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

```
for j in range(n):

    i = 1
    while i < 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):

    k = n
    while k > 1:
       k = k // 2
       print(k)

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

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 j in range(n*n):
       doMore(n)

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

main(n)
```

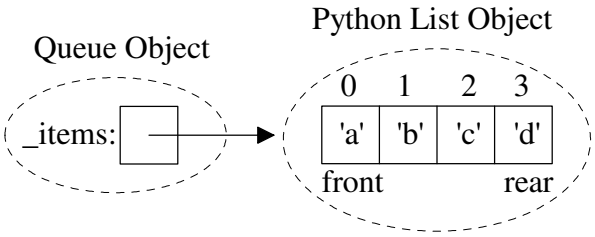
What is the big-oh notation $O(\ )$ for this code segment in terms of n?

Question 4. (6 points) Suppose a $O(\ n^4\ )$ algorithm takes 10 second when n = 1000. How long would the algorithm run when n = 10,000?

Question 5. (8 points) Why should a method/function having a "precondition" raise an exception if the precondition is violated?

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 expected 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`

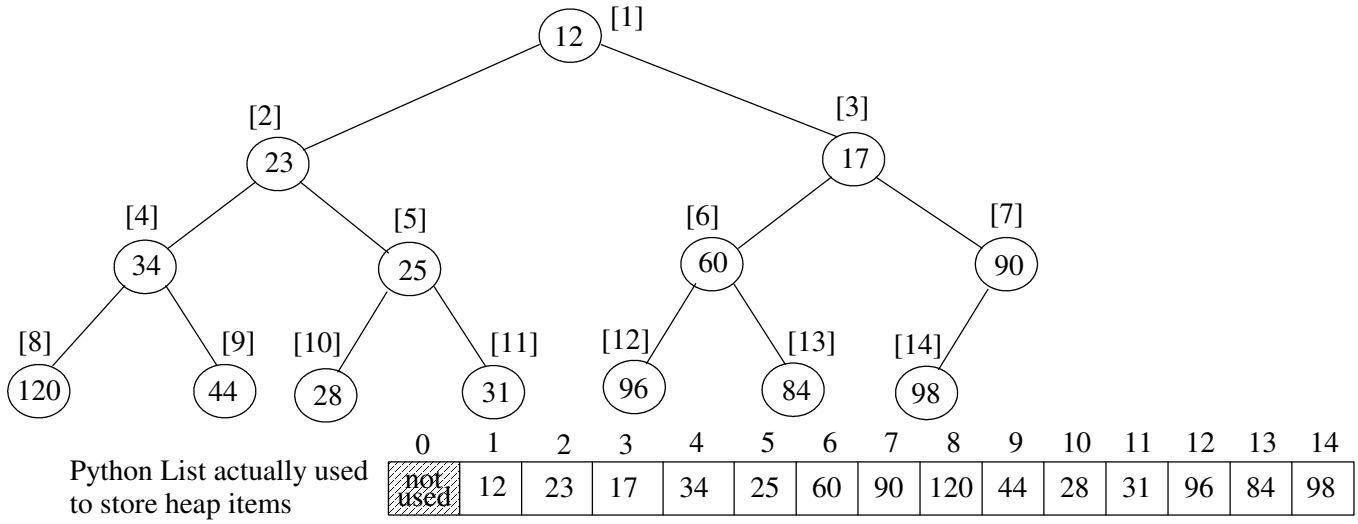
b) (8 points) Complete the method for the `dequeue` operation, **including the precondition check to raise an exception if it is violated.**

```
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) (8 points) Complete the method for the `__str__` operation,

```
def __str__(self):
    """ Returns a string representation of items from front to rear. """
    strResult = "(front) "
```

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:

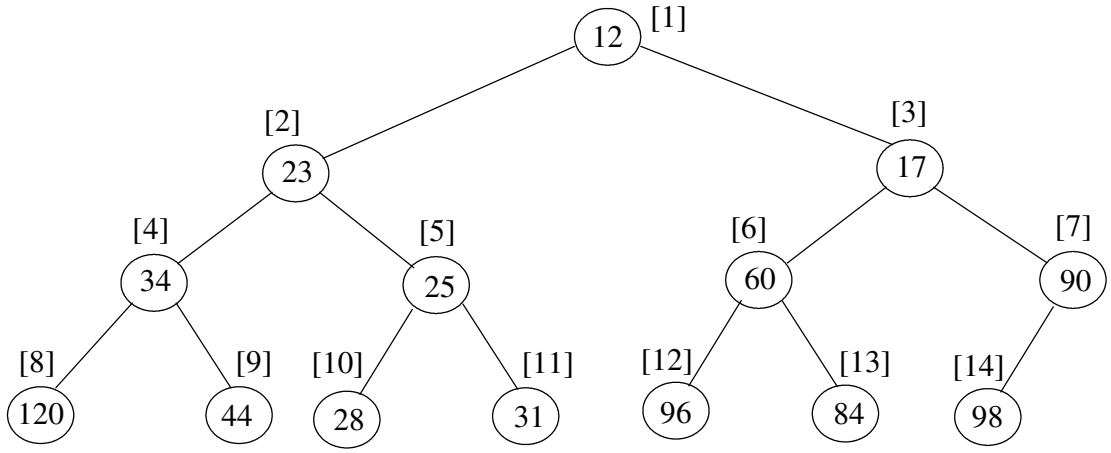


a) (3 points) For the above heap, the list indexes are indicated in [ ]'s. For a node at index *i*, what is the index of:

- 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 40 **and then** 20 (show the changes on above tree)

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

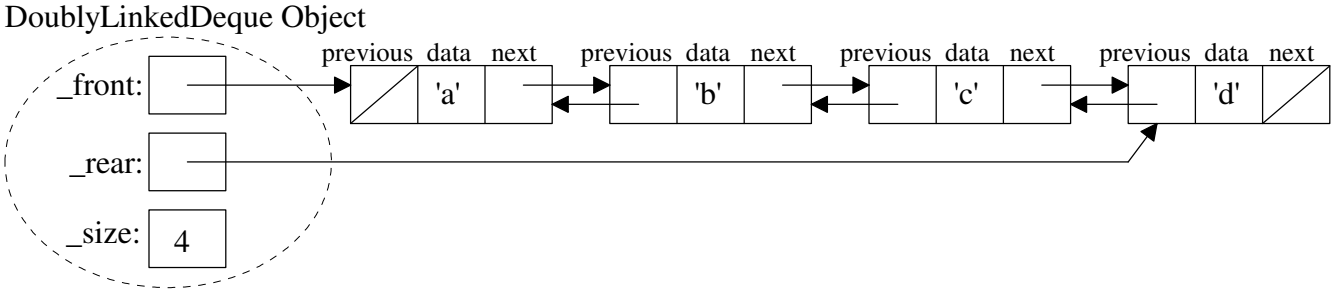


c) (2 point) What item would `delMin` remove and return from the above heap?

d) (7 points) What would the heap look like after `delMin`? (show the changes on tree in the middle of the page)

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 20,000 `delMin` operations take more time than the 20,000 `insert` operations?

Question 8. The `Node2Way` and `Node` classes 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) Complete the big-oh expected *O* ( ), for each DoublyLinkedDeque operation, assuming the above implementation. Let n be the number of items in the DoublyLinkedDeque.

isEmpty	addRear	removeRear	addFront	removeFront	__str__

b) (16 points) Complete the `addRear` method for the above DoublyLinkedDeque implementation.

```
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
```

```
from node import Node

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) Why would using singly-linked nodes (i.e., only Node objects with data and next) to implement the Deque lead to poor performance (i.e., cause some Deque operations to have worse big-oh notations)? Justify your answer.