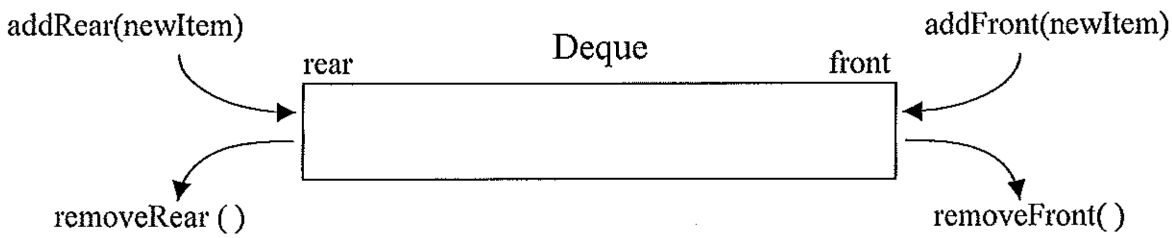
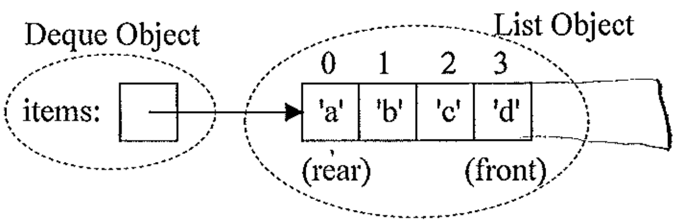
A Deque (pronounced "Deck") is a linear data structure which behaves like a double-ended queue, i.e., it allows adding or removing items from either the front or the rear of the Deque.



1. One possible implementation of a Deque would be to use a Python list to store the Deque items such that
- the rear item is **always stored at index 0**,
- the front item is always stored at the highest index (or -1)




```
class Deque(object):
   def __init__(self):
       self.items = [ ]
```

a) Complete the `__init__` method and determine the big-oh, O ( ), for each Deque operation, assuming the above implementation. Let n be the number of items in the Deque.

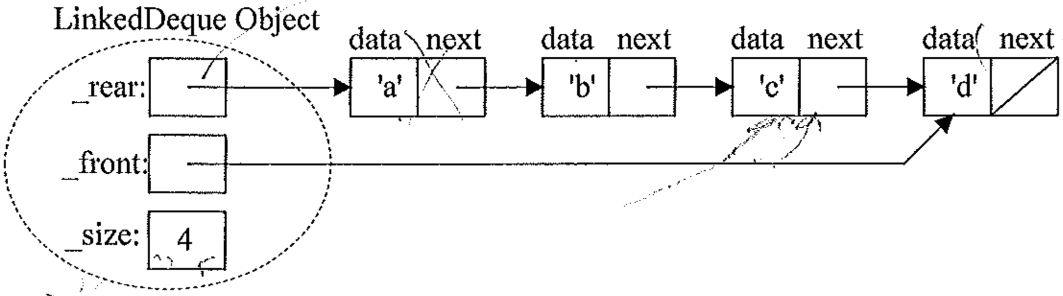
isEmpty	addFront	removeFront	addRear	removeRear	size
O(1)	O(1)	O(1)	O(n)	O(n)	O(1)

b) Write the methods for the `addRear` and `removeRear` operation.

```
def addRear(self, newItem):
    self.items.insert(0, newItem)
```

```
def removeRear(self):
    if len(self.items) == 0:
        raise Exception("Cannot... ")
    return self.items.pop(0)
```

2. An alternative implementation of a Deque would be a linked implementation as in:



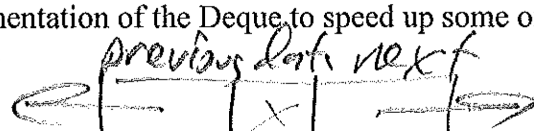

```
class LinkedDeque(object):
   def __init__(self):
       self._rear = None
       self._front = None
       self._size = 0
```

a) Complete the `__init__` method and determine the big-oh, O ( ), for each Deque operation assuming the above linked implementation. Let n be the number of items in the Deque.

isEmpty	addFront	removeFront	addRear	removeRear	size
O(1)	O(1)	O(n)	O(1)	O(1)	O(1)

b) Suggest an improvement to the above linked implementation of the Deque to speed up some of its operations.

doubly-linked nodes



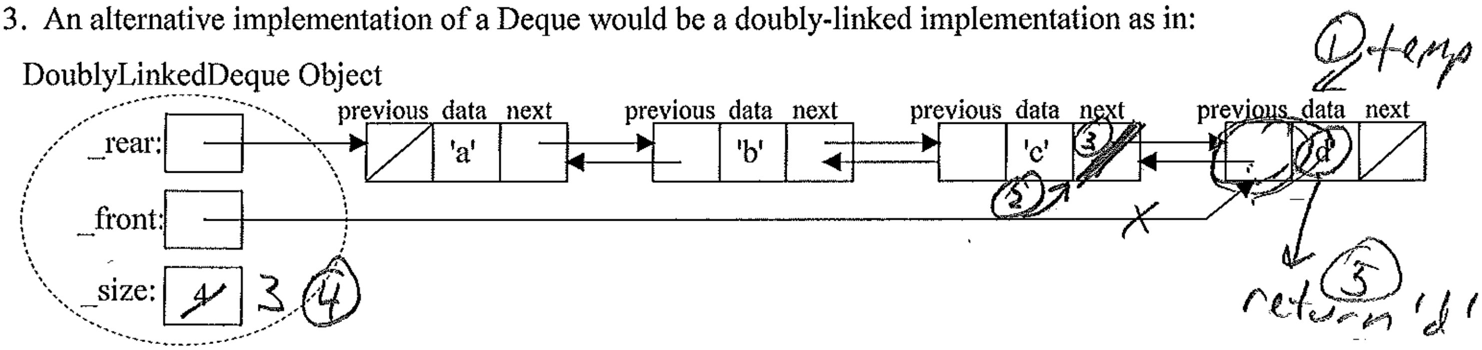
```
from node import Node

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
```

3. An alternative implementation of a Deque would be a doubly-linked implementation as in:



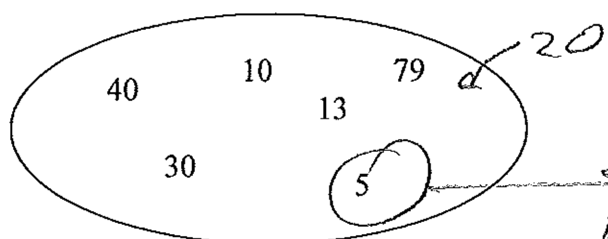
a) Determine the big-oh, O ( ), for each Deque operation assuming the above doubly-linked implementation. Let n be the number of items in the Deque.

isEmpty	addFront	removeFront	addRear	removeRear	size
O(1)	O(1)	O(1)	O(1)	O(1)	O(1)

4. A *priority queue* has the same operations as a regular queue, except the items are NOT returned in the FIFO (first-in, first-out) order. Instead, each item has a proirity that determines the order they are removed. A hospital emergence room operates like a priority queue -- the person with the most serious injure has highest priority even if they just arrived.

a) Suppose that we have a priority queue with integer priorities such that the smallest integer corresponds to the highest priority. For the following priority queue, which item would be dequeued next?

priority queue:



remove 5 because highest priority

b) To implement a priority queue, we could use an **unorder Python list**. If we did, what would be the big-oh notation for each of the following methods: (justify your answer)

- enqueue: O(1) — append to right end of list
- dequeue: | 30 | 40 | 10 | 5 | 79 | 13 | O(n)

c) To implement a priority queue, we could use a **Python list order by priorities** in decending order. If we did, what would be the big-oh notation for each of the following methods: (justify your answer)

- enqueue: | 79 | 40 | 30 | 13 | 10 | 5 | O(n) O($\log_2 n$) search n, $\frac{n}{2}$, $\frac{n}{4}$, $\frac{n}{8}$; O($\frac{n}{2}$) insert; enqueue overall O(n)
- dequeue O(1)

Normal-case removeFront Deque

if self._size == 0:
raise Exception('')

(1) temp = self._front

(2) self._front = self._front.getPrevious()

(3) self._front.setNext(None)

if self._size == 1:
(3') self._rear = None
else:

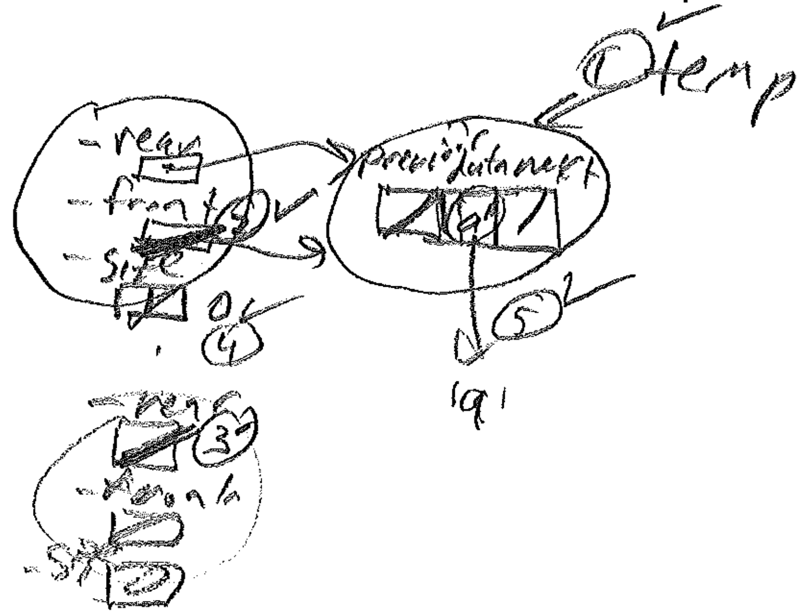
(4) self._size -= 1

(5) return temp.getData()

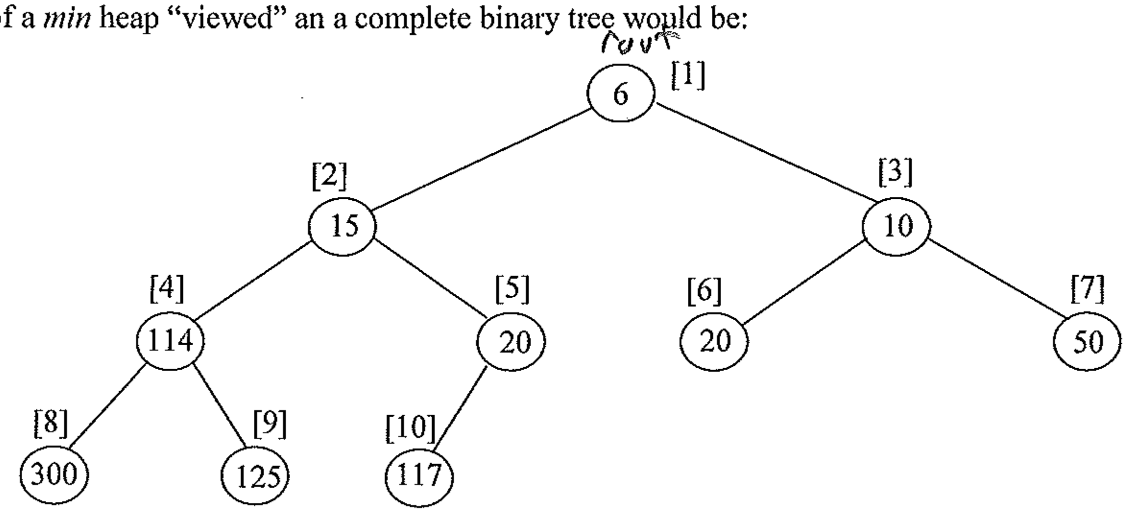
Special cases

(1) removingFront of only / last node

(2) precondition - empty Deque



1. Section 6.6 discusses a very "non-intuitive", but powerful list/array-based approach to implement a priority queue, call a binary heap. The list/array 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" an 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	6	15	10	114	20	20	50	300	125	117

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

- its left child if it exists: 2*i
- its right child if it exists: 2*i + 1
- its parent if it exists: i // 2

b) What would the above heap look like after inserting 13 and then 3? (show the changes on above tree)

General Idea of insert(newItem):
- append newItem to the end of the list (easy to do, but violates heap-order property)
- restore the heap-order property by repeatedly swapping the newItem with its parent until it *percolates* to correct spot

c) What is the big-oh notation for inserting a new item in the heap?

d) Complete the code for the percUp method used by insert.

```
class BinHeap:
    def __init__(self):
        self.heapList = [0]
        self.currentSize = 0

    def percUp(self,currentIndex):
        parentIndex =
        while








    def insert(self,k):
        self.heapList.append(k)
        self.currentSize = self.currentSize + 1
        self.percUp(self.currentSize)
```