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

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

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

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

```
for i in range(n):

    j = n
    while j > 1:
        print( i, j )
        j = j // 2

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

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*n*n)

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

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

main(n)
```

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

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

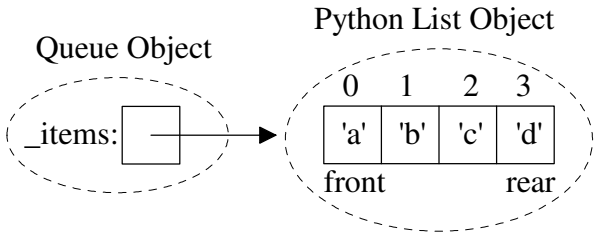
Question 5. (10 points) For a built-in Python list, explain each of the following average big-oh notations:

a) Why does `myList.insert(0, "item")` have an average big-oh of O(n), where n is the # of list items?

b) Why does `myList.append("item")` have an average big-oh of O(1), where n is the # of list items?

Question 6. A FIFO queue allows adding a new item at the rear using an enqueue operation, and removing an item from the front using a dequeue operation. One possible implementation of a queue would be to use a built-in Python list to store the queue items such that

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



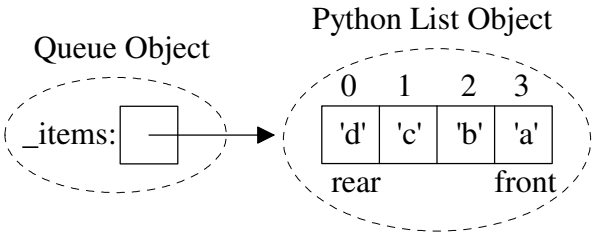
a) (6 points) Complete the big-oh *O* ( ), for each Queue operation, assuming the above implementation. Let n be the number of items in the queue.

`isEmpty`	`enqueue(item)`	`dequeue`	`peek` - returns front item without removing it	`__str__`	`size`

b) (9 points) Complete the method for the `dequeue` operation, **including the precondition check to raise an exception if it is violated.**

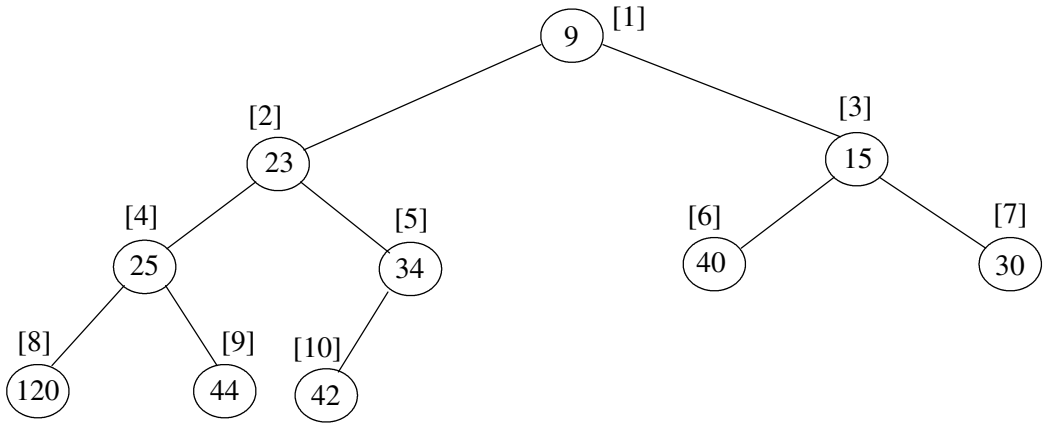
```
def dequeue(self):
    """Removes and returns the Front item of the Queue
       Precondition:  the Queue is not empty.
       Postcondition: Front item is removed from the Queue and returned"""
```

c) (5 points) An alternate Queue implementation would swap the location of the front and rear items as in:



Why is this alternate implementation probably not very helpful with respect to the Queue's performance?

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

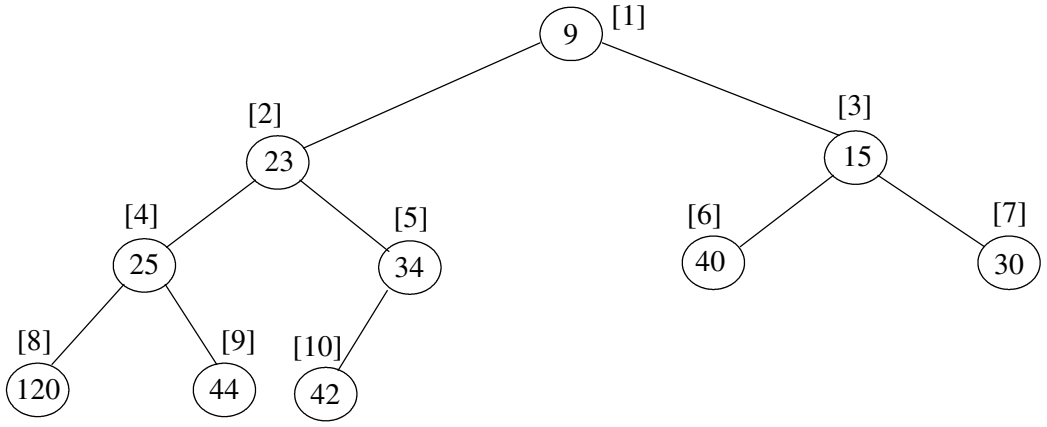
0	1	2	3	4	5	6	7	8	9	10
not used	9	23	15	25	34	40	30	120	44	42

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 5 and then 3 (show the changes on above tree)

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

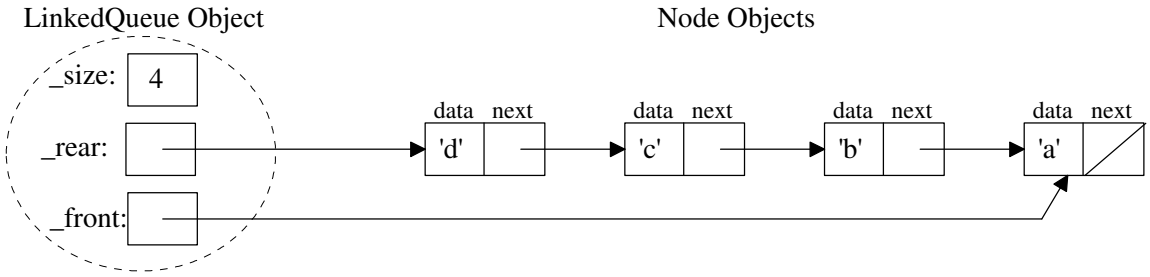


c) (2 point) What item would `delMin` remove and return from the above heap?

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

e) (6 points) Performing 20,000 `inserts` into an initially empty binary heap takes 0.23 seconds. Now, if we perform 20,000 `delMin` operations, it takes 0.39 seconds. Explain why these 20,000 `delMin` operations take more time than the 20,000 `insert` operations?

Question 8. The `Node` class can be used to dynamically create storage for each new item added to a Queue using a singly-linked implementation as in:



a) (6 points) Determine the big-oh, *O* ( ), for each LinkedQueue operation assuming the above singly-linked implementation. Let n be the number of items in the queue.

`isEmpty`	`enqueue(item)`	`dequeue`	`peek` - returns front item without removing it	`__str__`	`size`

b) (14 points) Complete the `enqueue` method for the above LinkedQueue implementation.

```
class LinkedQueue(object):
    """ Singly-linked list based Queue implementation."""

    def __init__(self):
        self._size = 0
        self._rear = None
        self._front = None

    def enqueue(self, newItem):
        """ Adds the newItem to the rear of the queue.
            Precondition:  none """
.
```

```
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
```

c) (5 points) Suggest an improvement to the above implementation to speed up some of the queue operations enough to change their big-oh notation? Justify your answer