

Name: _____

Today's Date: _____

Today's Goals

- Motivate the “ChunkyString” data structure
- Prepare to write (good) tests
- Describe the Heap data structure

Today's Question(s)

Why can't you write tests that depend on undefined behavior?

Lingering Questions

Linear data structures

Iterators and undefined behavior

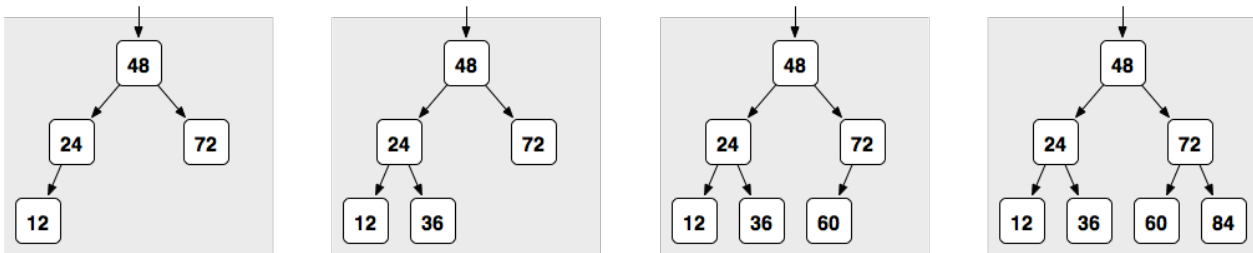
What is wrong with the following snippet?

```
vector<int> values;  
values.push_back(70);  
vector<int>::iterator i = values.begin();  
cout << *i << endl;  
values.pop_back();  
cout << *i << endl;
```

Heaps

Complete Tree

Every level of the tree is completely full *except* the bottom level, which may be partially full and fills from left to right.



Breadth-first encoding

You can store a complete tree in an array!

| | | | | | | |
|----|----|----|----|----|----|----|
| 48 | 24 | 72 | 12 | 36 | 60 | 84 |
|----|----|----|----|----|----|----|

Given a node at index i ,

- ▶ What's the position of i 's left child?
- ▶ What's the position of i 's right child?
- ▶ What's the position of i 's parent?

For a complete tree with n nodes, what is the index of the first leaf?

Heap

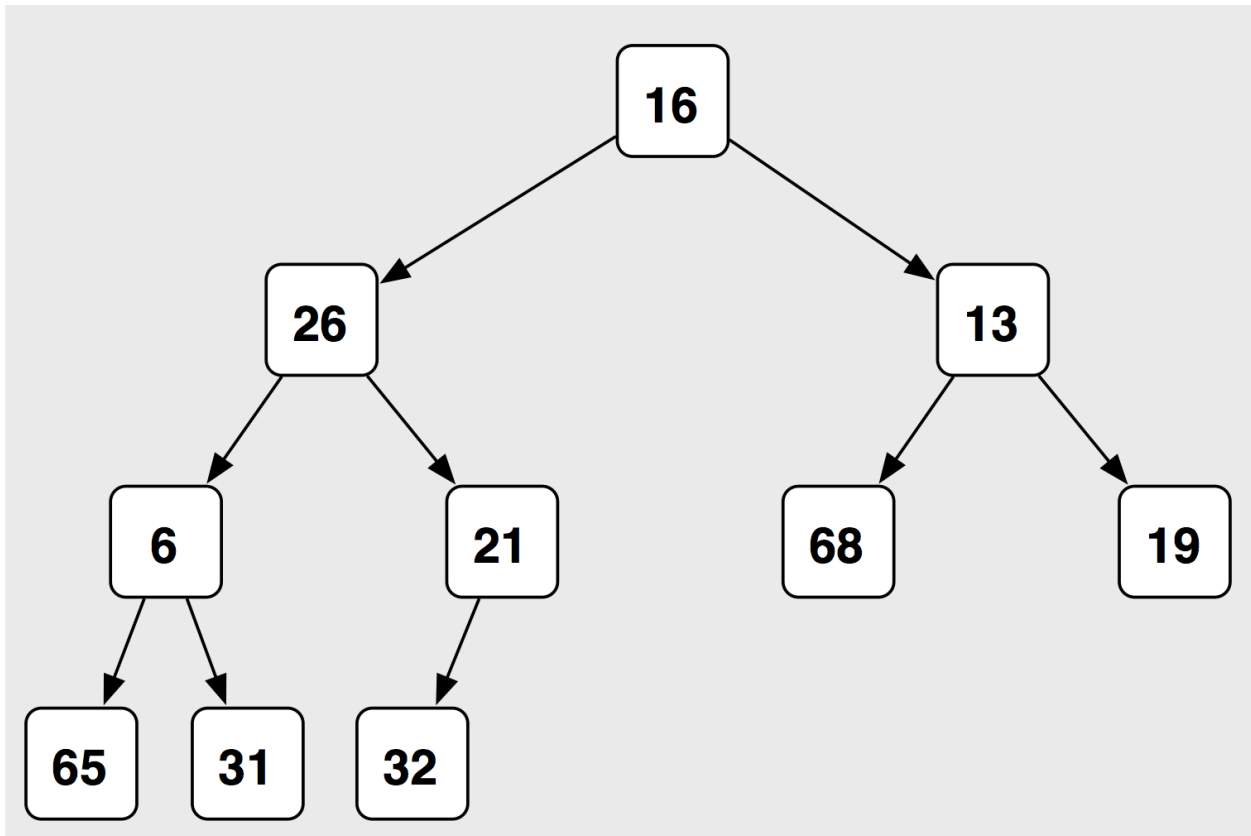
Structure

- ▶ Must be a complete tree

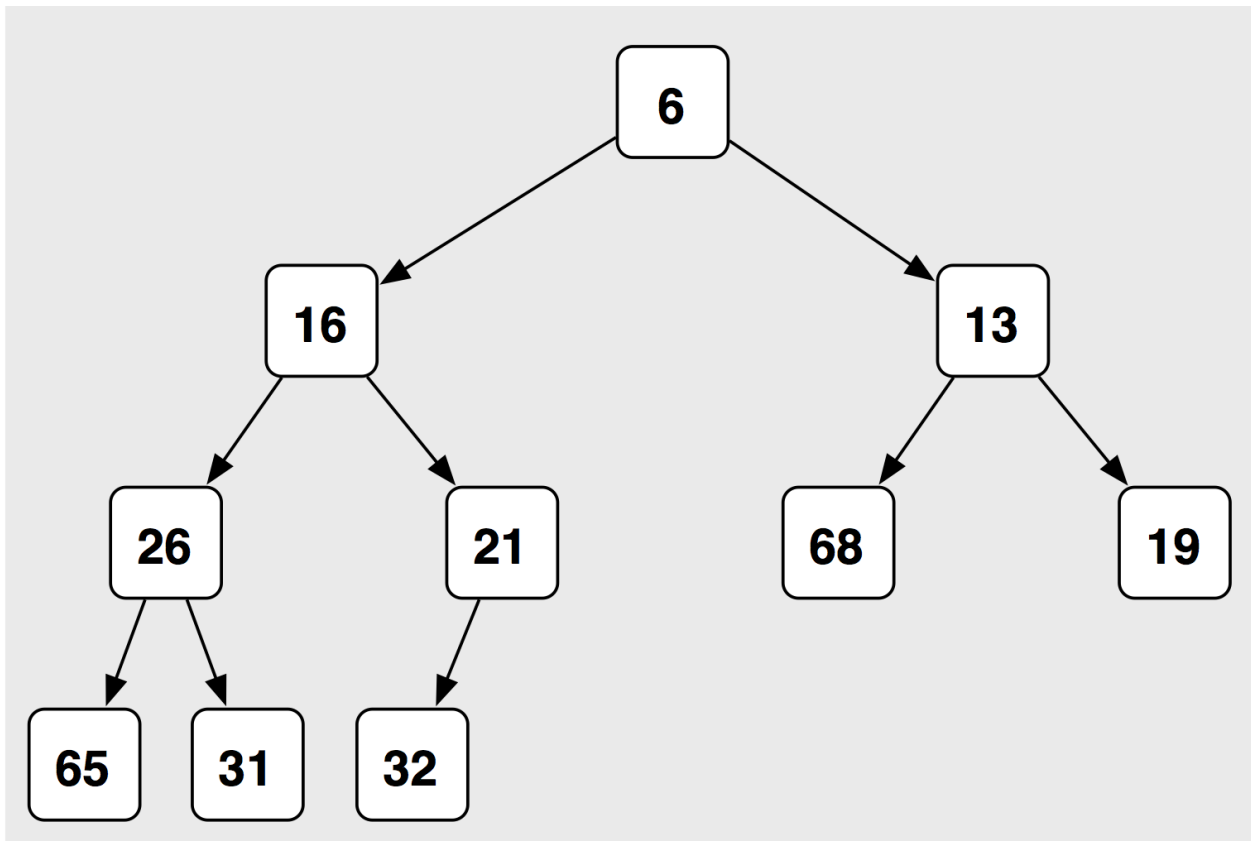
Order

- ▶ parent is always less than its children (min-heap) or
- ▶ parent is always greater than its children (max-heap)

Is this a heap?



What about this?



Heap costs

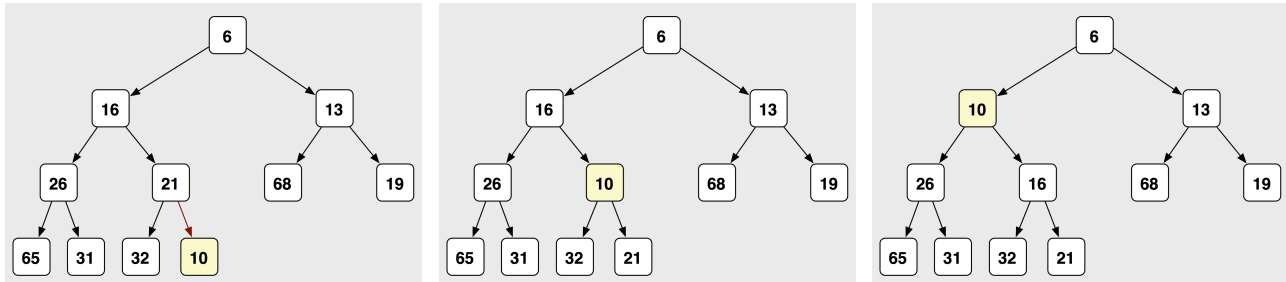
What's the cost of finding the min?

What's the cost of an arbitrary lookup?

What's the cost of finding the max?

Heaps: Insert

How do you insert 10 into this heap?



So, what's the cost of insert?

Heaps: deleteMin

What if we want to remove the minimum value (i.e., the root) of a min-heap?

