A New Data Structure Arrives:

ADT:
  insert

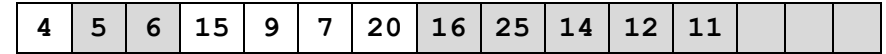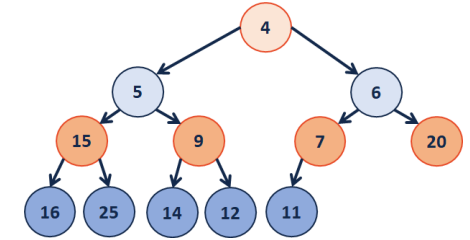 remove

  isEmpty

Implementation of _____

insert	removeMin	Implementation
O(n)	O(n)	Unsorted Array
O(1)	O(n)	Unsorted List
O(lg(n))	O(1)	Sorted Array
O(lg(n))	O(1)	Sorted List

Q1: What errors exist in this table? (Fix them!)

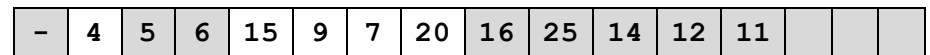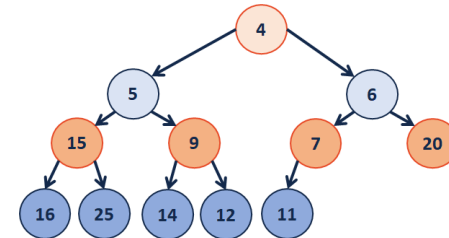**Q2:** Which algorithm would we use?

Implementing a (min)Heap as an Array

| 4 | 5 | 6 | 15 | 9 | 7 | 20 | 16 | 25 | 14 | 12 | 11 | | | |

Operations:
  leftChild(index) :=

  rightChild(index) :=

  parent(index) :=

Inserting into a Heap

| – | 4 | 5 | 6 | 15 | 9 | 7 | 20 | 16 | 25 | 14 | 12 | 11 | | | |

...running time?

```
                    Heap.hpp (partial)
 1 | template <class T>
 2 | void Heap<T>::_insert(const T & key) {
 3 |   // Check to ensure there's space to insert an element
 4 |   // ...if not, grow the array
 5 |   if ( size_ == capacity_ ) { _growArray(); }
 6 |
 7 |   // Insert the new element at the end of the array
 8 |   item_[++size] = key;
 9 |
10 |   // Restore the heap property
11 |   _heapifyUp(size);
12 | }
31 | template <class T>
32 | void Heap<T>::_heapifyUp( _____ ) {
33 |   if ( index > _____ ) {
34 |     if ( item_[index] < item_[ parent(index) ] ) {
35 |       std::swap( item_[index], item_[ parent(index) ]
36 | );
37 |       _heapifyUp( _____ );
38 |     }
39 |   }
40 | }
```

```
                    Heap.hpp (partial)
 1 | template <class T>
 2 | void Heap<T>::_removeMin() {
 3 |   // Swap with the last value
 4 |   T minValue = item_[1];
 5 |   item_[1] = item_[size_];
 6 |   size--;
 7 |
 8 |   // Restore the heap property
 9 |   heapifyDown();
10 |
11 |   // Return the minimum value
12 |   return minValue;
13 | }
 1 | template <class T>
 2 | void Heap<T>::_heapifyDown(int index) {
 3 |   if ( !_isLeaf(index) ) {
 4 |     T minChildIndex = _minChild(index);
 5 |     if ( item_[index] ____ item_[minChildIndex] ) {
 6 |       std::swap( item_[index], item_[minChildIndex] );
 7 |       _heapifyDown( _____ );
 8 |     }
 9 |   }
10 | }
```
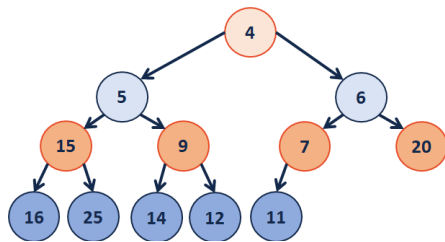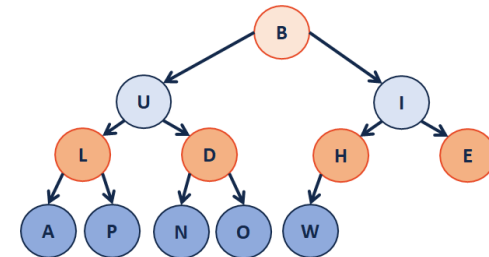
What's wrong with this code?

Heap Operation: removeMin / heapifyDown:

| – | 4 | 5 | 6 | 15 | 9 | 7 | 20 | 16 | 25 | 14 | 12 | 11 | | | |

Q: How do we construct a heap given data?

| – | B | U | I | L | D | H | E | A | P | N | O | W | | | |

CS 225 – Things To Be Doing:
1. Theory Exam 3 starts next Thursday (April. 4th)
2. MP5 +5 deadline is tonight; due next Monday (April. 1st)
3. lab_hash is out today, due on Sunday (March. 31st)
4. Daily POTDs are ongoing :)