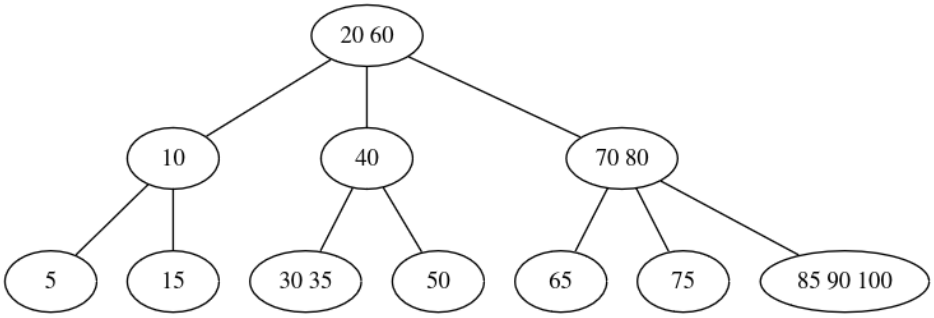
This homework covers 2-4 trees, hashtables, and heaps. It is due in class Friday, February 21.

Write your solutions carefully — your work should be neat, readable, and organized.

See the Policies page on the course website for information about revise-and-resubmit, late work, and academic integrity as it applies to homework.

1. Insert the elements 5, 16, 22, 45, 2, 10, 18, 30, 50, 12, 47 into an initially-empty 2-4 tree, drawing the tree after each insertion. When splitting a node, promote the leftmost middle element.

2. Remove the elements 75, 50, 100, 65, 40, 5, 60, 80 from the 2-4 tree shown. If swaps are needed, swap the element with its successor.



3. Perform the following series of operations on a hashtable of size 11 using separate chaining and the hash function $h(k) = k\%11$. Show the contents of the hashtable after each step.

   - insert 5
   - insert 16
   - insert 22
   - insert 45
   - insert 33
   - insert 2
   - insert 56
   - insert 10
   - delete 22
   - delete 33
   - insert 20
   - insert 32
   - insert 50
   - insert 12
   - delete 2
   - delete 56
   - insert 47

4. Perform the following series of operations on a hashtable of size 11 using sequential probing and the hash function $h(k) = k\%11$. Use the reinsert strategy to handle deletions. Show the contents of the hashtable after each step.

   - insert 5
   - insert 16
   - insert 22
   - insert 45
   - insert 33
   - insert 2
   - insert 56
   - insert 10
   - delete 22
   - delete 33
   - insert 20
   - insert 32
   - insert 50
   - insert 12
   - delete 2
   - delete 56
   - insert 47

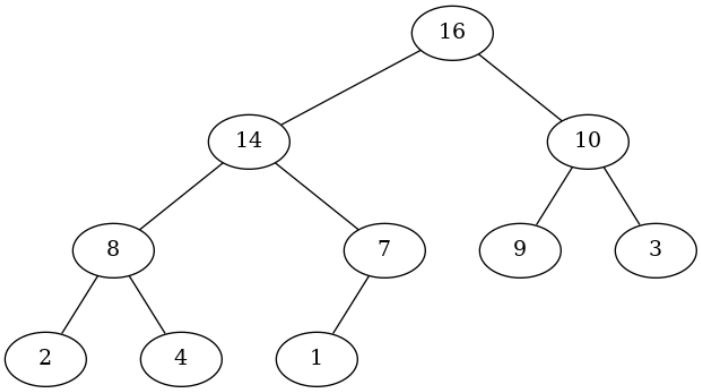
5. Perform the following series of operations on a hashtable of size 11 under each of the scenarios listed. Use the deletion marker strategy to handle deletions. Show the contents of the hashtable after each step.

   - insert 5
   - insert 16
   - insert 22
   - insert 45
   - insert 33
   - insert 2
   - insert 56
   - insert 10
   - delete 22
   - delete 33
   - insert 20
   - insert 32
   - insert 50
   - insert 12
   - delete 2
   - delete 56
   - insert 47

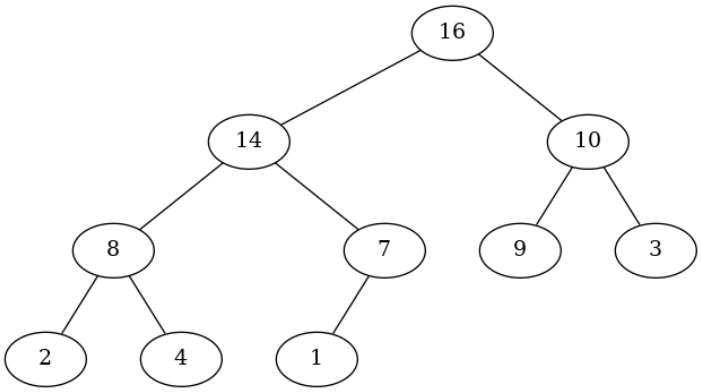
   (a) quadratic probing, using hash function $h(k) = k\%11$

   (b) double hashing, using hash function $h(k) = k\%11$ and secondary hash function $h'(k) = 7 - k\%7$

6. Insert 6, 30, 12 into the following max heap, showing the heap after each insertion.



7. Apply three remove-max operations to the following max heap, showing the heap after each deletion.



8. ADM 4-19, page 142. Assume the standard implementation of a heap (using an array). As part of your answer, explain how each operation would be carried out in a max heap and in a sorted array. For (b), consider both if you know where the element to be deleted is (you know what slot it is in) and if you don't and have to find it first.