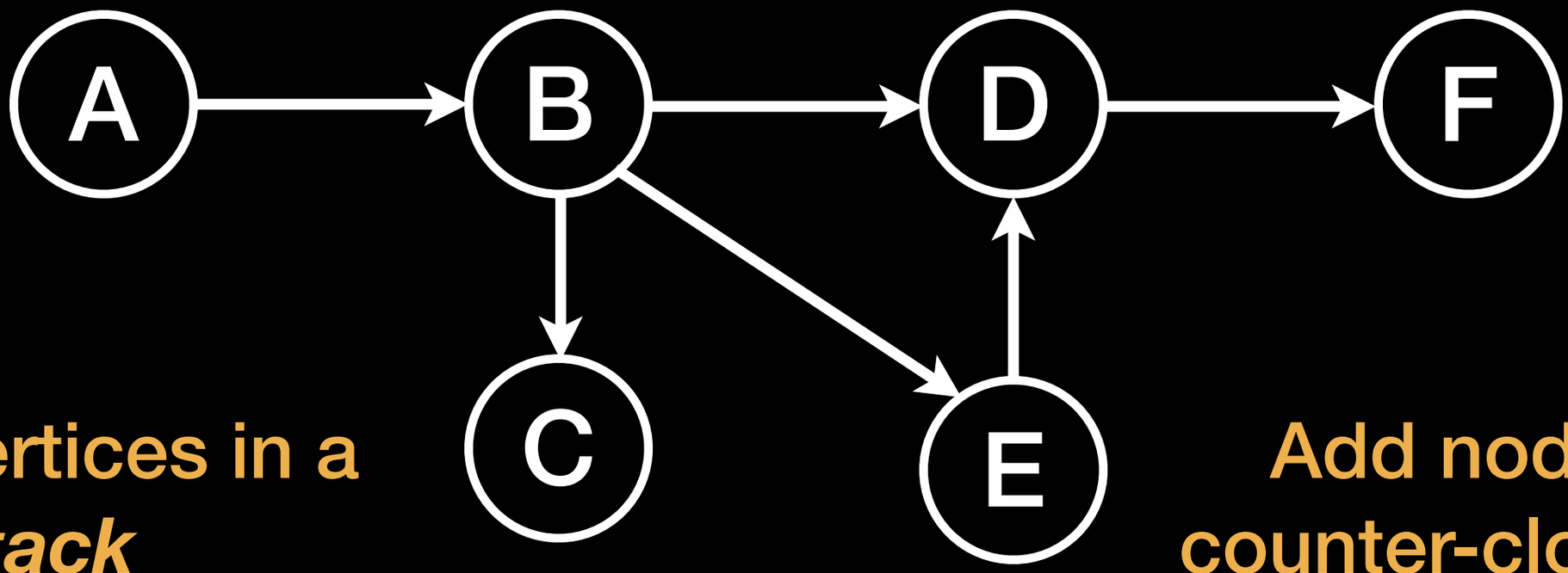

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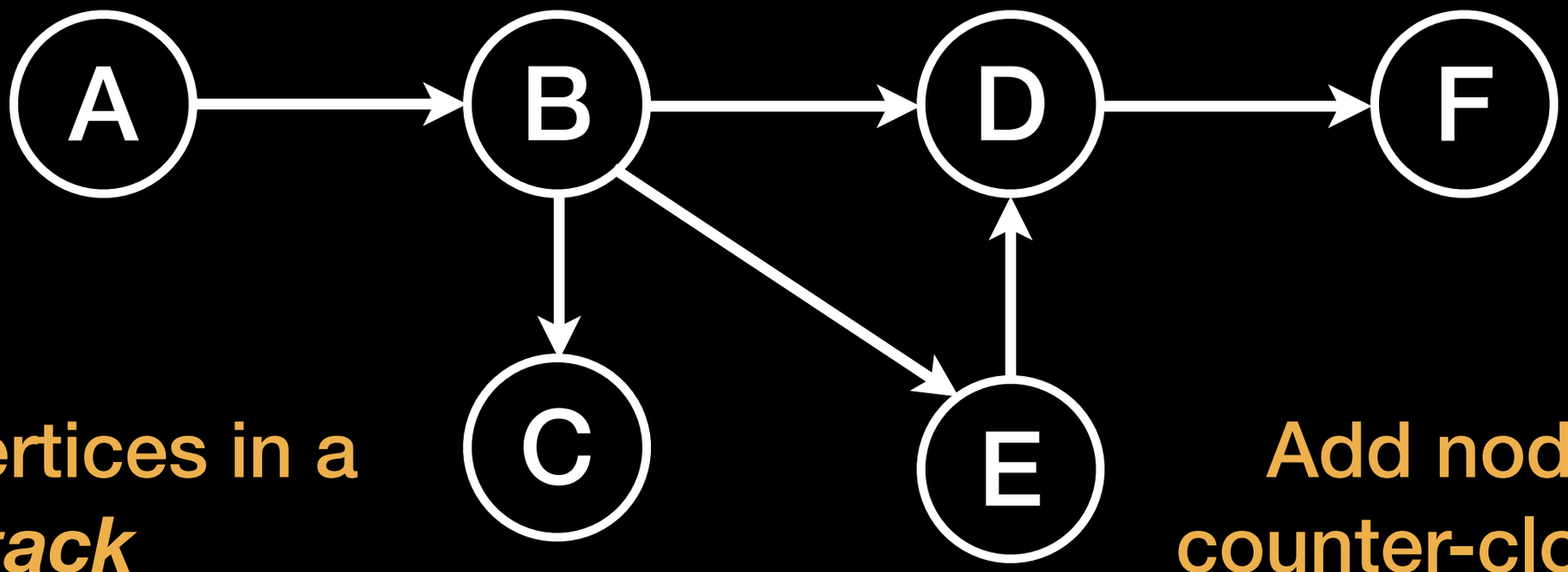

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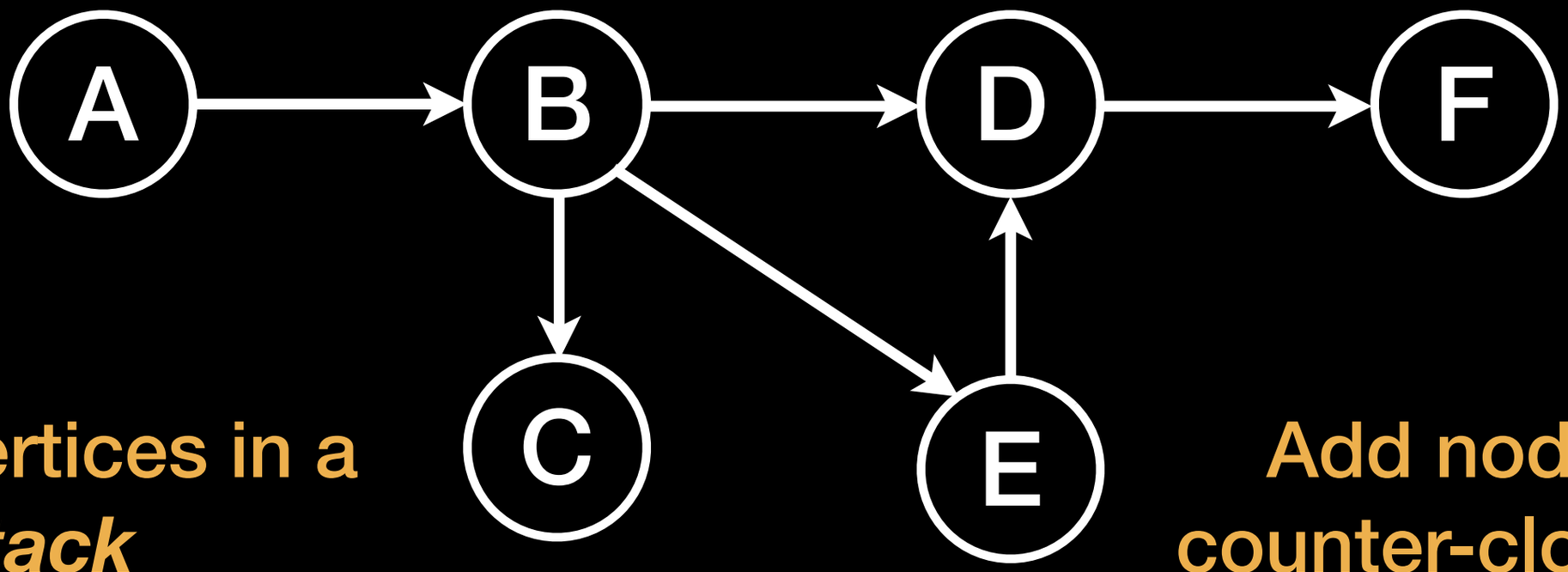

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Reachable: A

Known: B

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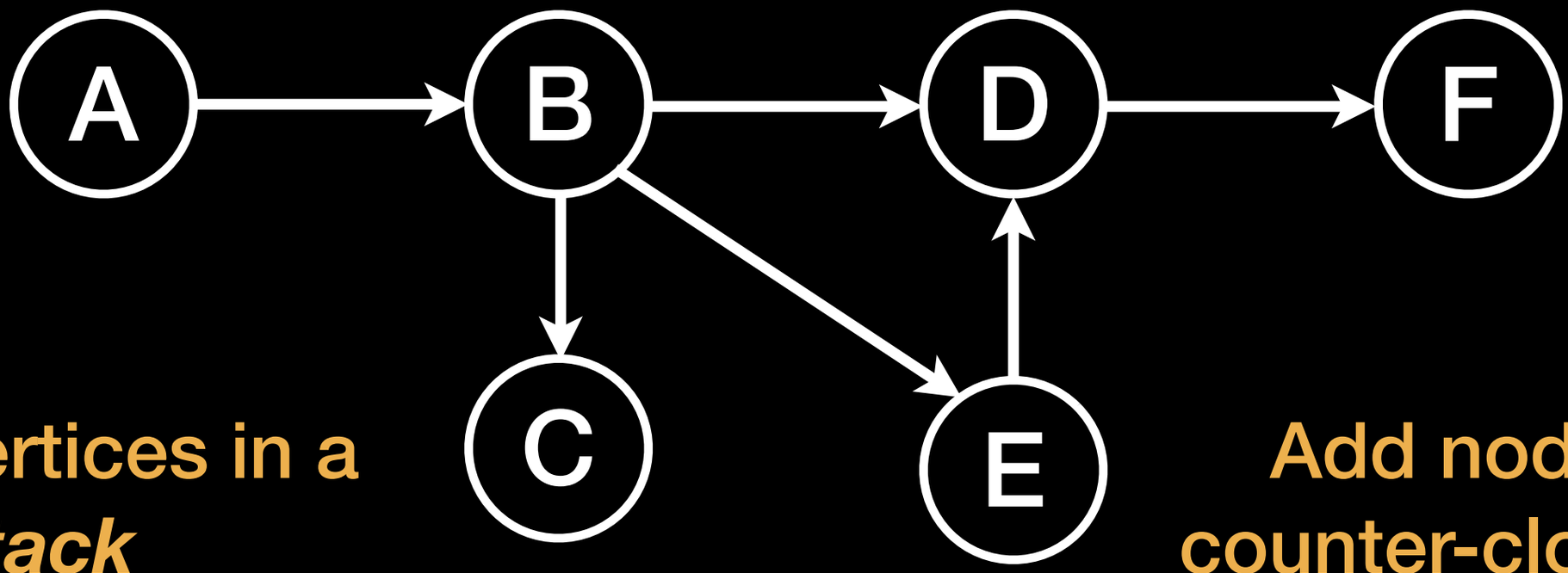

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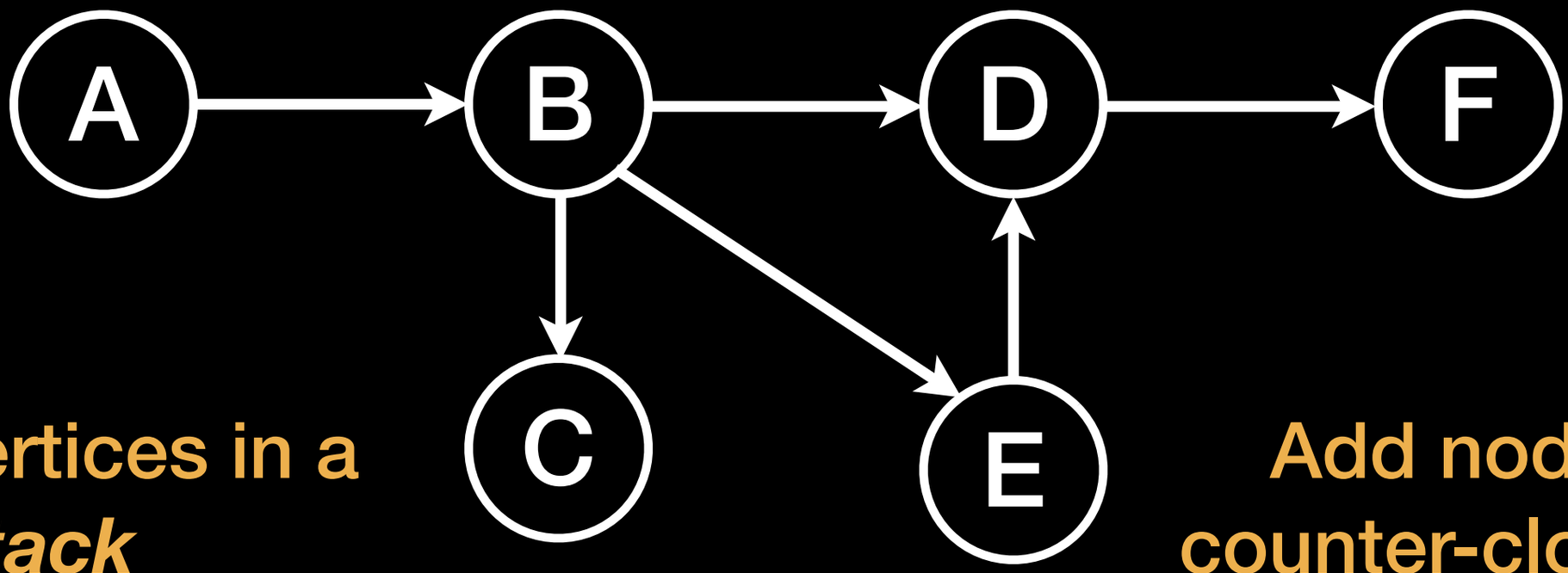

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Reachable: A B

Known: C

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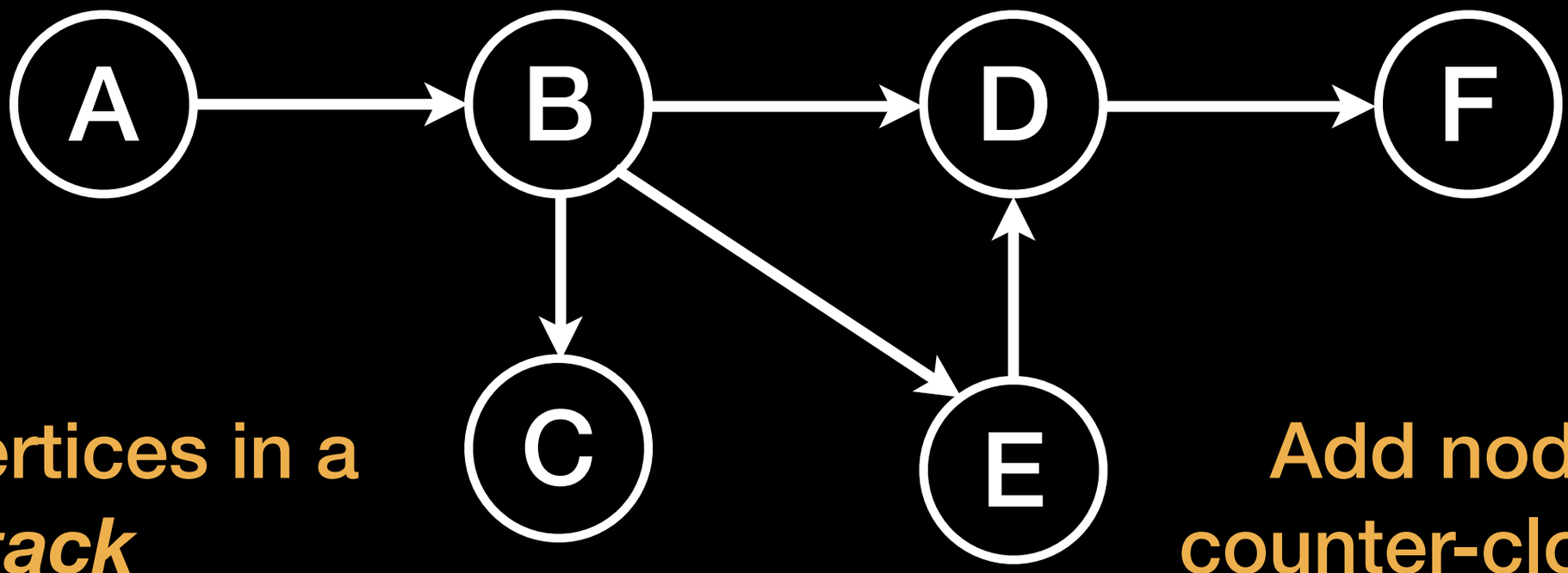

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Reachable: A B

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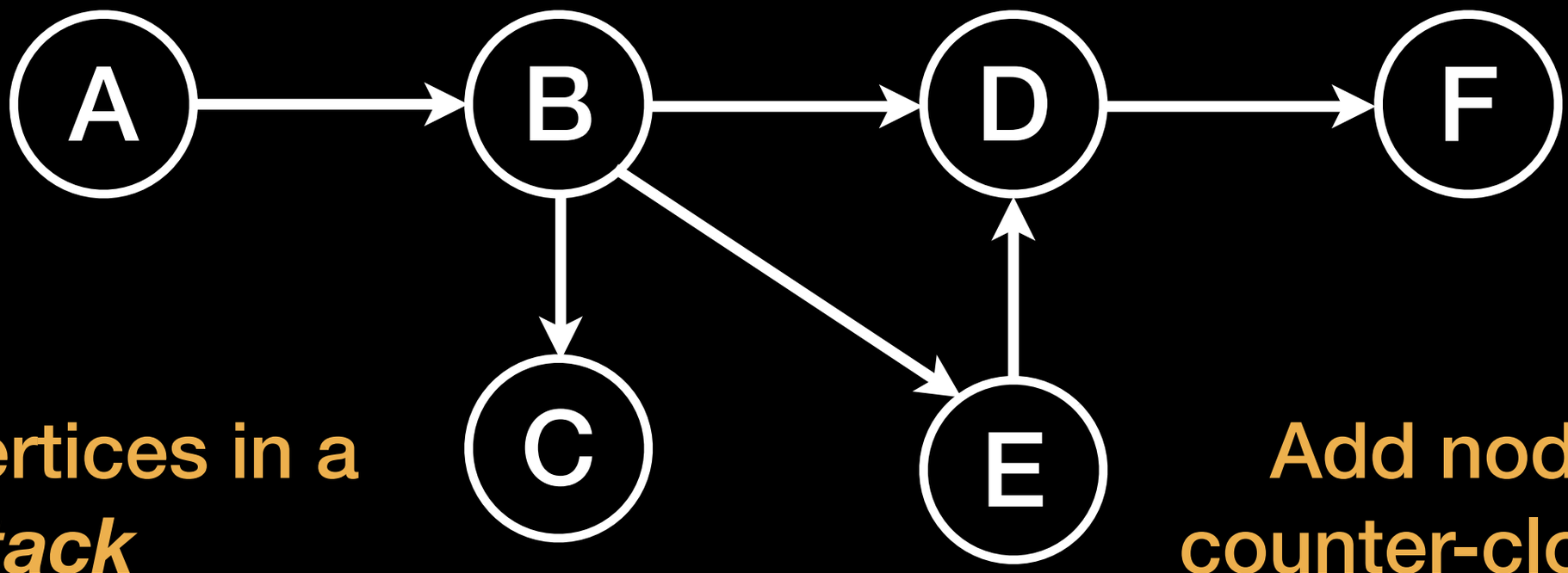

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Reachable: A B

Known: C E D

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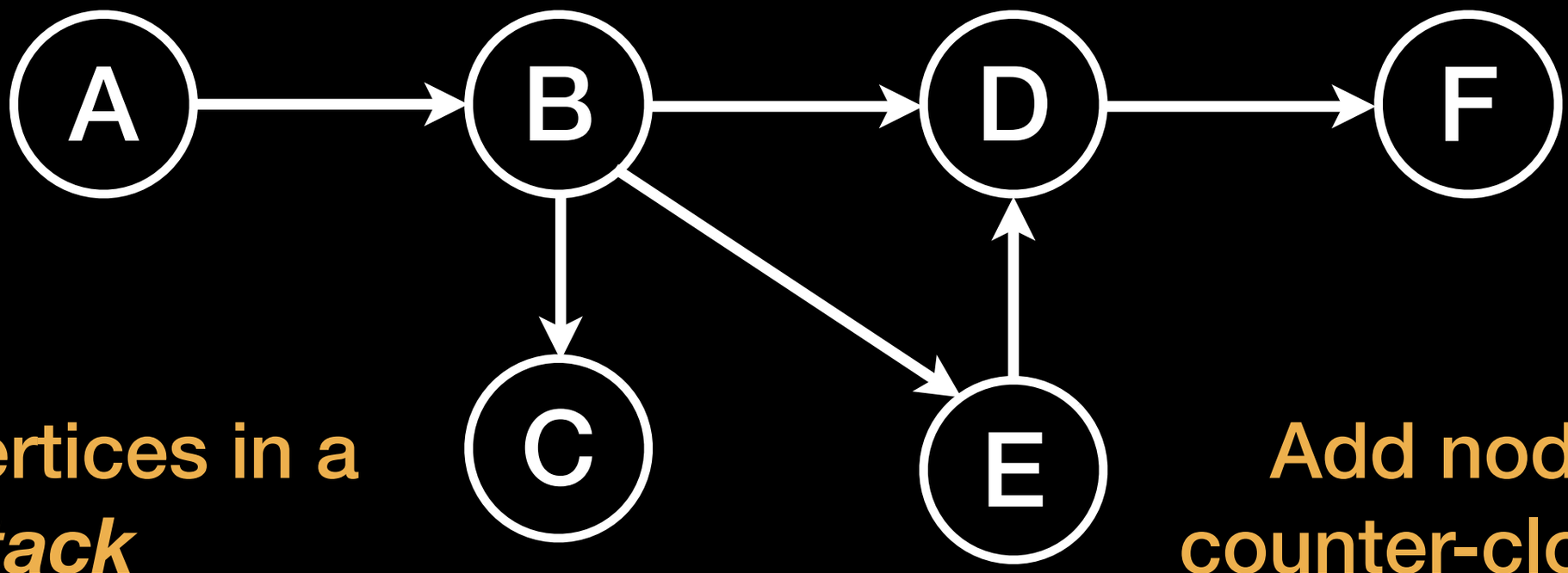

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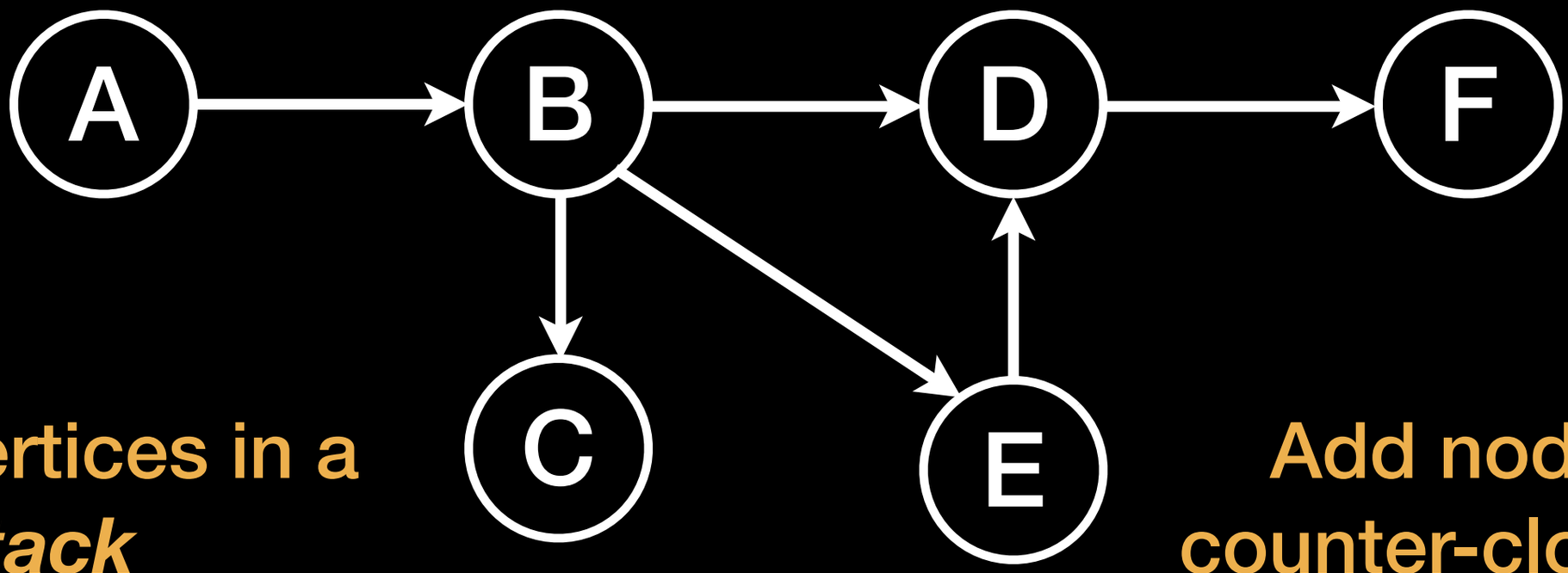

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Reachable: A B D

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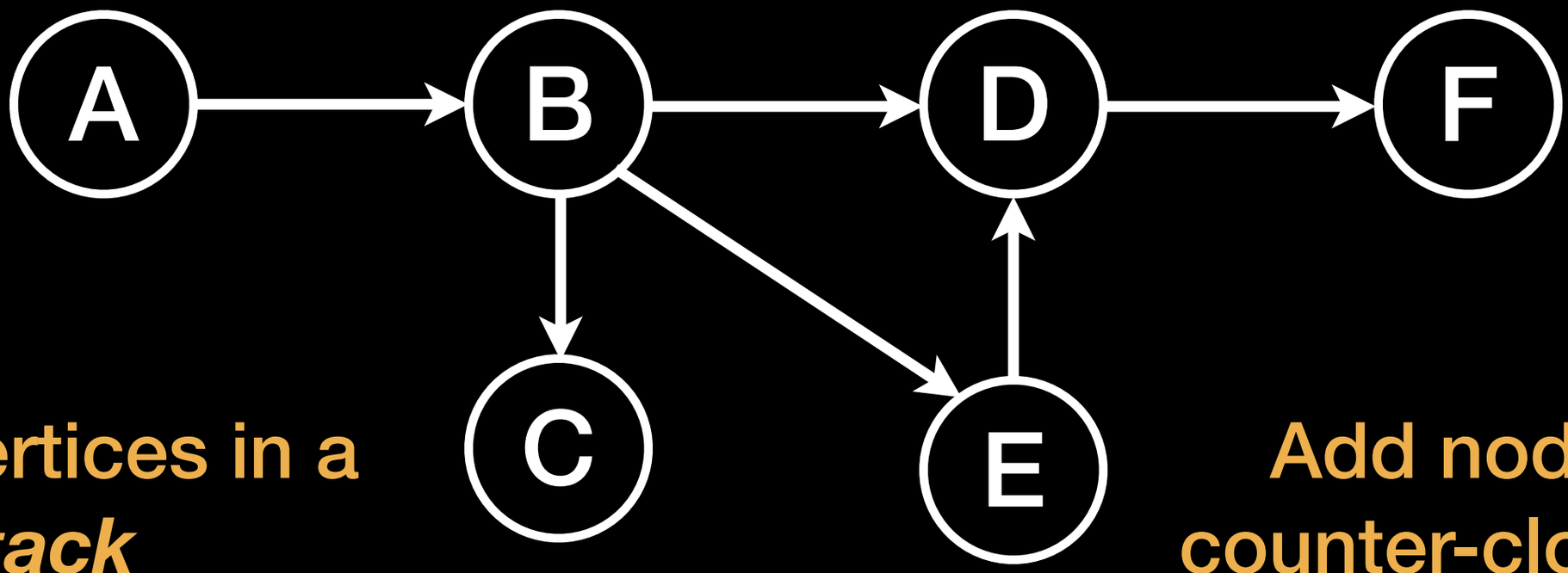

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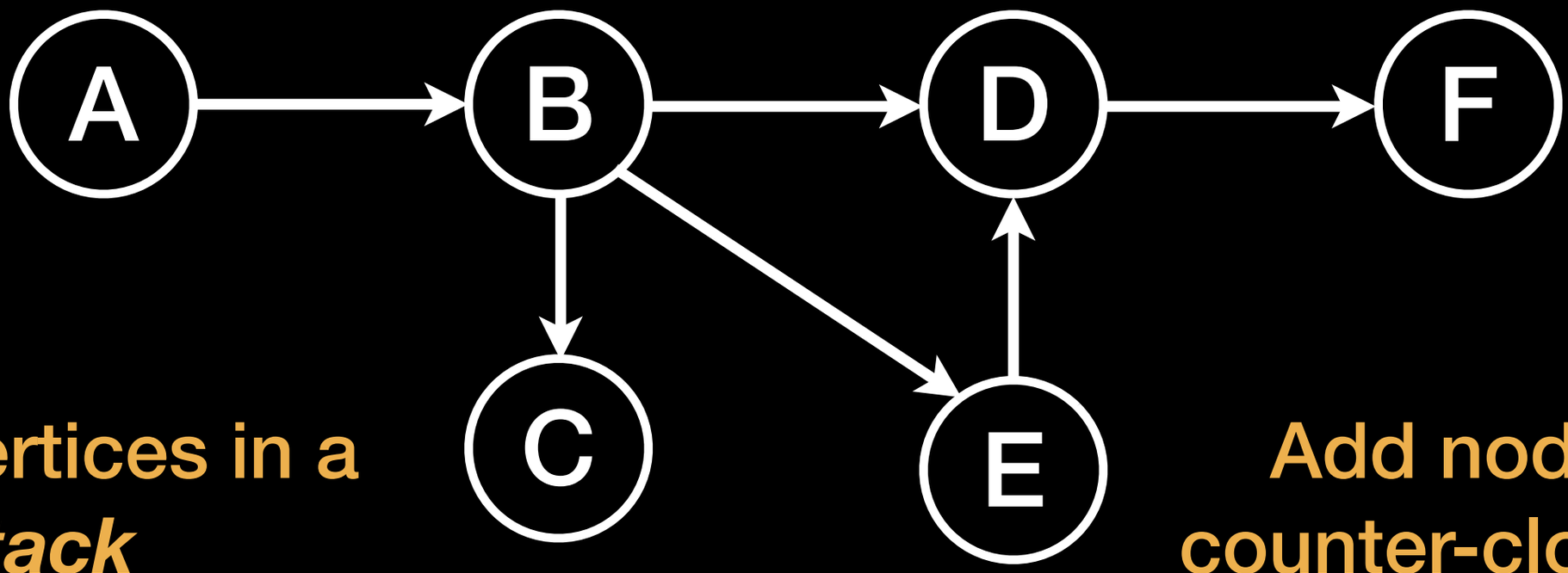


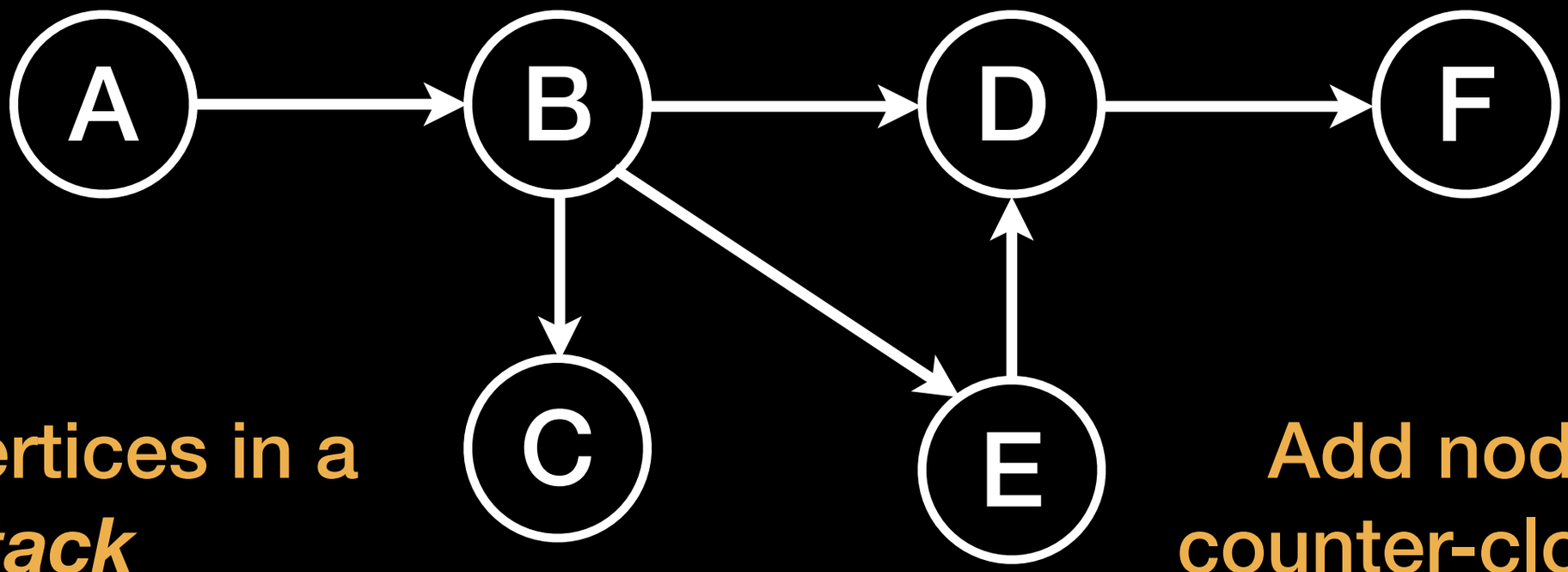
Store vertices in a *stack* (last in, first out)

Add nodes in counter-clockwise order

Reachable: A B D F E

Known: C

Simulate **depth-first search** on this graph



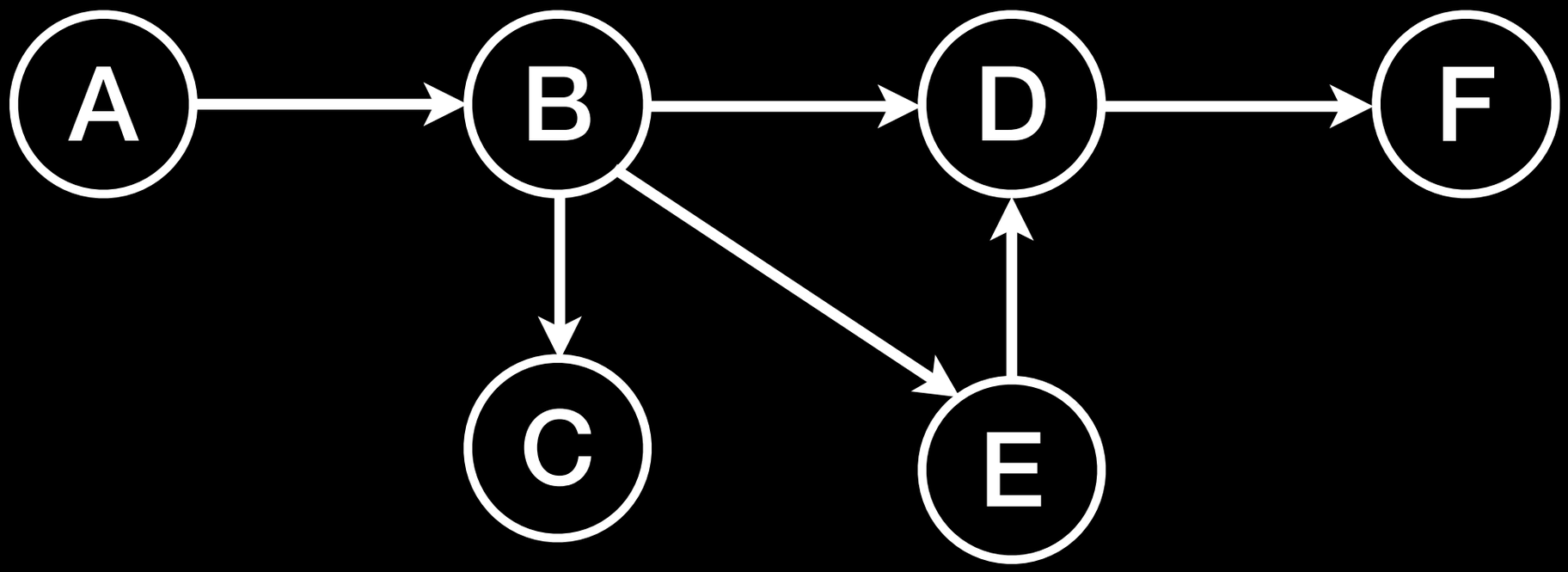
Store vertices in a *stack* (last in, first out)

Add nodes in counter-clockwise order

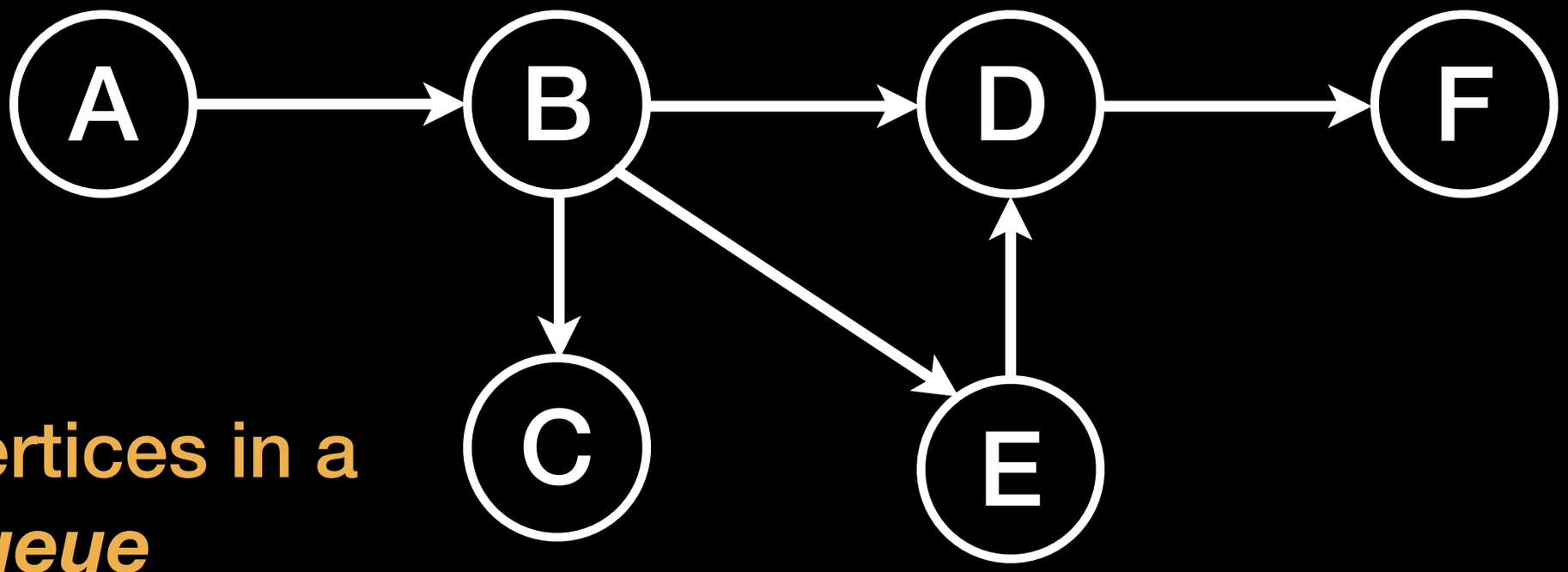
Reachable: A B D F E C

Known:

Simulate **breadth-first search** on this graph

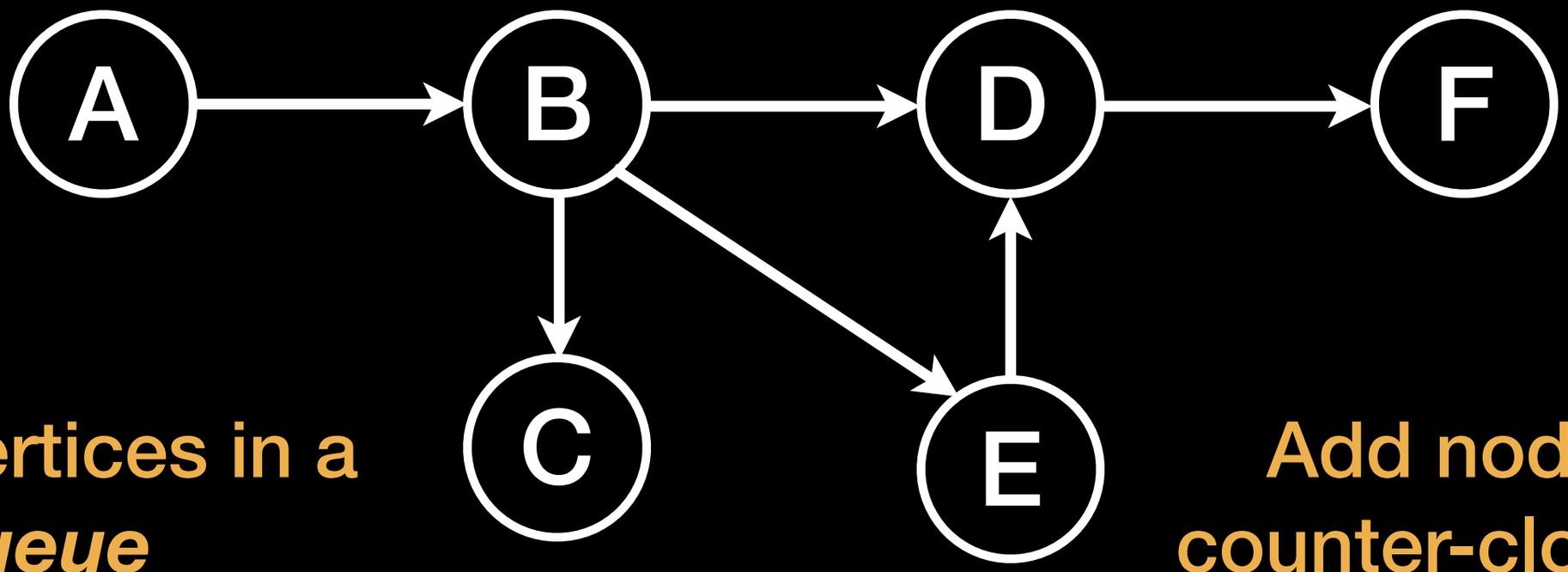


Simulate **breadth-first search** on this graph



Store vertices in a *queue*
(first in, first out)

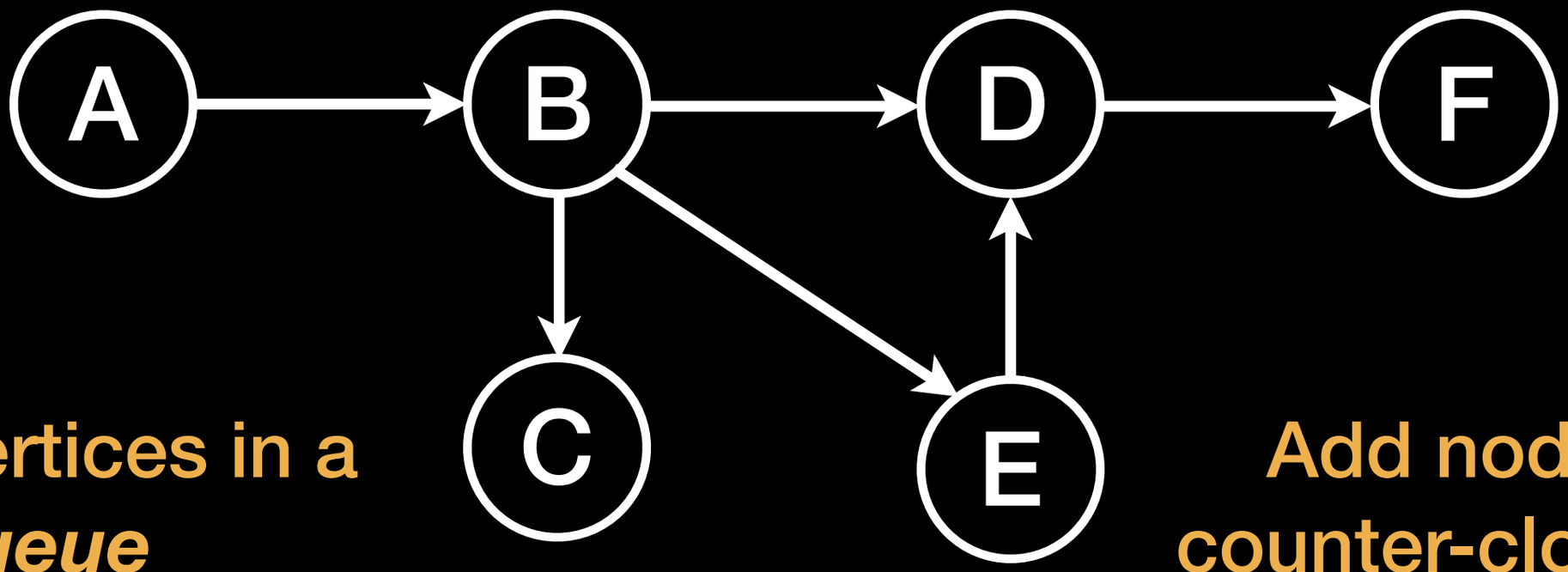
Simulate **breadth-first search** on this graph



Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Simulate **breadth-first search** on this graph



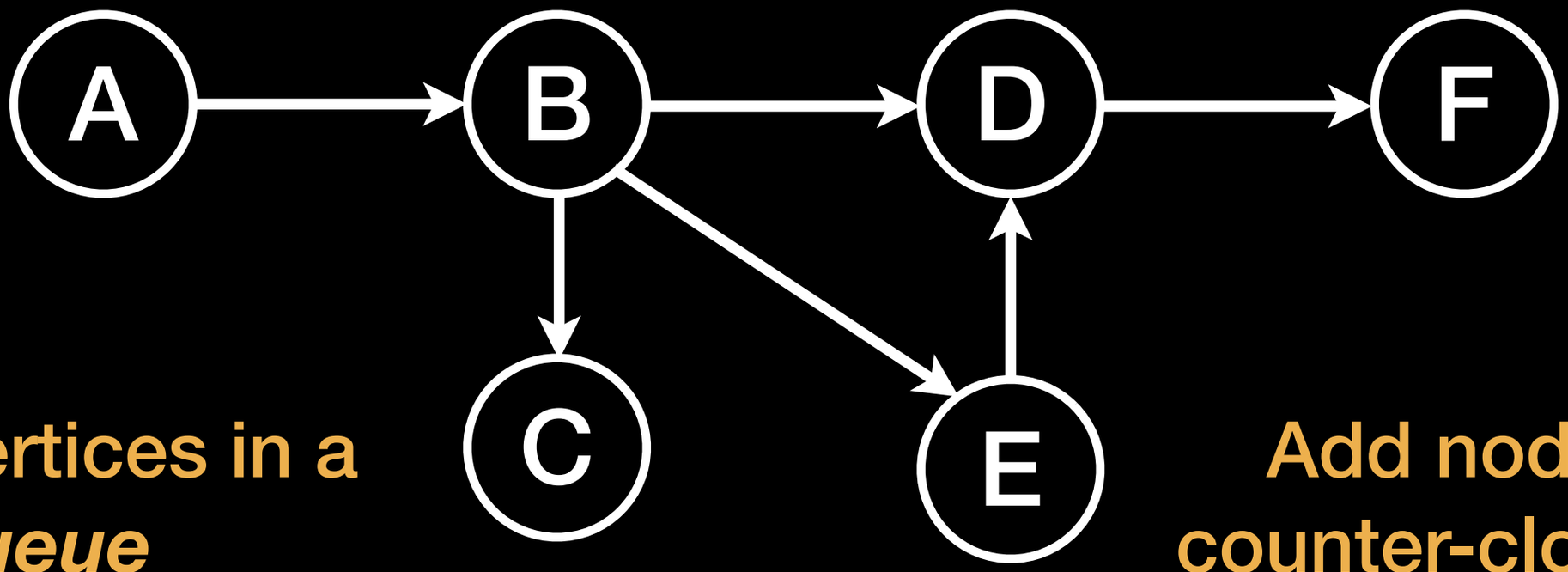
Store vertices in a ***queue*** (first in, first out)

Add nodes in counter-clockwise order

Reachable:

Known:

Simulate **breadth-first search** on this graph



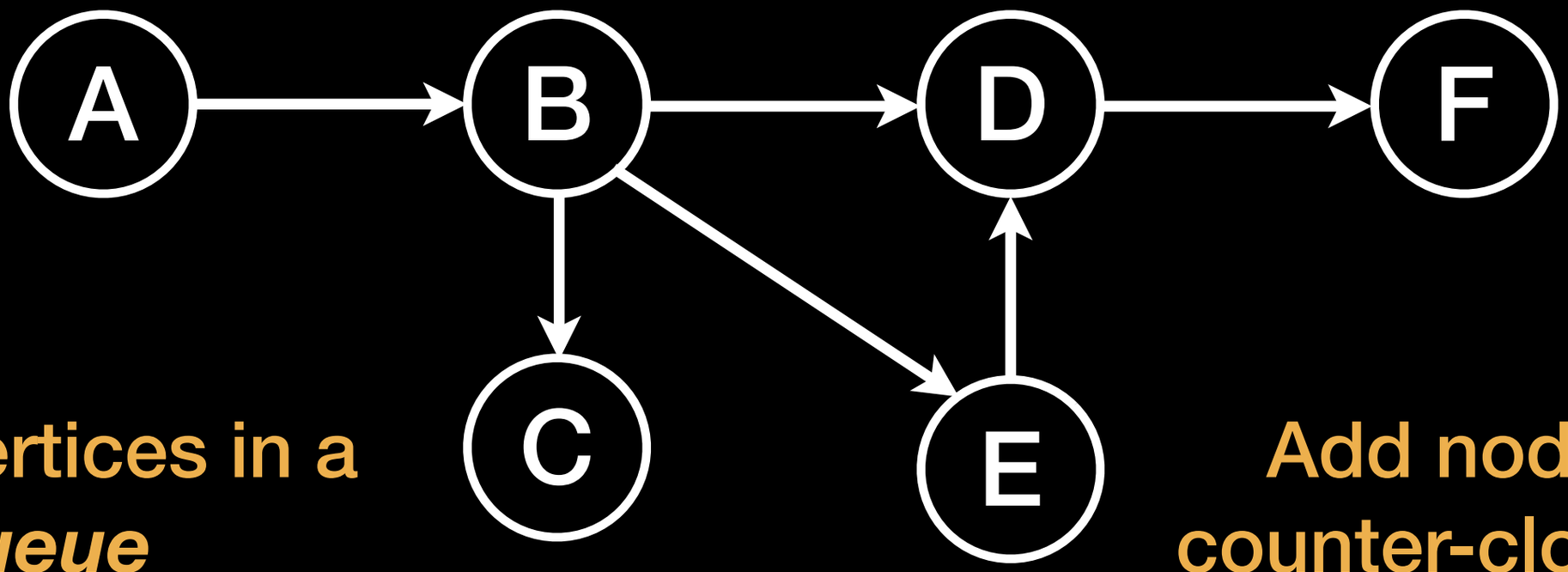
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable:

Known: A

Simulate **breadth-first search** on this graph



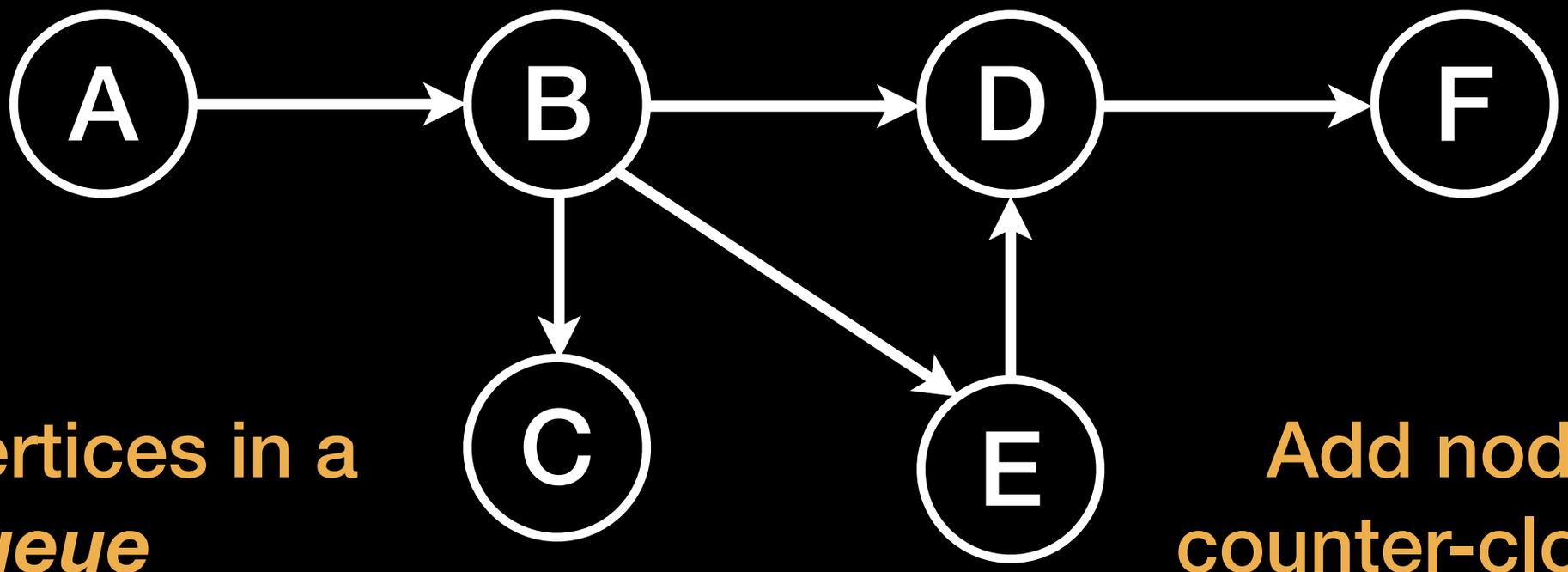
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A

Known:

Simulate **breadth-first search** on this graph



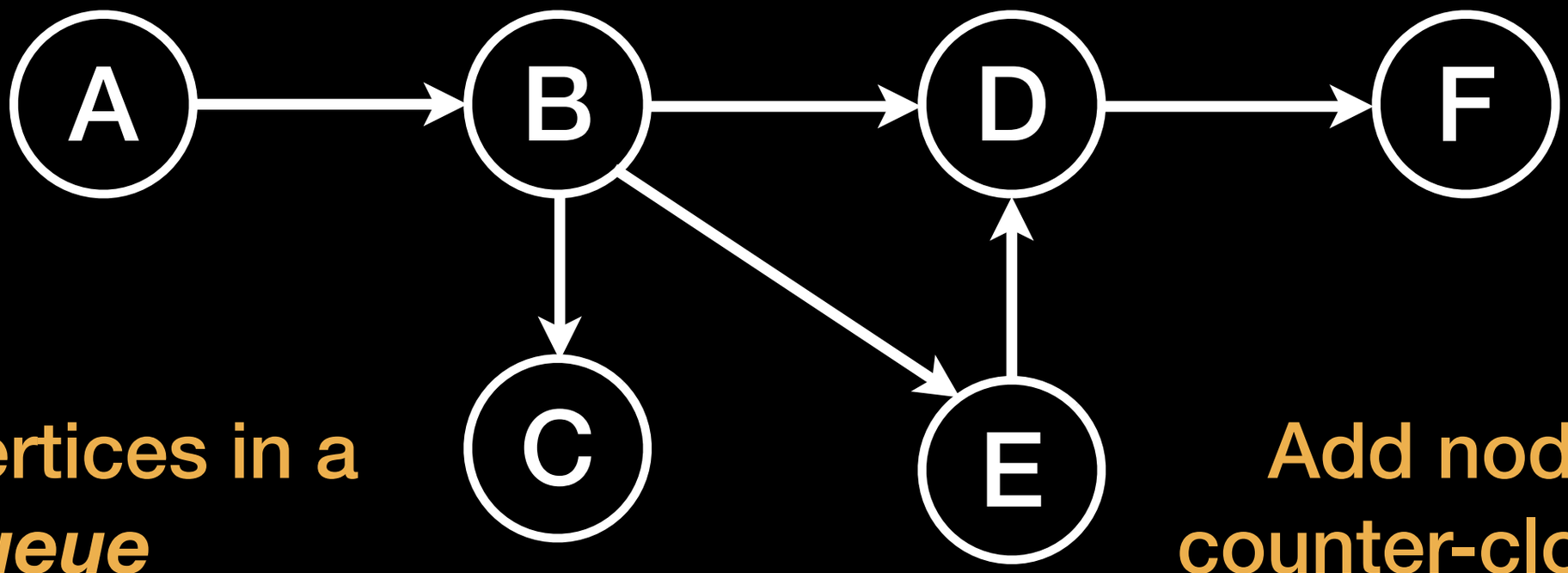
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A

Known: B

Simulate **breadth-first search** on this graph



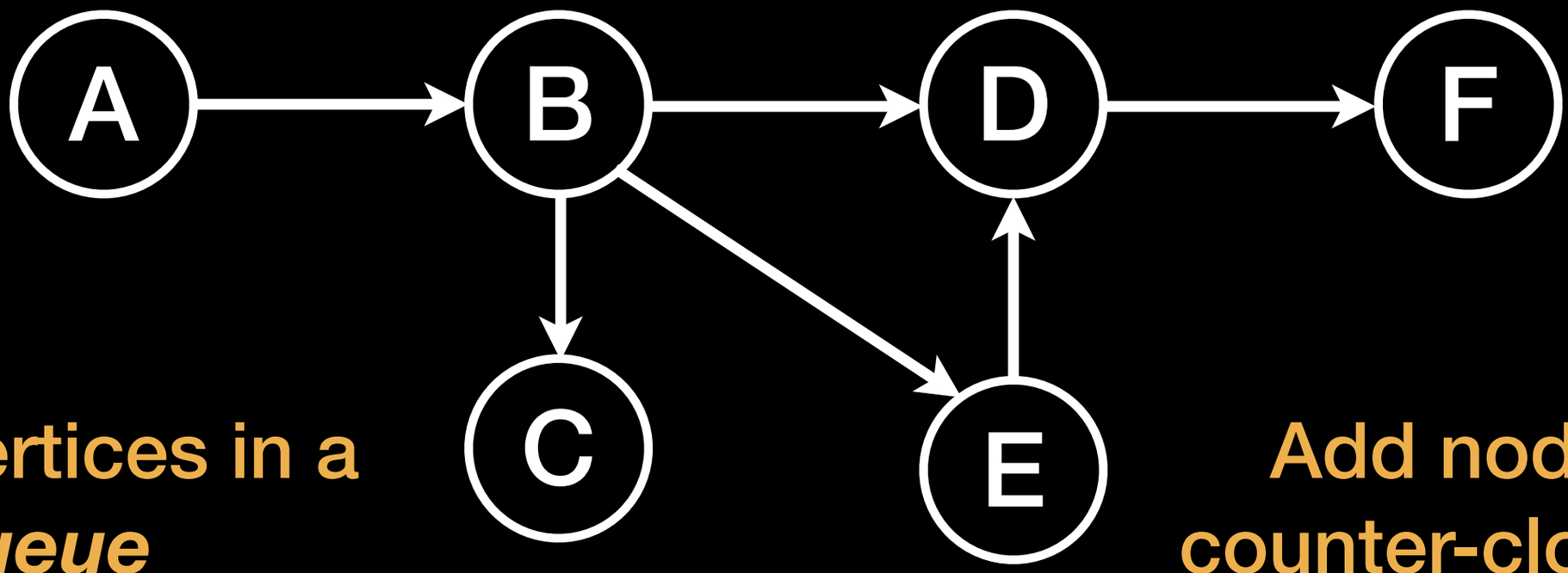
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B

Known:

Simulate **breadth-first search** on this graph



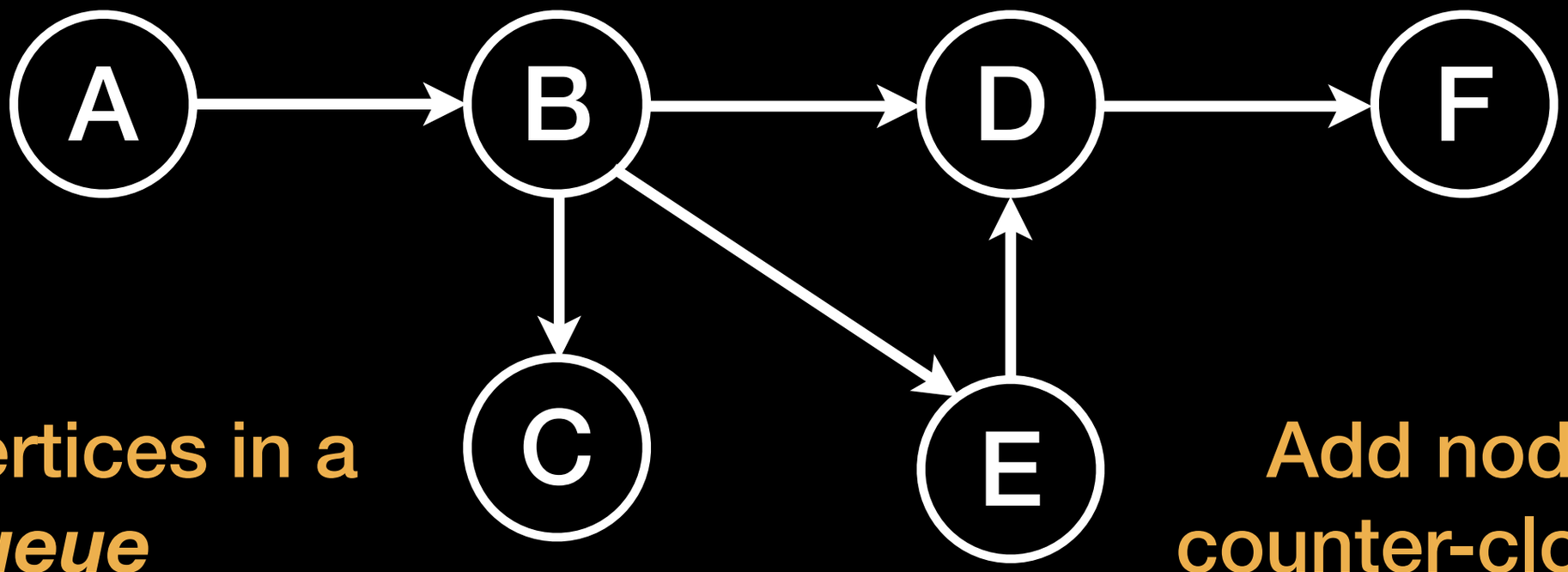
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B

Known: C

Simulate **breadth-first search** on this graph



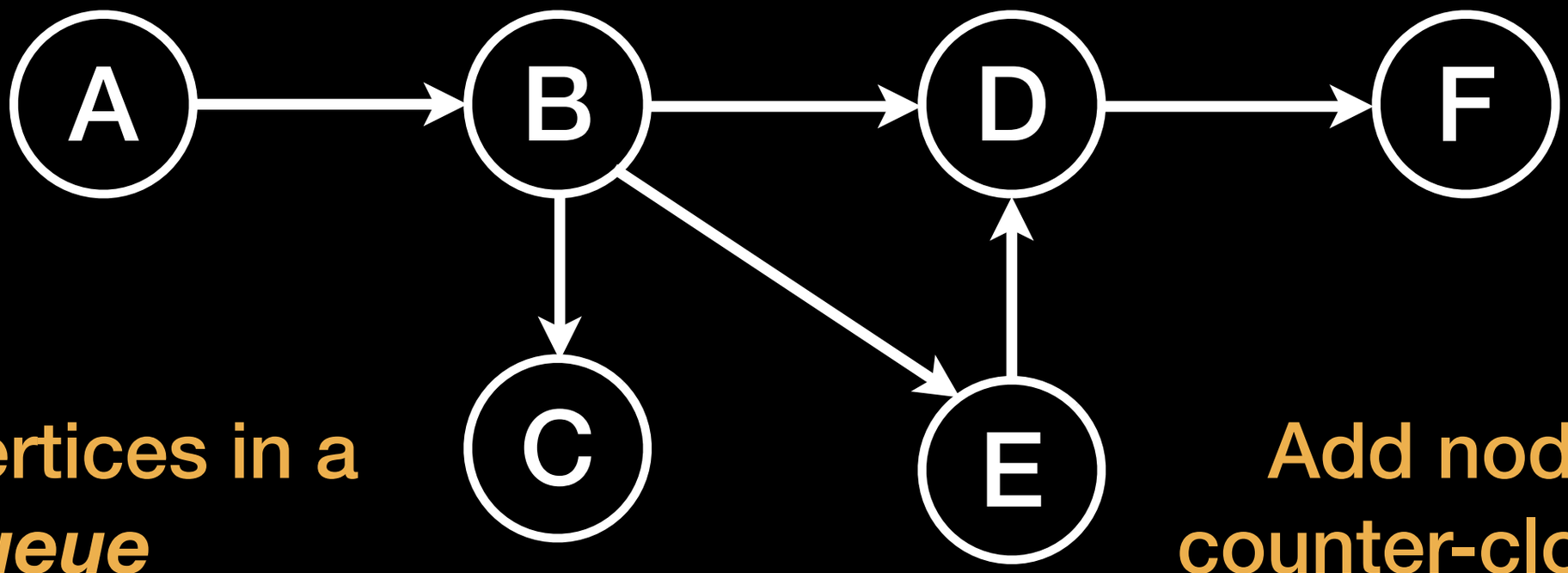
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B

Known: C E

Simulate **breadth-first search** on this graph



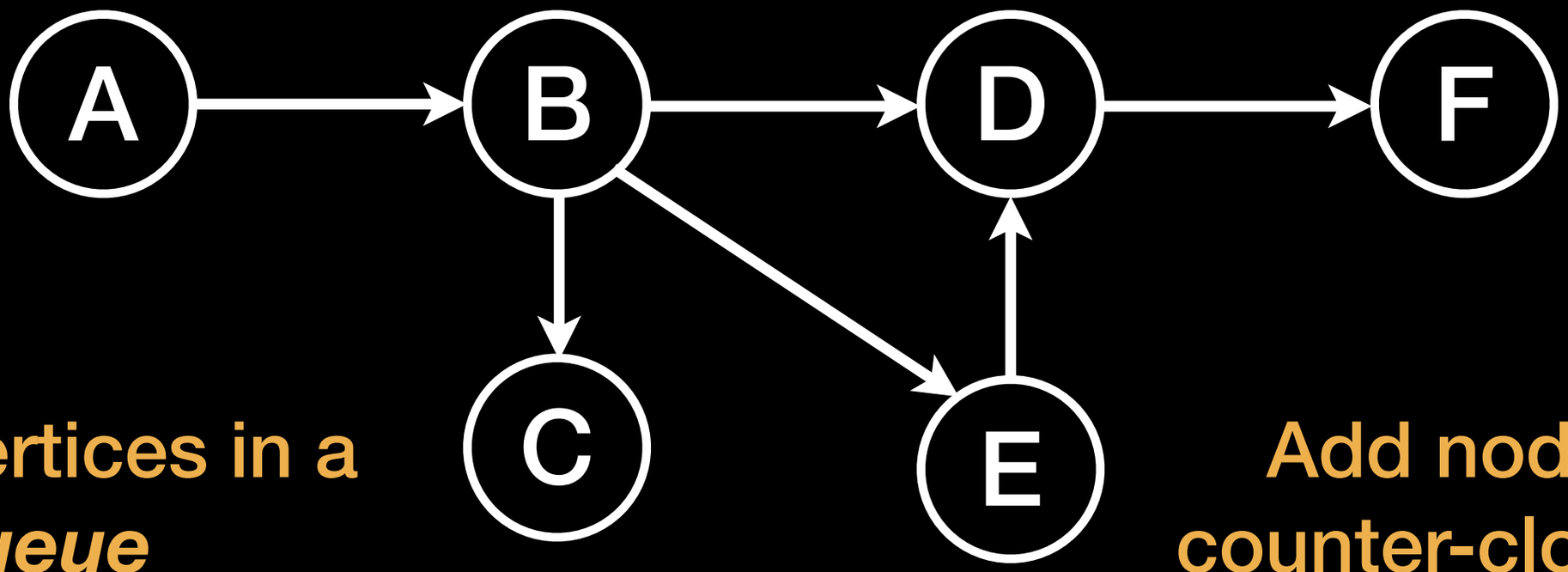
Store vertices in a ***queue*** (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B

Known: C E D

Simulate **breadth-first search** on this graph



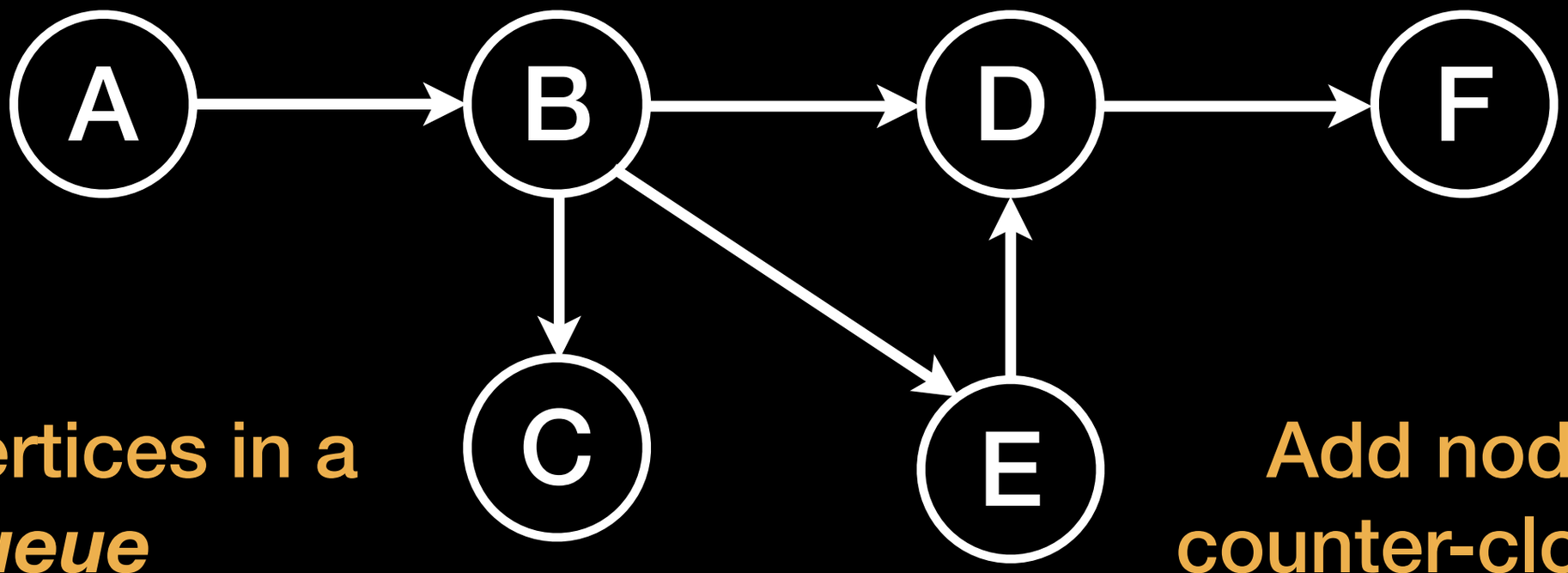
Store vertices in a ***queue*** (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C

Known: E D

Simulate **breadth-first search** on this graph



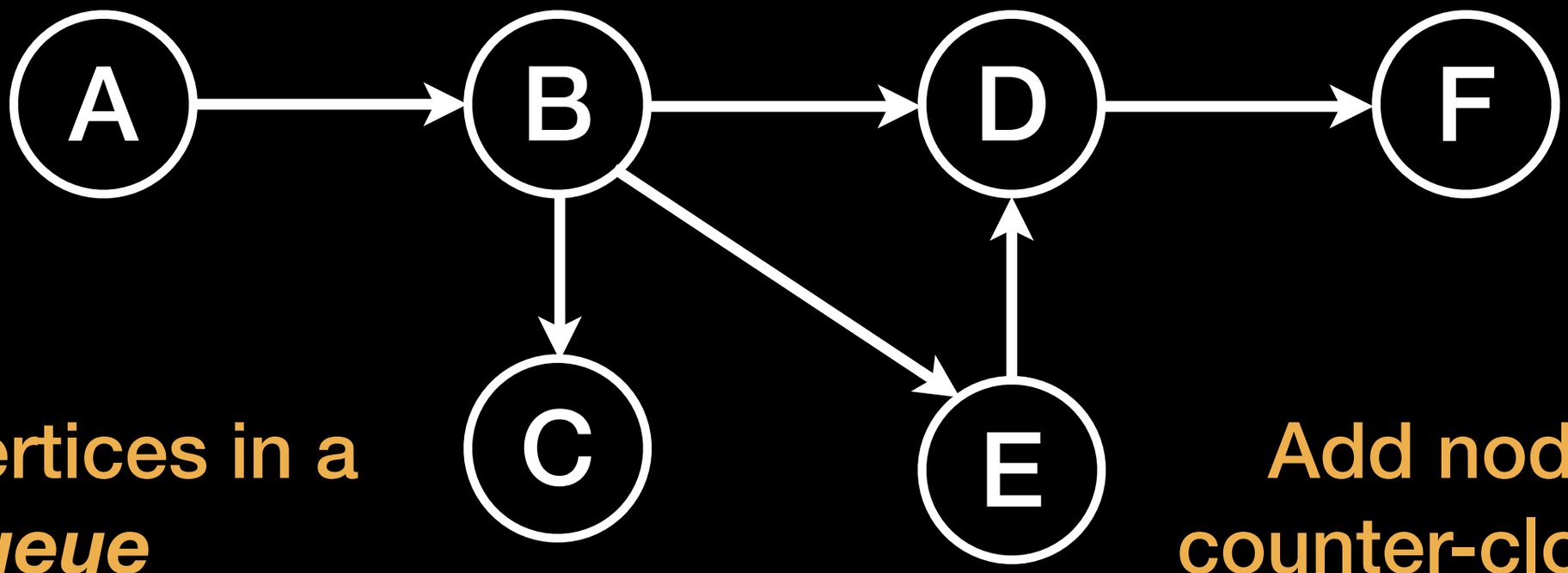
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E

Known: D

Simulate **breadth-first search** on this graph



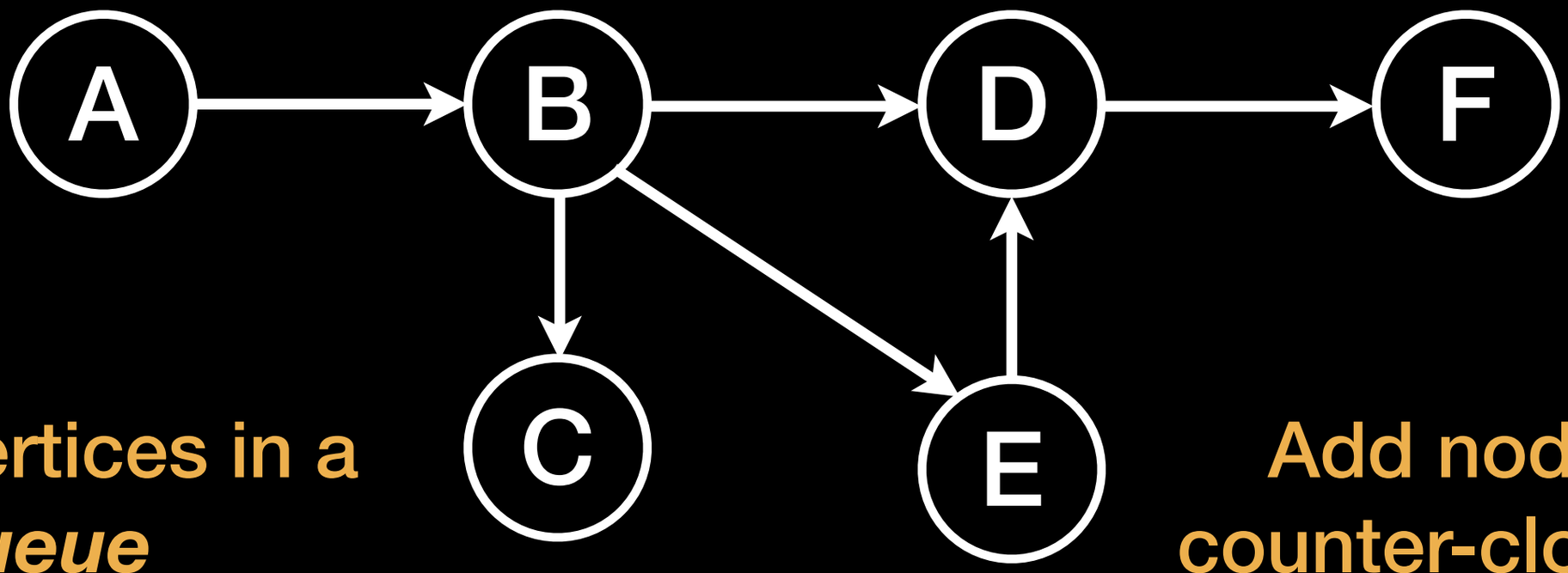
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E

Known: D D

Simulate **breadth-first search** on this graph



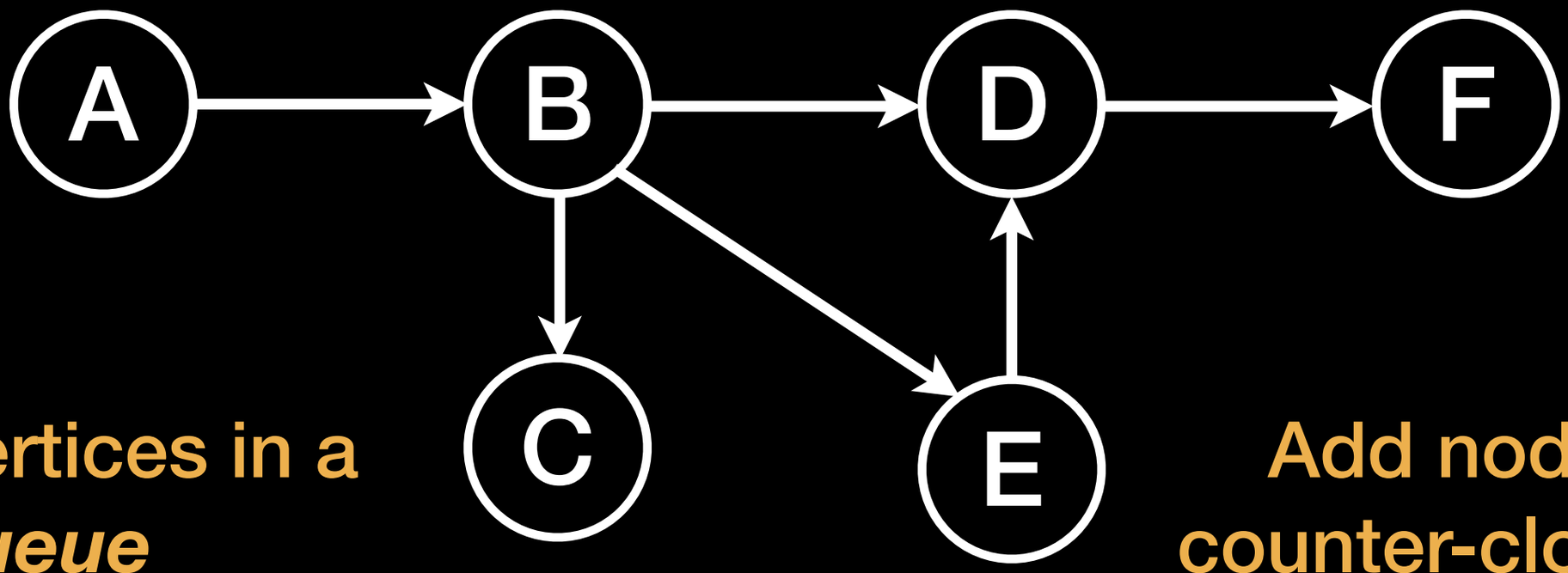
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E D

Known: D

Simulate **breadth-first search** on this graph



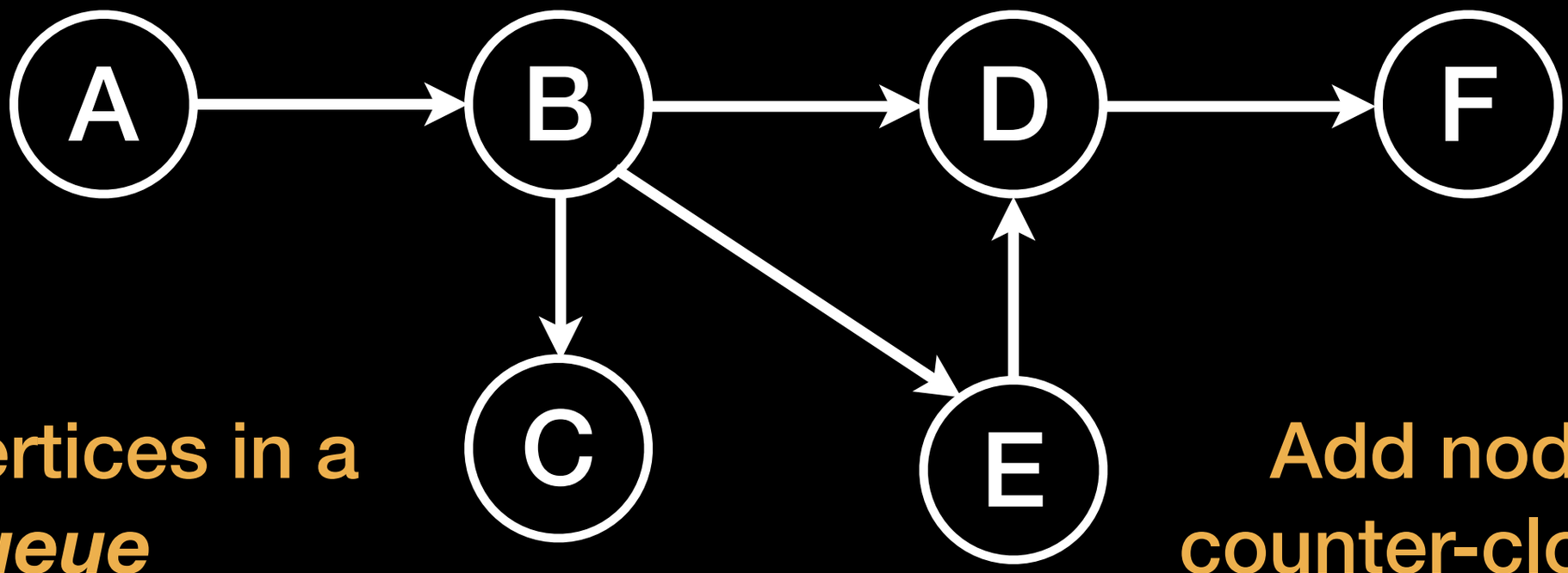
Store vertices in a ***queue*** (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E D

Known: D F

Simulate **breadth-first search** on this graph



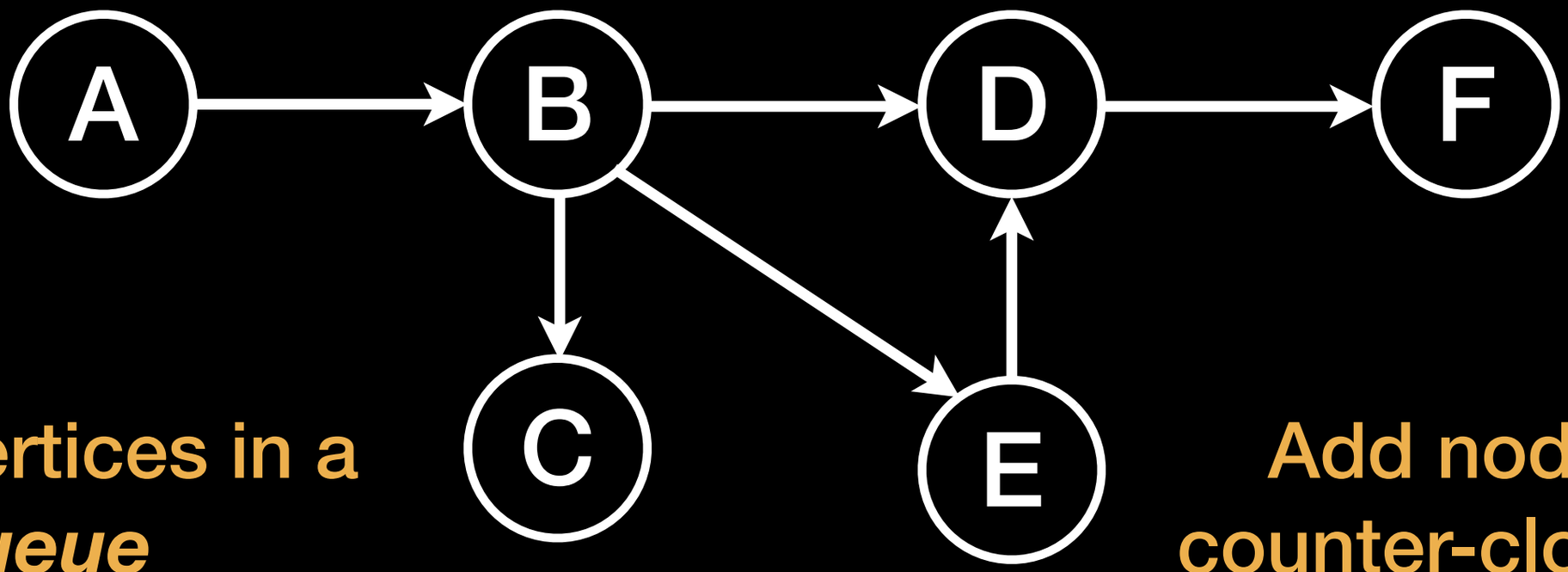
Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E D F

Known:

Simulate **breadth-first search** on this graph



Store vertices in a *queue* (first in, first out)

Add nodes in counter-clockwise order

Reachable: A B C E D F

Known: