Fall 2013 Name: ______________________

Data Structures - Test 1

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

```
for i in range(n):
    for j in range(n*n):
        print (i, j)
```

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)

    i = i * 2
```

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)
        doMore(n)

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

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

main(n)
```

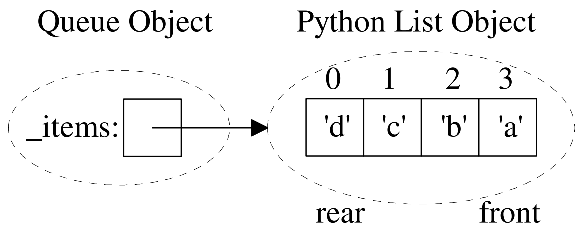
What is the big-oh notation $O(\ )$ for this code segment in terms of n?

Question 4. (8 points) Suppose a $O(n^3)$ algorithm takes 10 seconds when n = 1,000. How long would you expect the algorithm to run when n = 10,000?

Question 5. (5 points) Why should any method/function having a "precondition" raise an exception if the precondition is violated?

Question 6. Consider the following FIFO (First-In-First-Out) Queue implementation utilizing a Python list: Recall that a queue is a linear data structure that allows adding new items at the rear and removing items from the front. One possible implementation of a queue would be to use a built-in Python list to store the 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) (8 points) Complete the big-oh *O* ( ), for each Queue operation, assuming the above implementation. Let n be the number of items in the Queue.

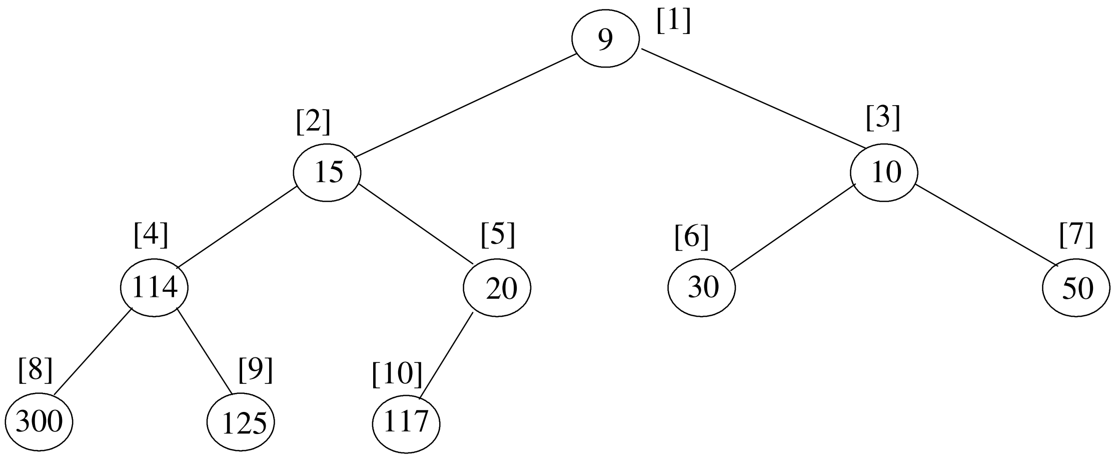
`isEmpty`	`enqueue`	`dequeue`	`size`

b) (10 points) Complete the method for the dequeue operation including the precondition check.

```
def dequeue(self):
    """Removes and returns the front item of the queue
       Precondition:  the queue is not empty.
       Postcondition: front item is removed from the queue and returned"""
```

c) (7 points) Suggest an alternate Queue implementation to speed up some of its operations.

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:



	0	1	2	3	4	5	6	7	8	9	10
Python List actually used to store heap items	not used	9	15	10	114	20	30	50	300	125	117

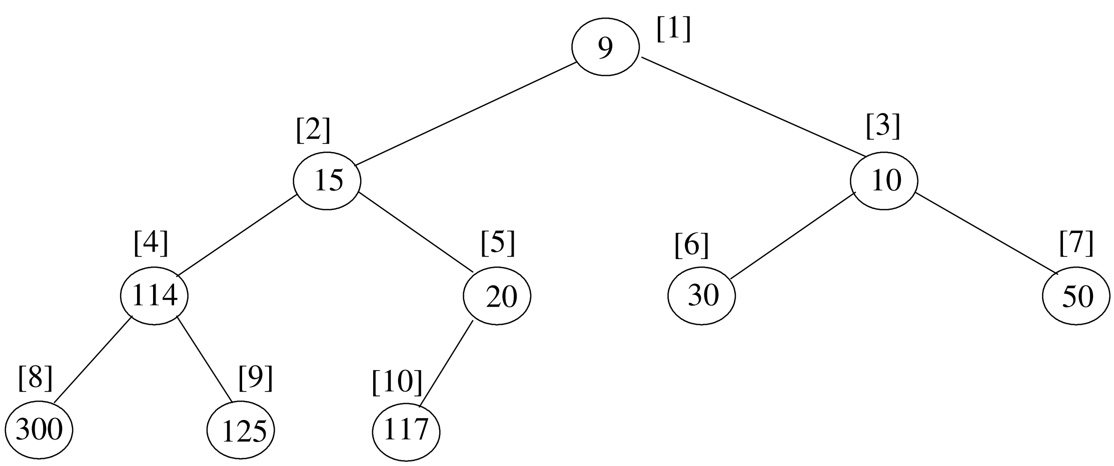
a) (3 points) For the above heap, the list indexes are indicated in [ ]'s. For a node at index *i*, what is the index of:

- its left child if it exists:
- its right child if it exists:
- its parent if it exists:

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?

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



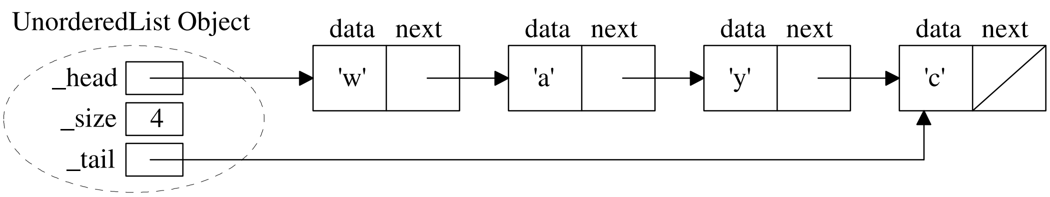
	0	1	2	3	4	5	6	7	8	9	10
Python List actually used to store heap items	not used	9	15	10	114	20	30	50	300	125	117

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

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`?

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



a) (15 points) The `insert(position, item)` method adds the `item` to the list at the specified `position`. Unlike the textbook's implementation, ASSUME that the list may contain duplicate items!!! The precondition is that `position` is a nonnegative integer. If `position` is 0, then add it to the head of the list. If `position` is `_size` **or bigger**, then add it to the tail of the list. Complete the `insert(position, item)` method code including the precondition check.

```
class UnorderedList:

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

   def insert(self, position, item):
```

```
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
```

b) (10 points) Assuming the unordered list ADT described above **that allows duplicate items**. Complete the big-oh *O* ( ) for each operation. Let n be the number of items in the list.

`insert(position,item)`	`pop()` removes and returns tail item	`length()` returns number of items in the list	`append(item)` adds item to the tail of list	`add(item)` adds item to the head of list