 Name: Mark F.

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

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

4

$O(n^2 \log_2 n)$

+2 $O(n^3)$

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)

    k = n
    while k > 0:
        print(k)
        k = k // 2
```

4

$O(n^2)$

(12)

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

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):  -n x
        doSomething(n)
    doMore(n)

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

def doMore(n):
    for j in range(n * n * n):  - n^3 x
        print(j)

main(n)
```

4

$O(n^3)$

+2 $O(n^4)$

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

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

$T(n) = cn^4 \quad T(100) = c\,100^4 = 10sec$

$c = \frac{10sec}{100^4}$

$c = \frac{10sec}{10^8} = 10^{-7}sec$

$T(1000) = c\,1000^4$

$= 10^{-7}sec\,10^{12}$

$= 10^5 sec$

6

Question 5. (10 points) Why should you design a program instead of "jumping in" and start by writing code?

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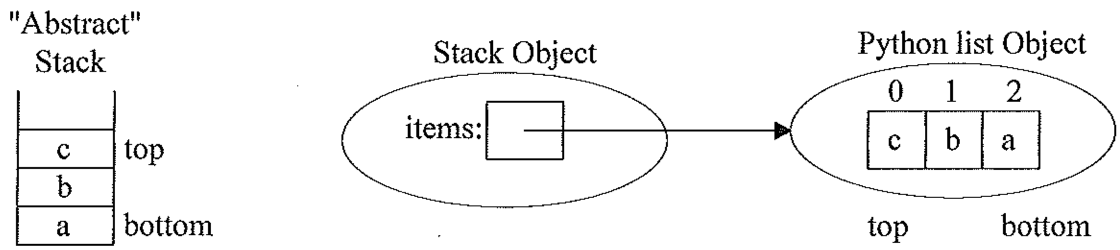
By designing the program first you are able to avoid mistakes and reworking of code, so overall time is saved.

30

Question 6. Consider the following Stack implementation utilizing a Python list:



a) (6 points) Complete the big-oh notation for the Stack methods assuming the above implementation: ("n" is the # items)

6

	push(item)	pop( )	peek( )	size( )	isEmpty( )	__~~init~~__ str
Big-oh	O(n)	O(n)	O(1)	O(1)	O(1)	O(n)

b) (9 points) Complete the code for the pop method including the precondition check.

```
class Stack:

   def __init__(self):
      self._items = []

   def pop(self):
       """Removes and returns the top item of the stack
          Precondition:  the stack is not empty.
          Postcondition: the top item is removed from the stack and returned"""
```

9

if len(self._items) == 0:
    raise ValueError("Cannot pop empty stack!")
return self._items.pop(0)
+1 +2

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

5

Flip the order of the stack so the top is at the largest index, so all operations (except __str__) are O(1).

20

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:

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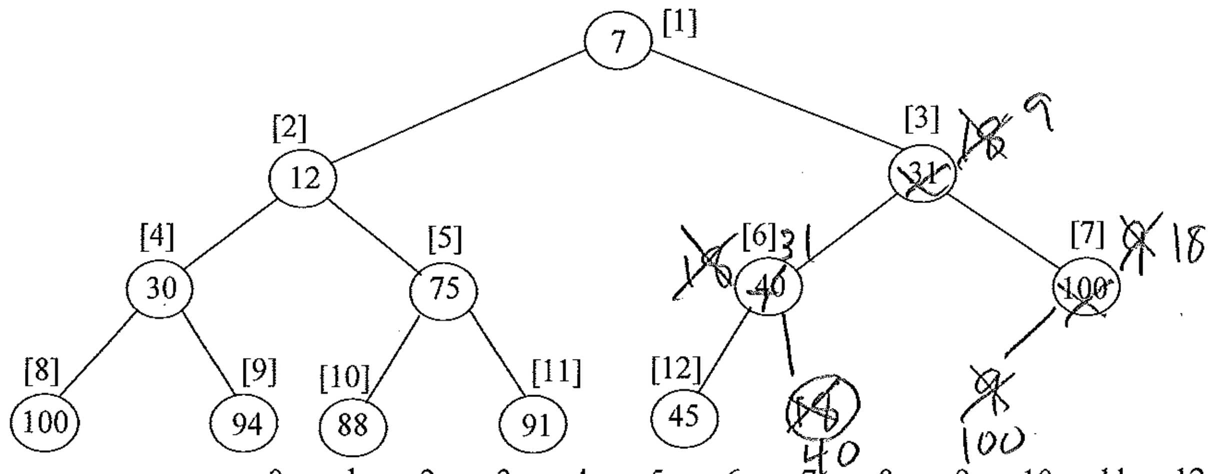


Python List actually used to store heap items

0	1	2	3	4	5	6	7	8	9	10	11	12
not used	7	12	31	30	75	40	100	100	94	88	91	45

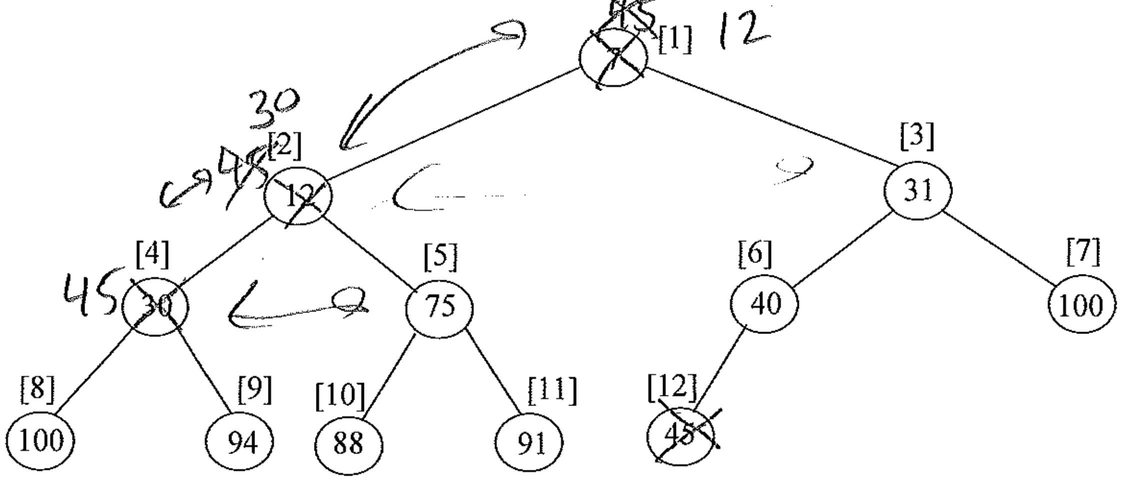
a) (3 points) For the above heap, the list indexes are indicated in [ ]'s. For a node at index *i*, what is the index of:

3
- 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 18 and then 9 (show the changes on above tree)

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

7



Python List actually used to store heap items

0	1	2	3	4	5	6	7	8	9	10	11	12
not used	7	12	31	30	75	40	100	100	94	88	91	45

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

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

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

6 $O(\log_2 n)$ Moving last item to index 0 takes O(1), percolating down from index 1 cause the index to at least double. You can only double the index 1 $\log_2(n)$ times before it reaches n, so $\log_2 n$

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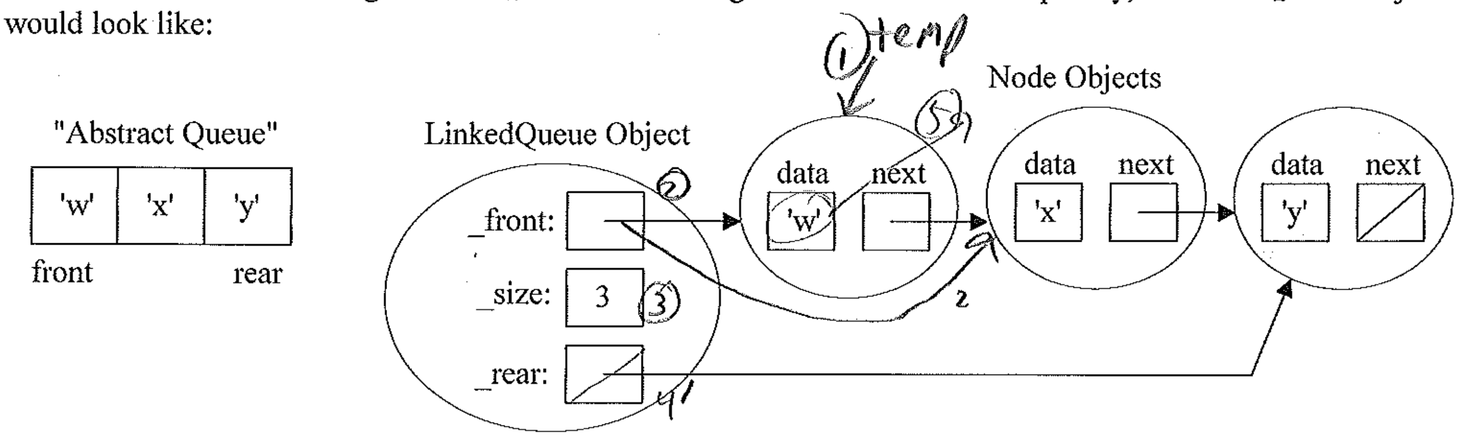
Question 8. The `Node` class (in `node.py`) is used to dynamically create storage for a new item added to the stack. Consider the following `LinkedQueue` class using this Node class. Conceptually, a `LinkedQueue` object would look like:



a) (13 points) Complete the `dequeue` method including the precondition check.

```
class LinkedQueue(object):
    """ Linked-list based queue implementation."""

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

    def dequeue(self):
        """ Removes and returns the front item in the queue.
            Precondition:  the queue is not empty. """
        if self._size == 0:
            raise ValueError("Cannot dequeue from empty queue.")
        temp = self._front
        self._front = self._front.getNext()
        self._size -= 1
        if self._size == 0:
            self._rear = None
        return temp.getData()
```

```
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
```

13 +3

+ normal case
- temp ptr
- change _front
- change _size

return getData()

special case dequeue last item set _rear.

7

b) (7 points) Assuming the queue ADT described above. Complete the big-oh $O(\,)$ for each queue operation. Let n be the number of items in the queue.

`__init__`	`enqueue(item)` +2	`dequeue( )`	`size()`	`__str__()` +2
O(1)	O(1)	O(1)	O(1)	O(n)

c) (5 points) Would using doubly-linked nodes (i.e., `Node2way`) speed up some of queue operations? Justify your answer. No, slow down operations if "previous" links must be maintained.

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