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

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

    i = i // 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):

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

    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)

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

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

main(n)
```

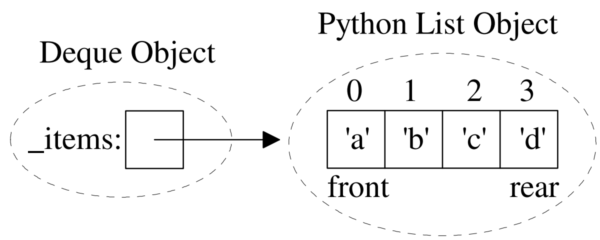
What is the big-oh notation $O(\ )$ for this code segment in terms of n?

Question 4. (8 points) Suppose a $O(n^3)$ algorithm takes 10 second when n = 100. How long would the algorithm run when n = 1,000?

Question 5. (10 points) Why should any method/function having a "precondition" raise an exception if the precondition is violated?

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



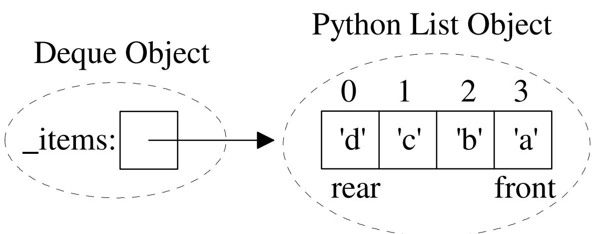
a) (6 points) Complete the big-oh *O* ( ), for each Deque operation, assuming the above implementation. Let n be the number of items in the Deque.

isEmpty	addRear	removeRear	addFront	removeFront	size

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

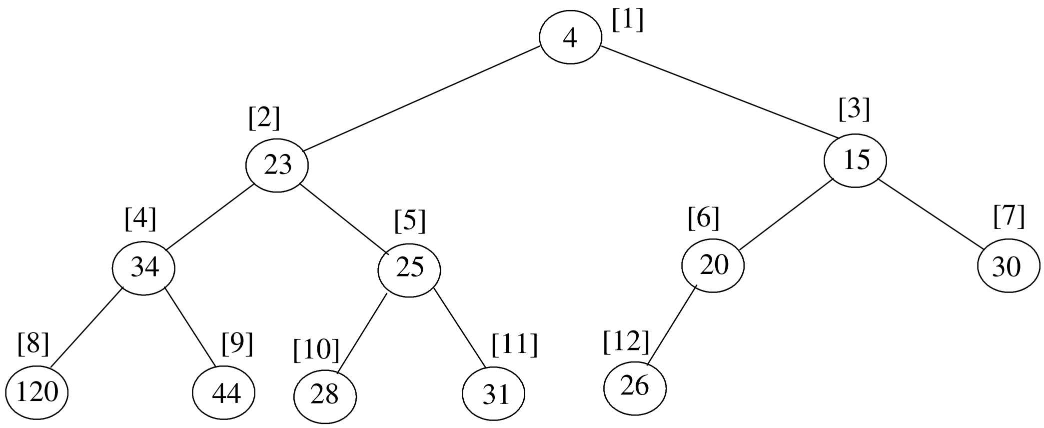
```
def removeFront(self):
    """Removes and returns the Front item of the Deque
       Precondition:  the Deque is not empty.
       Postcondition: Front item is removed from the Deque and returned"""
```

c) (5 points) An alternate Deque 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 Deque’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	11	12
not used	4	23	15	34	25	20	30	120	44	28	31	26

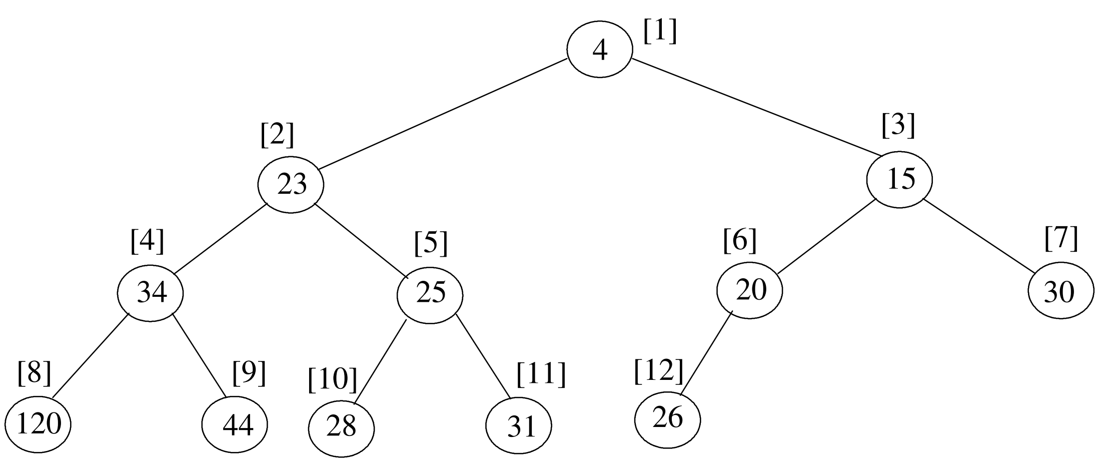
a) (3 points) For the above heap, the list indexes are indicated in [ ]'s. For a node at index *i*, what is the index of:

- 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 18 and then 9 (show the changes on above tree)

c) (6 points) What is the big-oh notation for the `insert` operation? **(EXPLAIN YOUR ANSWER)**

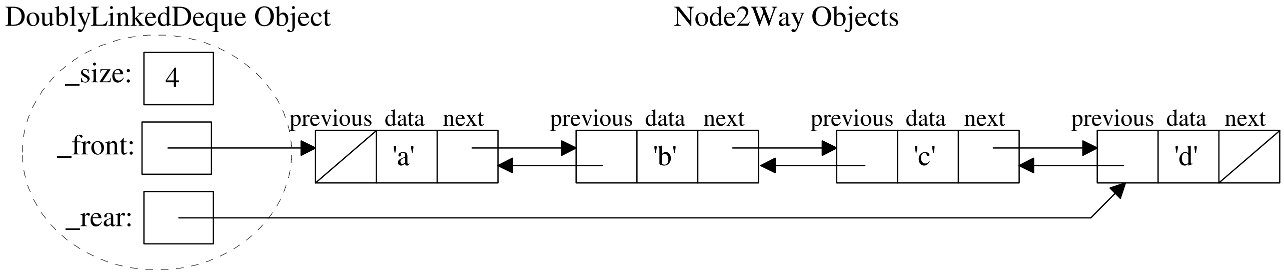
Now consider the `delMin` operation that removes and returns the minimum item.



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)

Question 8. The `Node2Way` class (which inherits the `node.py` class) can be used to dynamically create storage for each new item added to a Deque using a doubly-linked implementation as in:



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

addFront	removeFront	addRear	removeRear	size	`__str__`

b) (14 points) Complete the `addRear` method.

```
class DoublyLinkedDeque(object):
    """ Doubly-Linked list based Deque implementation."""

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

    def addRear(self, newItem):
        """ Adds the newItem to the rear of the Deque.
            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
```

```
class Node2Way(Node):
    def __init__(self,initdata):
        Node.__init__(self,initdata)
        self.previous = None

    def getPrevious(self):
        return self.previous

    def setPrevious(self,newprevious):
        self.previous = newprevious
```

c) (5 points) Would using singly-linked nodes (i.e., `Node` objects instead of `Node2Way`) slow down any of the Deque operations? Justify your answer