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Data Structures - Test 1

Question 1. (4 points) Consider the following Python code.

```
for i in range(n*n):
    j = 1
    while j < n:
        print (i, j)
        j = j * 2
```

$-n^2$

$-\log_2 n$

4 $O(n^2 \log_2 n)$

What is the big-oh notation $O(\,)$ for this code segment in terms of n?

Question 2. (4 points) Consider the following Python code.

```
i = 1
while i < n:
    for j in range(n):
        print(j)

        for k in range(n):
            print(k)

    i = i * 2
```

$-\log n$

4 $O(n^2 \log n)$

What is the big-oh notation $O(\,)$ for this code segment in terms of n?

Question 3. (4 points) Consider the following Python code.

```
def main(n):
    for i in range(n):
        doSomething(n)

def doSomething(n):
    for k in range(n):
        doMore(n)

def doMore(n):
    for k in range(n):
        print(k)

main(n)
```

4 $O(n^3)$

What is the big-oh notation $O(\,)$ for this code segment in terms of n?

Question 4. (8 points) Suppose a $O(n^5)$ algorithm takes 10 seconds when n = 100. How long would you expect the algorithm to run when n = 1,000?

$T(n) = c\,n^5$

8 $T(100) = c\,100^5 = 10\,sec$

$c = \frac{10}{100^5}\,sec = 10^{-9}\,sec$

$T(1000) = c\,1000^5$

$= 10^{-9}\,sec\;10^{15}$

$= 10^{6}\,sec$

Question 5. (5 points) Why should you design a program instead of "jumping in" and start by writing code?

5 You will make fewer mistakes working from a design.

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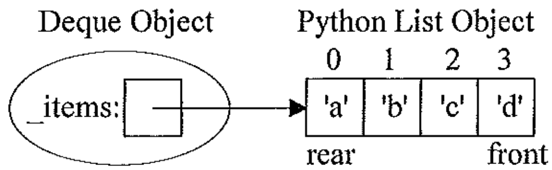
Question 6. A Deque (pronounced "Deck") is a linear data structure which behaves like a double-ended queue, i.e., it allows adding or removing items from either the front or the rear of the Deque. One possible implementation of a Deque would be to use a built-in Python list to store the Deque items such that

- the **rear** item is **always stored at index 0,**
- the front item is always at index len(self._items)-1 or -1



a) (6 points) Complete the big-oh O ( ), for each Deque operation, assuming the above implementation. Let n be the number of items in the Deque.

isEmpty	addRear	removeRear	addFront	removeFront	size
O(1)	O(n)	O(n)	O(1)	O(1)	O(1)

6

b) (9 points) Complete the method for the `removeRear` operation including the precondition check.

```
def removeRear(self):
    """Removes and returns the rear item of the Deque
       Precondition:  the Deque is not empty.
       Postcondition: Rear item is removed from the Deque and returned"""
```

```
    if len(self._items) == 0:
        raise ValueError("Cannot remove from empty Deque")
    return self._items.pop(0)
```

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c) (5 points) Suggest an alternate Deque implementation to speed up some of its operations.

A doubly-linked list implementation.

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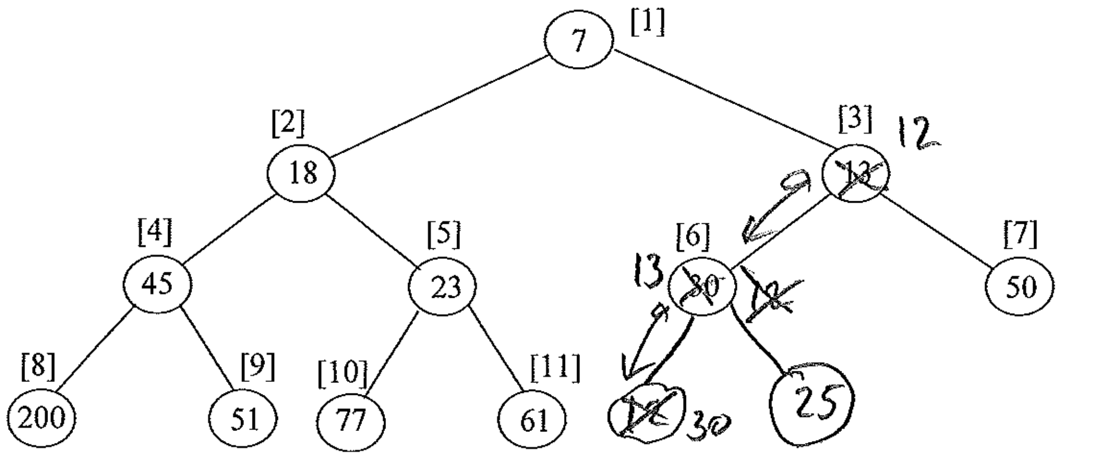
Question 7. Consider the binary heap approach to implement a priority queue. A Python list is used to store a *complete binary tree* (a full tree with any additional leaves as far left as possible) with the items being arranges by *heap-order property*, i.e., each node is ≤ either of its children. An example of a *min* heap "viewed" as a complete binary tree would be:



Python List actually used to store heap items

0	1	2	3	4	5	6	7	8	9	10	11
not used	7	18	13	45	23	30	50	200	51	77	61

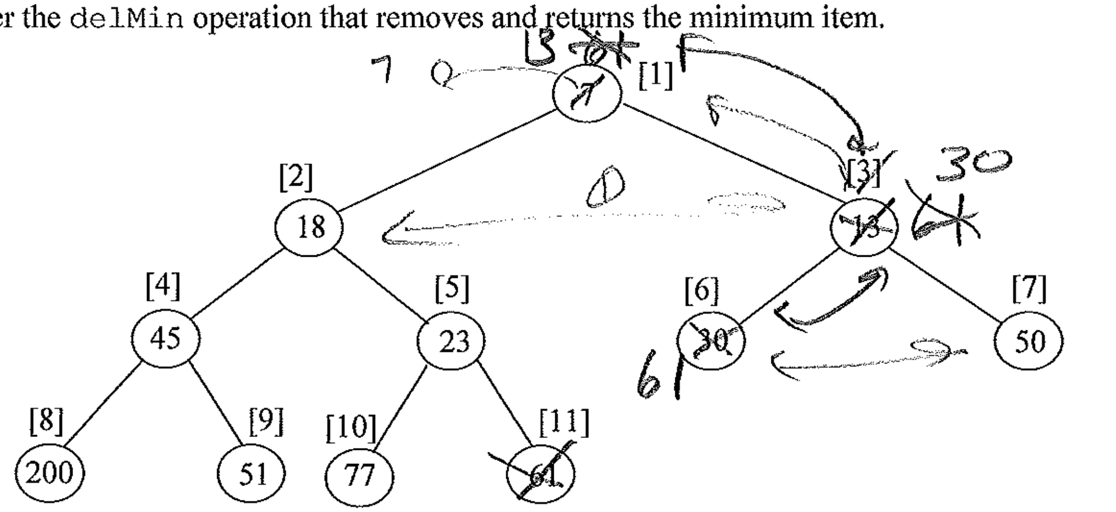
a) (3 points) For the above heap, the list indexes are indicated in [ ]'s. For a node at index *i*, what is the index of:

- its left child if it exists: i*2
- its right child if it exists: i*2+1
- its parent if it exists: i//2

b) (7 points) What would the above heap look like after inserting 12 and then 25 (show the changes on above tree)

c) (3 points) What is the big-oh notation for inserting a new item in the heap? $O(\log_2 n)$

Now consider the `delMin` operation that removes and returns the minimum item.



Python List actually used to store heap items

0	1	2	3	4	5	6	7	8	9	10	11
not used	7	18	13	45	23	30	50	200	51	77	61

d) (2 point) What item would `delMin` remove and return from the above heap? 7

e) (7 points) What would the above heap look like after `delMin`? (show the changes on above tree)

f) (3 points) What is the big-oh notation for `delMin`? $O(\log_2 n)$

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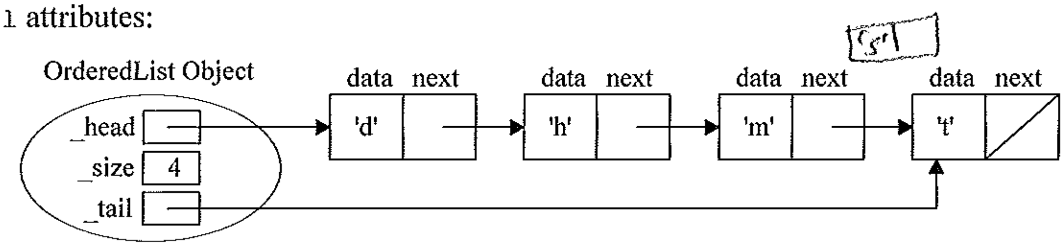
Question 8. The textbook's **Ordered list** ADT uses a singly-linked list implementation. I added the `_size` and `_tail` attributes:



a) (15 points) The `add(item)` method adds the add to the list. Recall that the textbook's implementation, cannot contain duplicate items!!! Thus, the precondition is that `item` is a not already in the list. Complete the `add(item)` method code including the precondition check.

```
class OrderedList(object):

   def __init__(self):
      self._head = None
      self._size = 0
      self._tail = None

   def add(self, item): temp = Node(item)
      prev = None
      current = self._head
      while current != None:
         if current.getData() == item:
            raise ValueError("cannot add duplicates")
         if current.getData() > item:
            break

         prev = current
         current = current.getNext()
      if prev == None:
         temp.setNext(self._head)
         self._head = temp
      else:
         temp.setNext(current)
         prev.setNext(temp)
      if current == None:
         self._tail = temp
      self._size += 1
```

```
class Node:
   def __init__(self, initdata):
      self.data = initdata
      self.next = None

   def getData(self):
      return self.data

   def getNext(self):
      return self.next

   def setData(self, newdata):
      self.data = newdata

   def setNext(self, newnext):
      self.next = newnext
```

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b) (10 points) Assuming the ordered list ADT described above **does not allows duplicate items**. Complete the big-oh $O(\,)$ for each operation. Let n be the number of items in the list.

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`add(item)`	`pop()` removes and returns tail item	`length()` returns number of items in the list	`remove(item)` removes the item from the list	`index(item)` returns the position of item in the list
$O(n)$	$O(n)$	$O(1)$	$O(n)$	$O(n)$

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