Prepared by Julian García, based on material by
David Albrecht and María García de la Banda

Lecture 19
Linked Queues

FIT 1008
Introduction to Computer Science

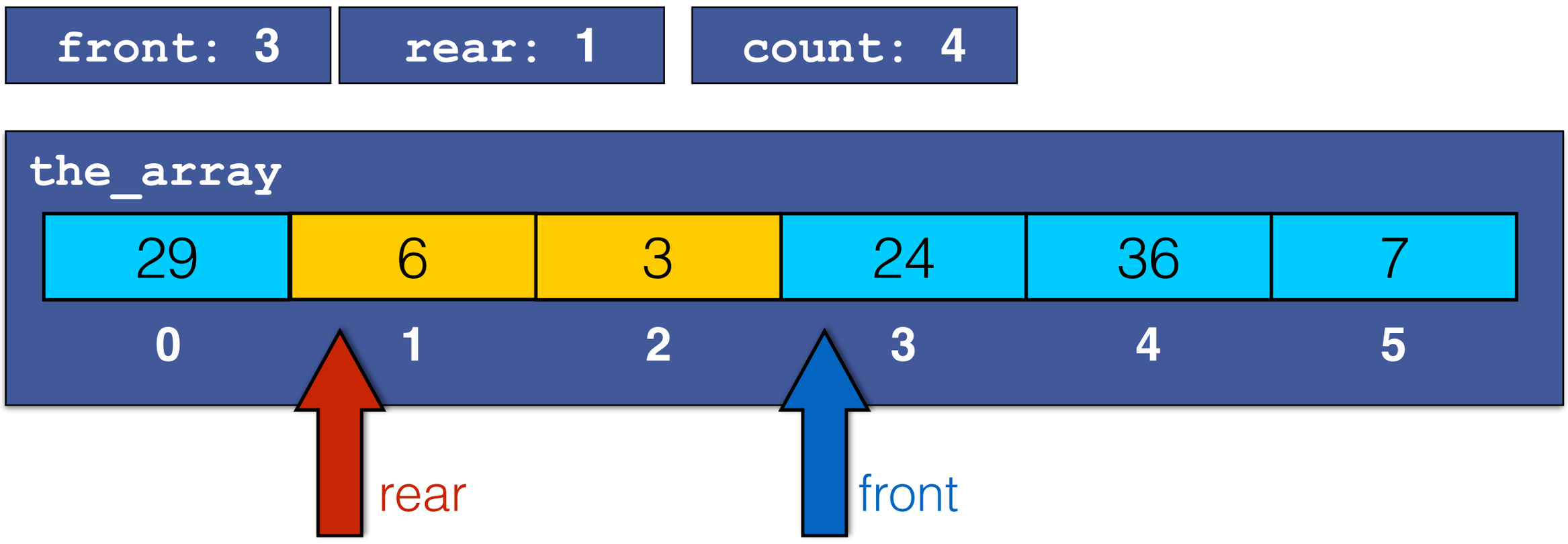
Objectives for these this lecture

- To understand:
  - The concept of linked data structures
  - Their use in **implementing queues**

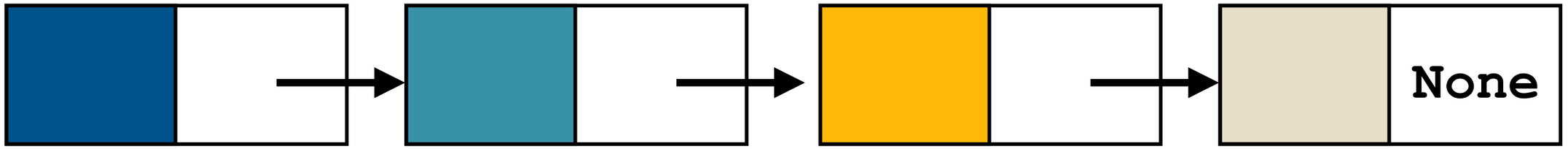
- To be able to:
  - Implement, use and modify **linked queues**.
  - Decide when it is appropriate to use them (rather than arrays)

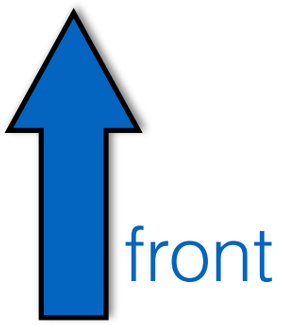
“Form an orderly queue to the left..”

Remember array-based queues?



Linked Queue





Important: Rear now designates the last node

No need for circularity.

count is optional…

```
from node import Node


class Queue:
    def __init__(self):
        self.front = None
        self.rear = None

    def is_empty(self):
        return self.front is None

def is_full(self):
    return False

def reset(self):
    self.front = None
    self.rear = None
```

Append: algorithm

Circular array implementation:

- If the array is full raise exception
- Else
  - Increase rear % length of the array
  - Add the item at the position designated by rear

No need for is_full check.
If no more memory can be allocated the system will raise an exception.

Linked implementation:

- Create a **new node** that contains item and points to None
- Link the current rear to it
- Change rear to point to new node.

Would this work?

```
def append(self, item):
    self.rear.next = Node(item, None)
    self.rear = self.rear.next
```

Let’s try

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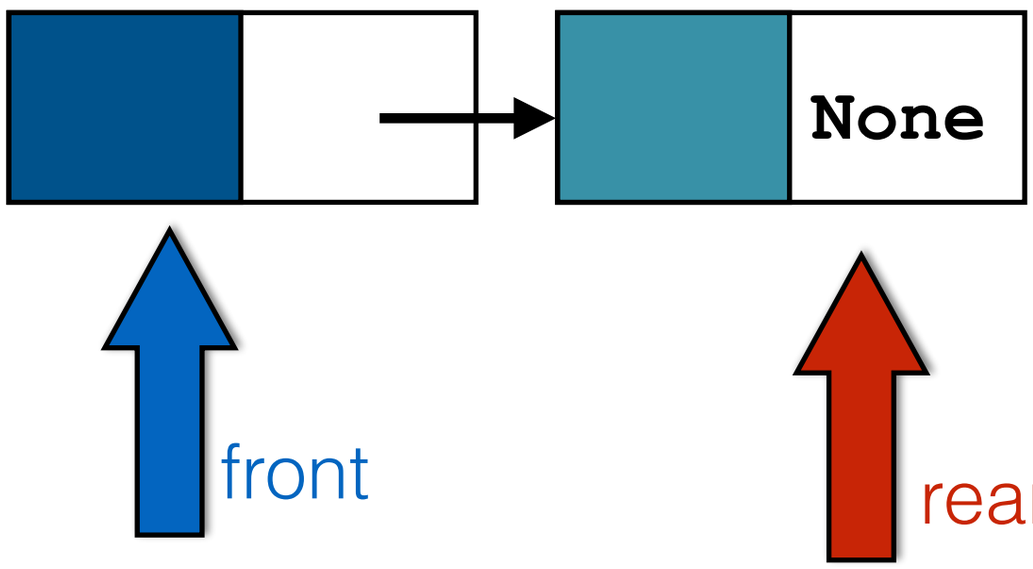

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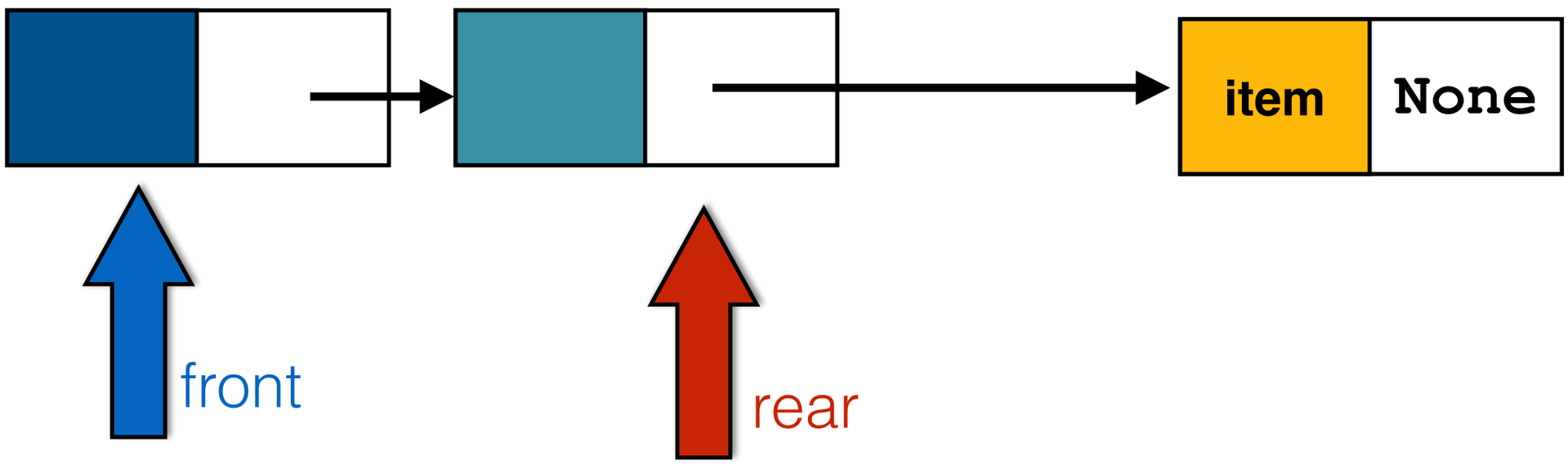

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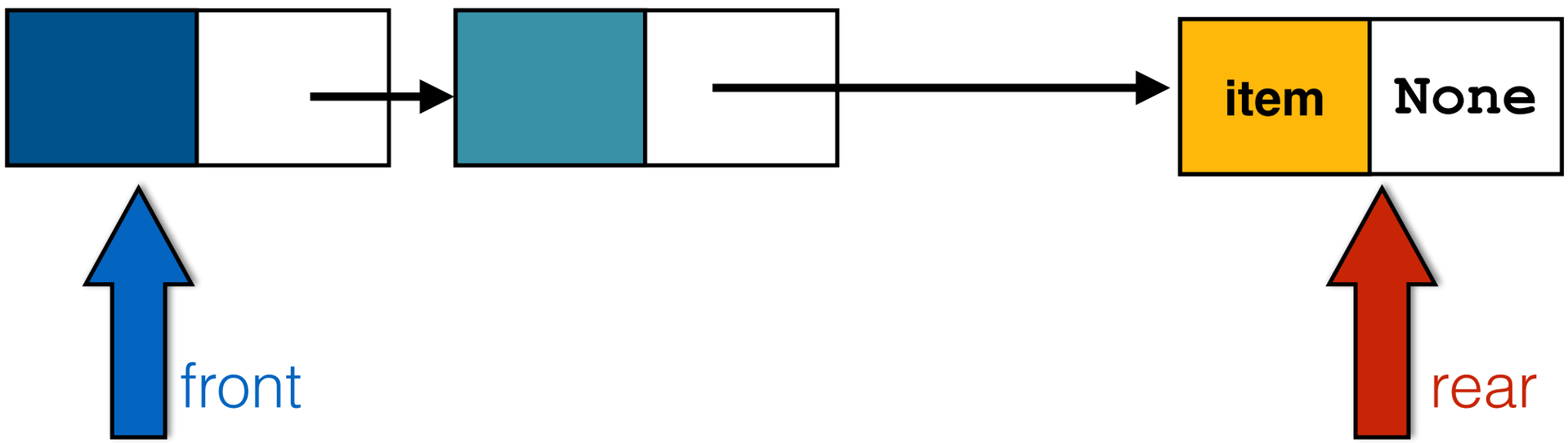

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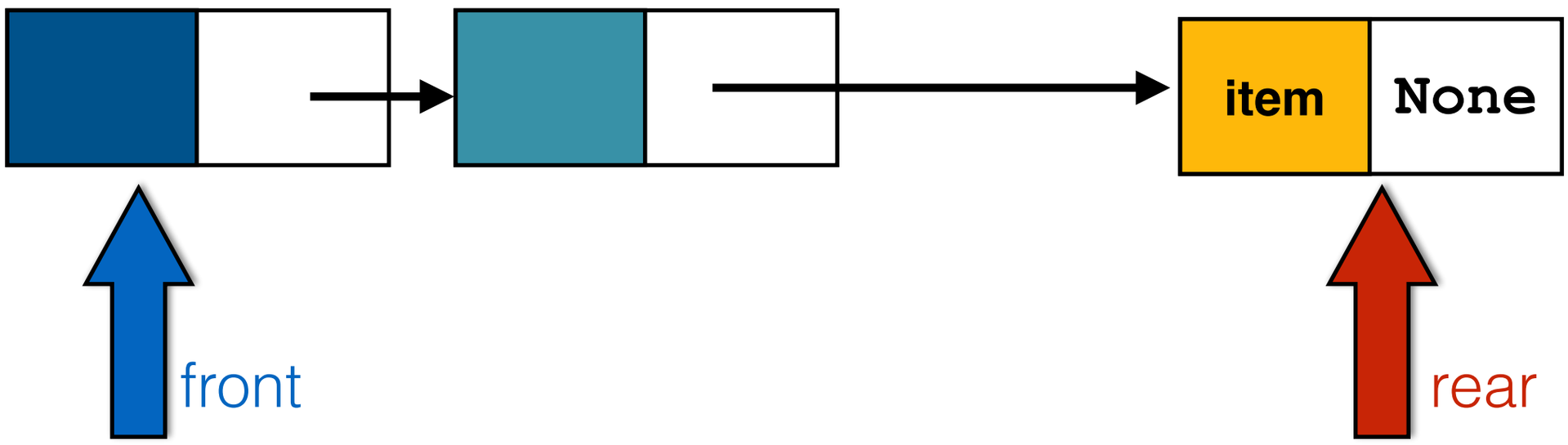
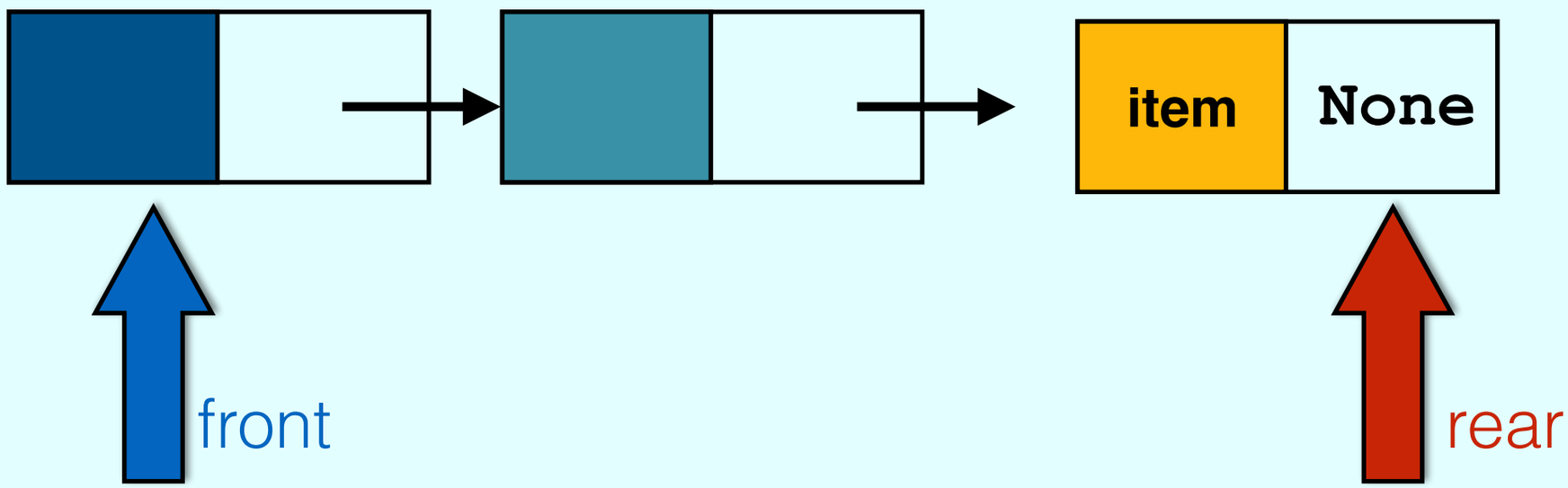


Goal



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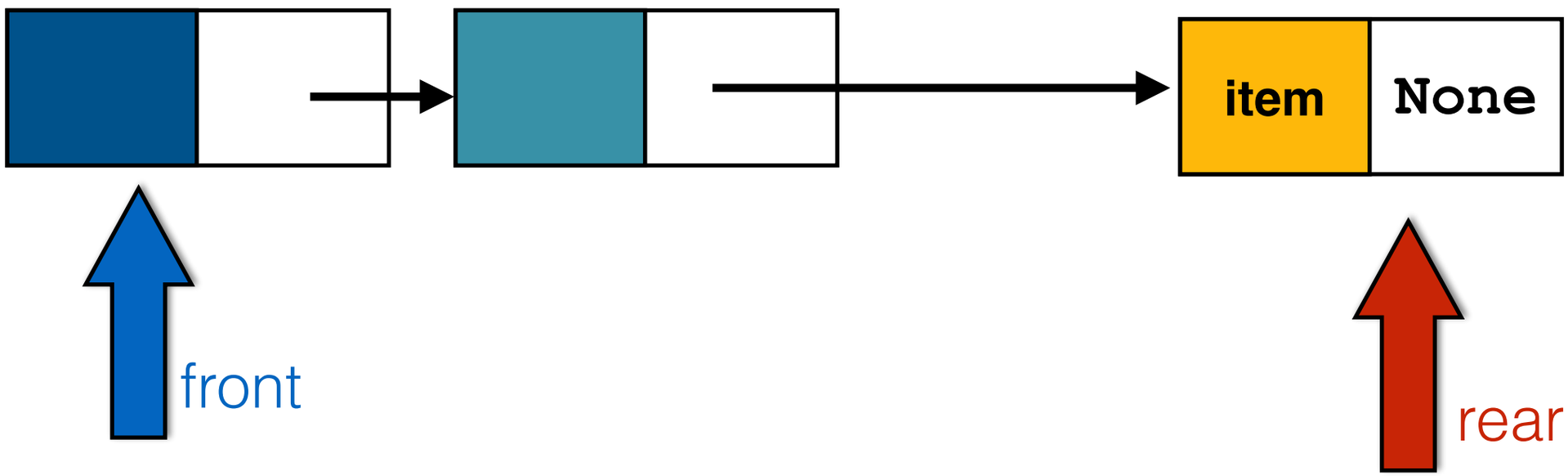

- Create a new node for item
- Make a link from current rear to new node
- The new node becomes the new rear

Boundary cases

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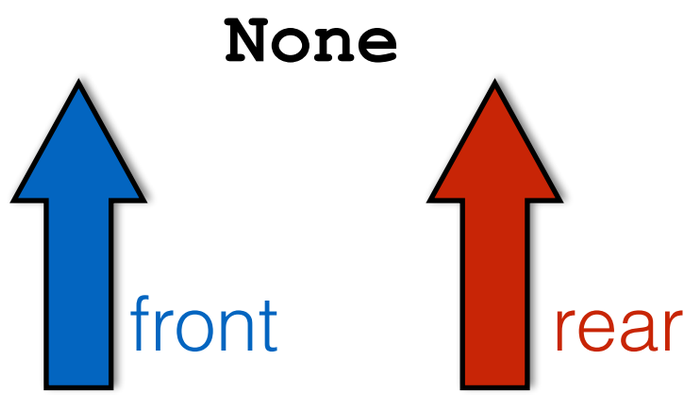

If the queue is empty
we need to do something with **front**

Would this work?

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def append(self, item):
    self.rear.next = Node(item, None)
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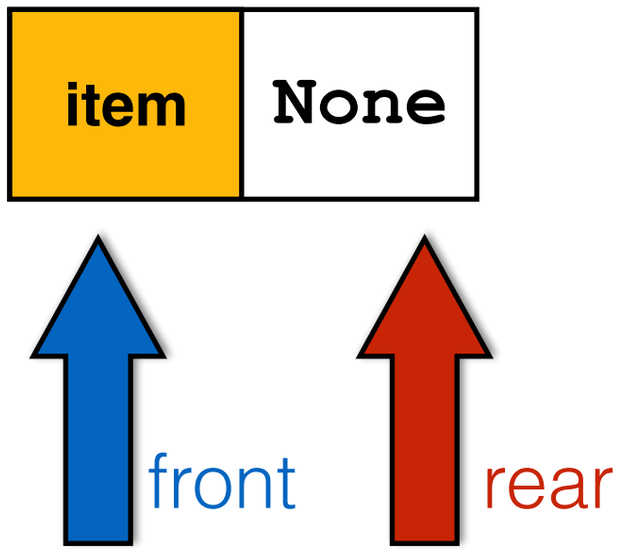
Nope



- Create a new node for item
- If the queue is empty:
    - Make the new node be the front
- If the queue is <u>not</u> empty:
    - Make a link from current rear to new node
- The new node becomes the new rear

```
def append(self, item):
    new_node = Node(item, None)
    if self.is_empty():
        self.front = new_node
    else:
        self.rear.next = new_node
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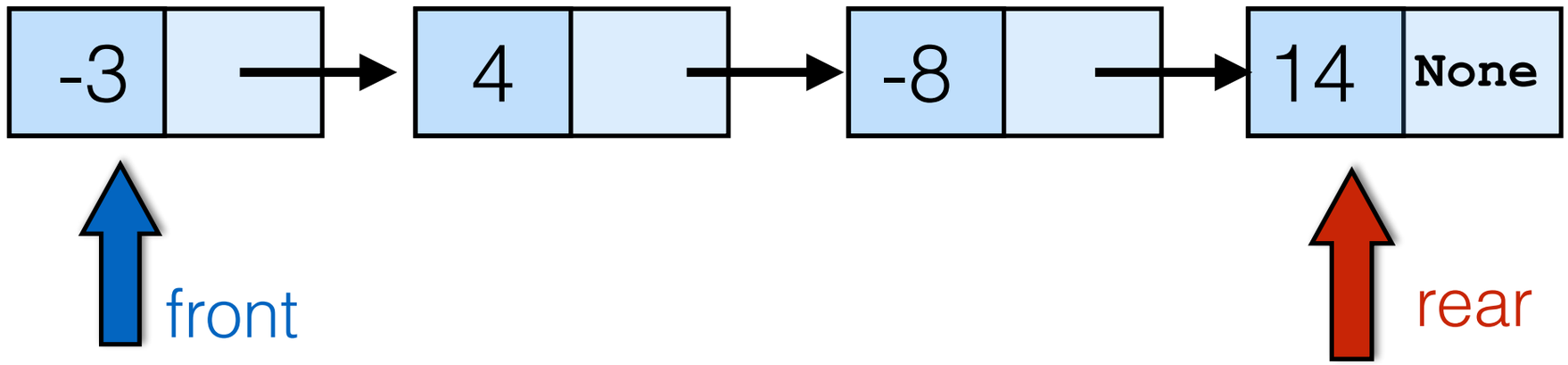


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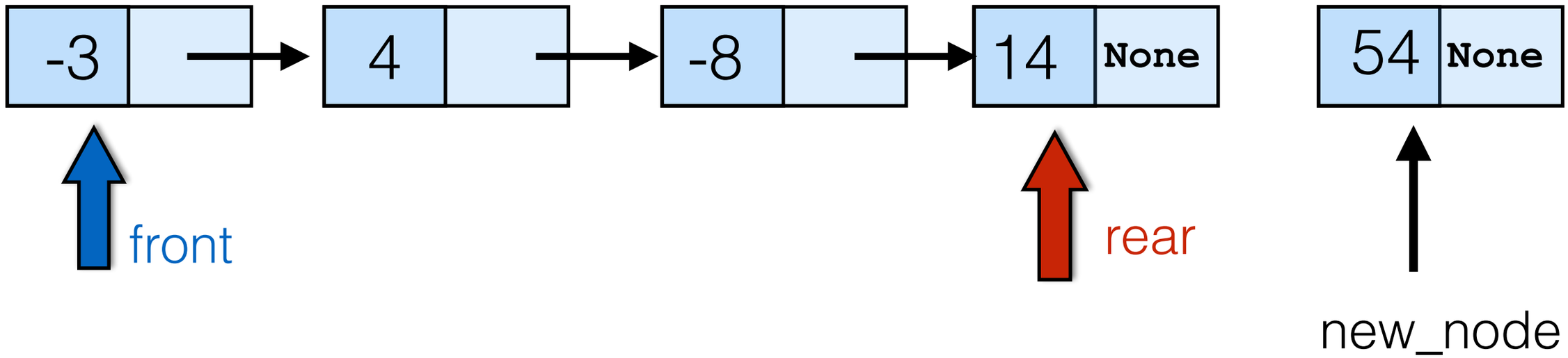


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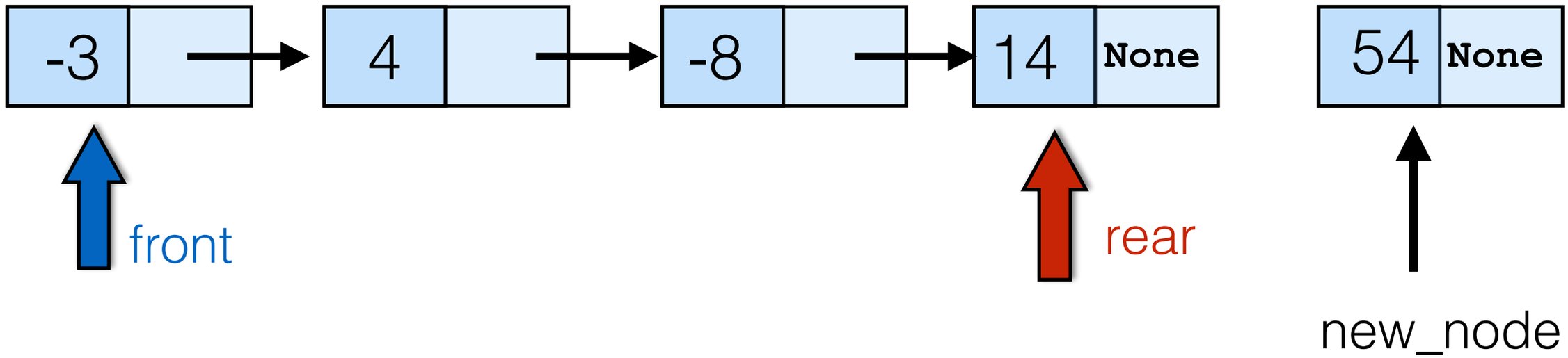


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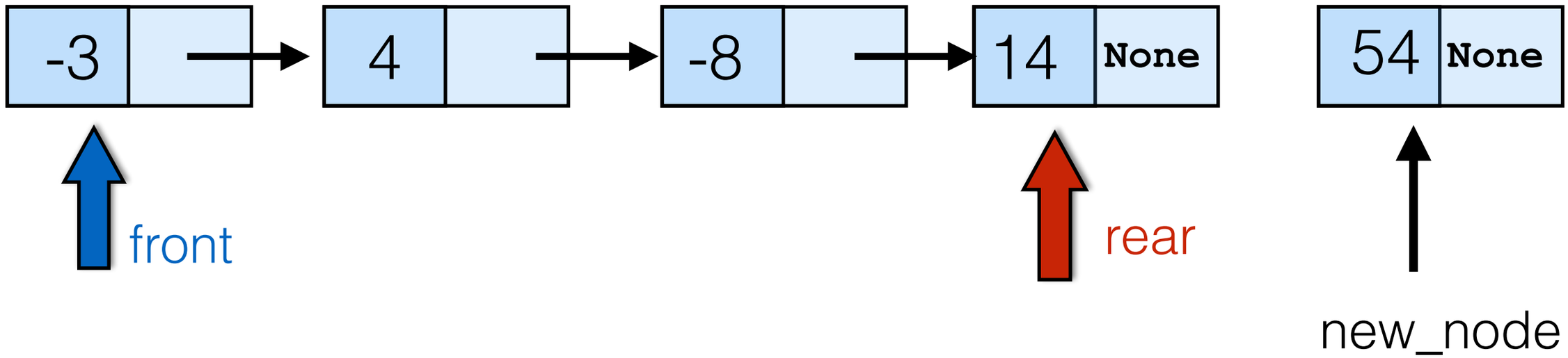


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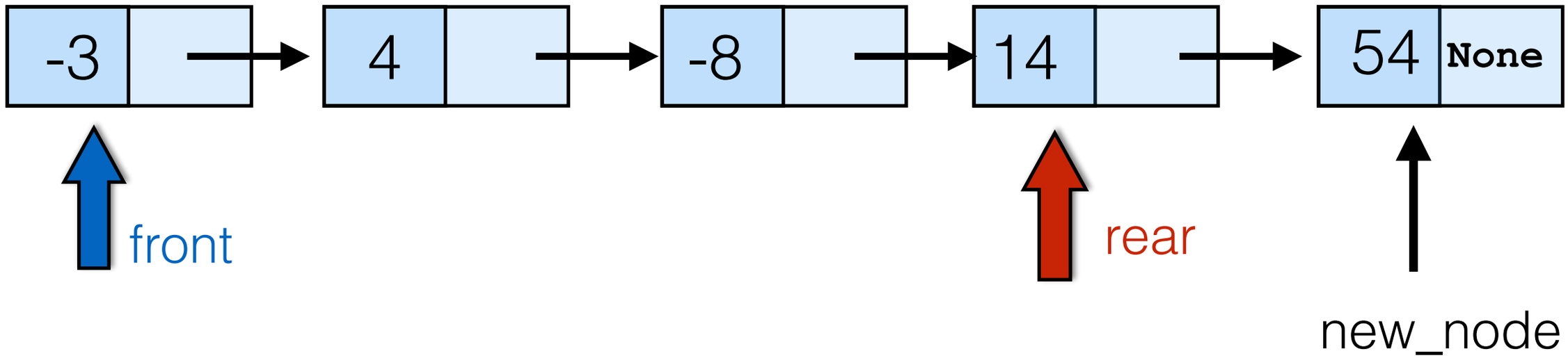


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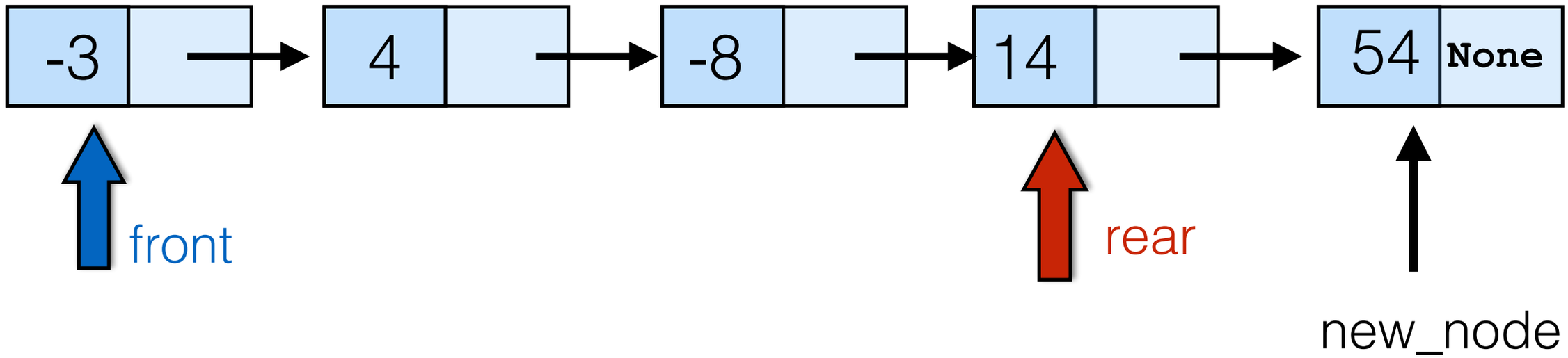


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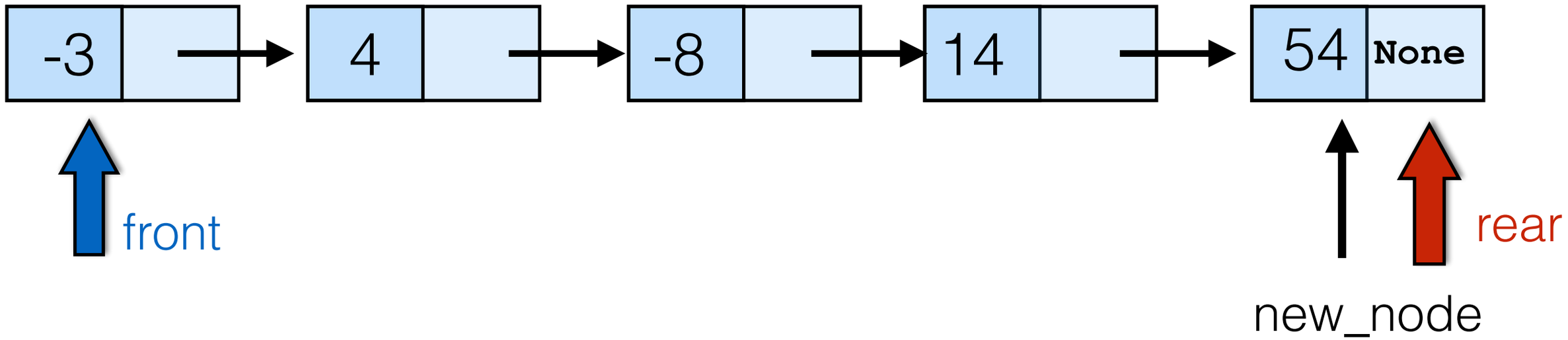


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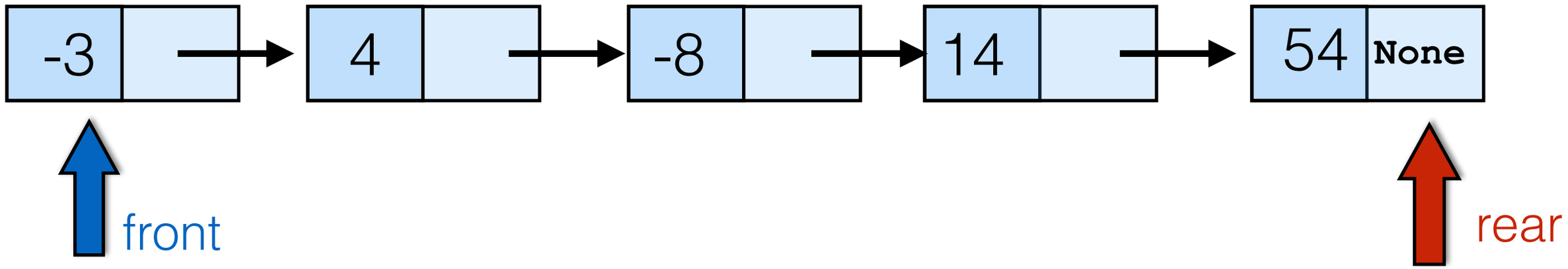


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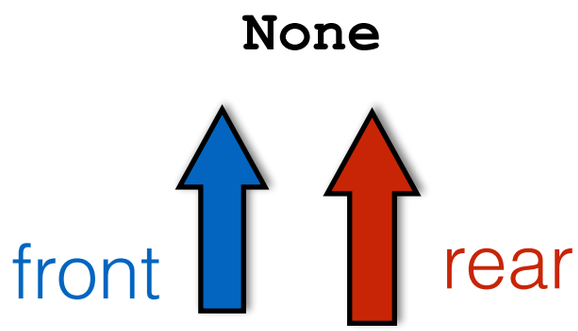


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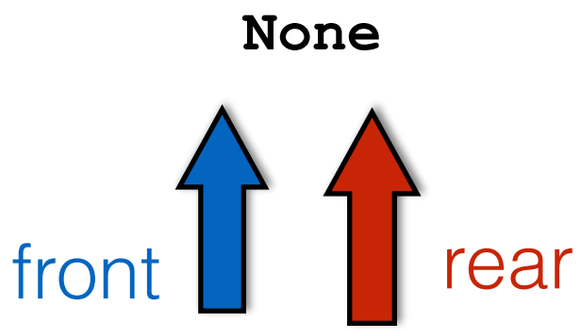

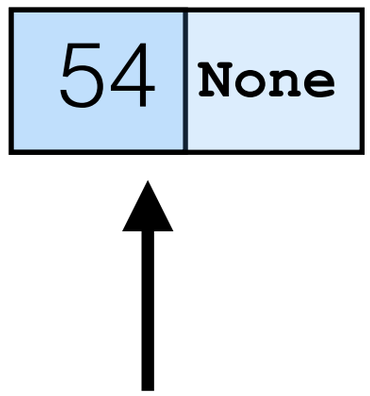


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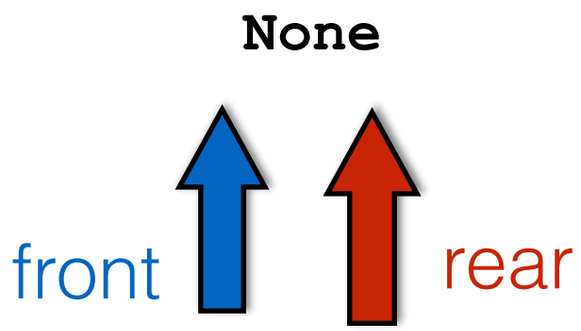

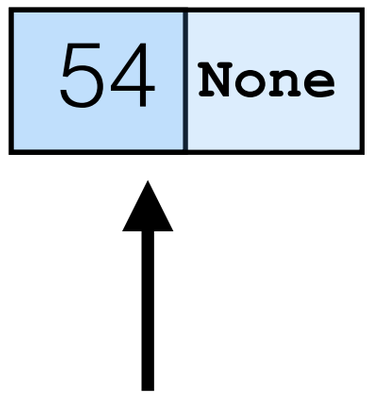


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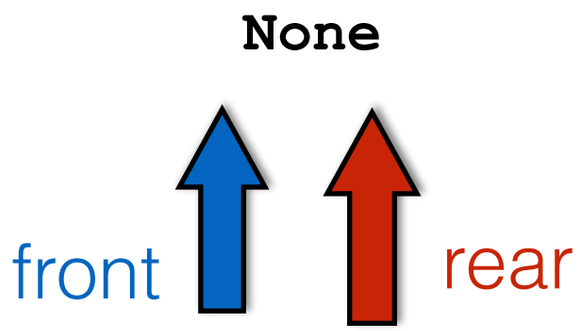

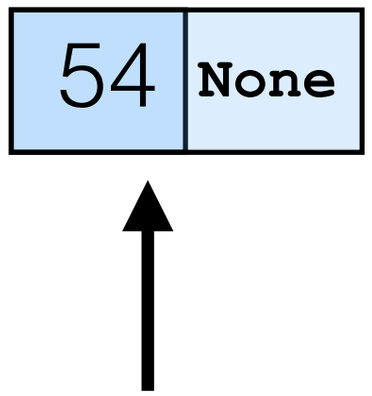


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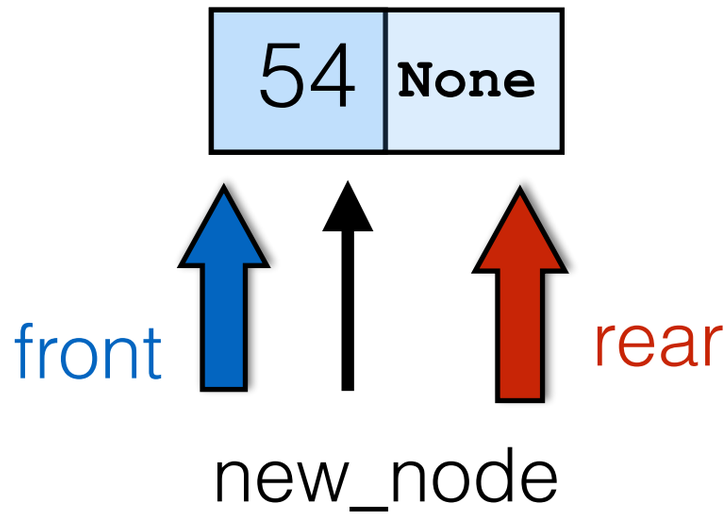


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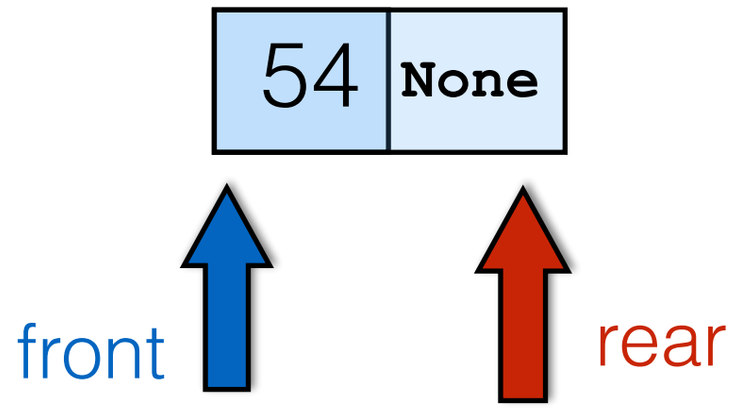


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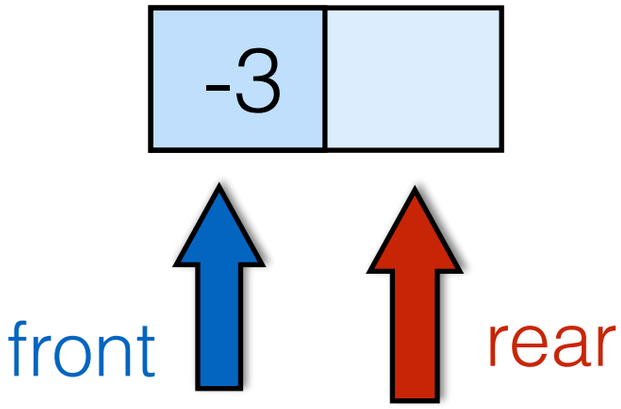


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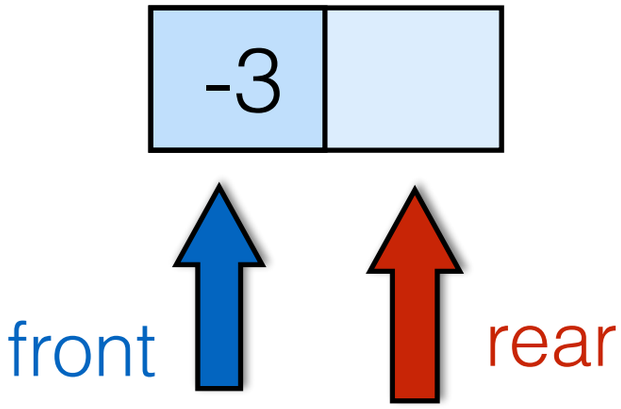


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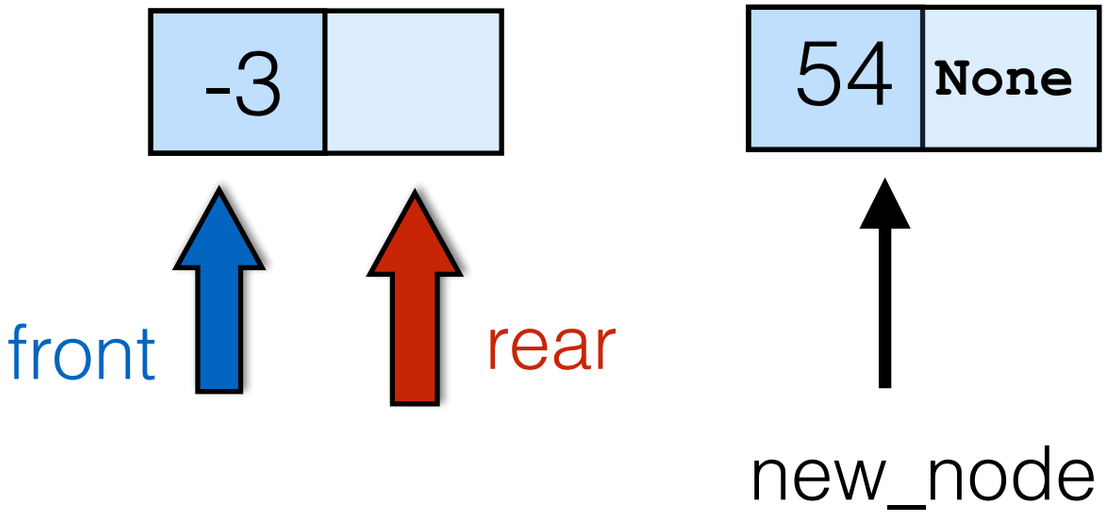


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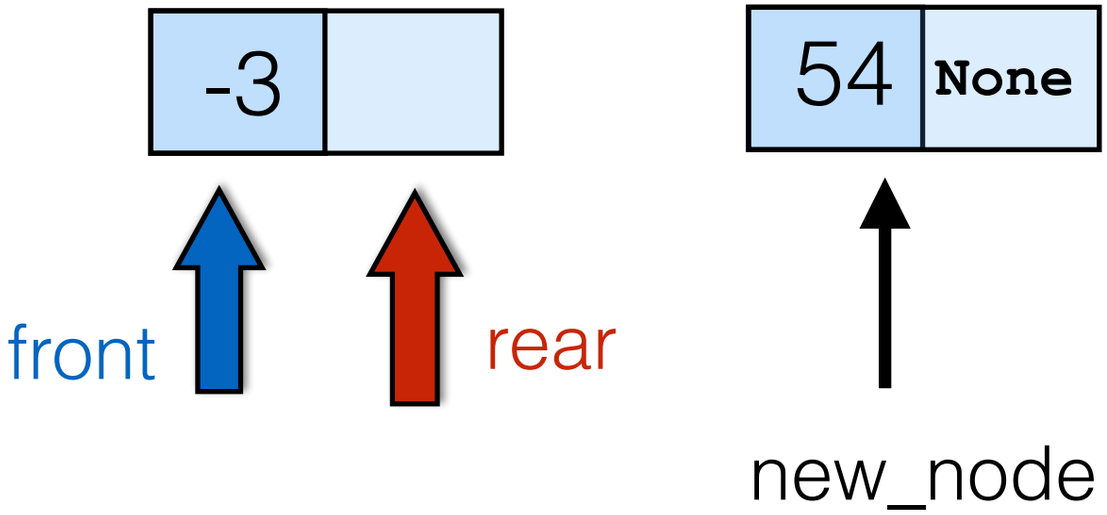


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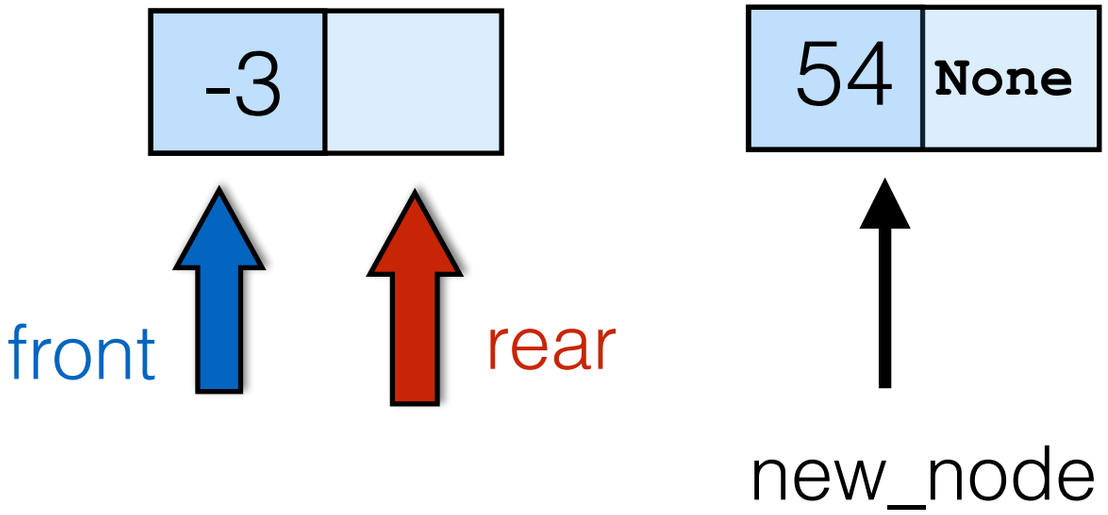


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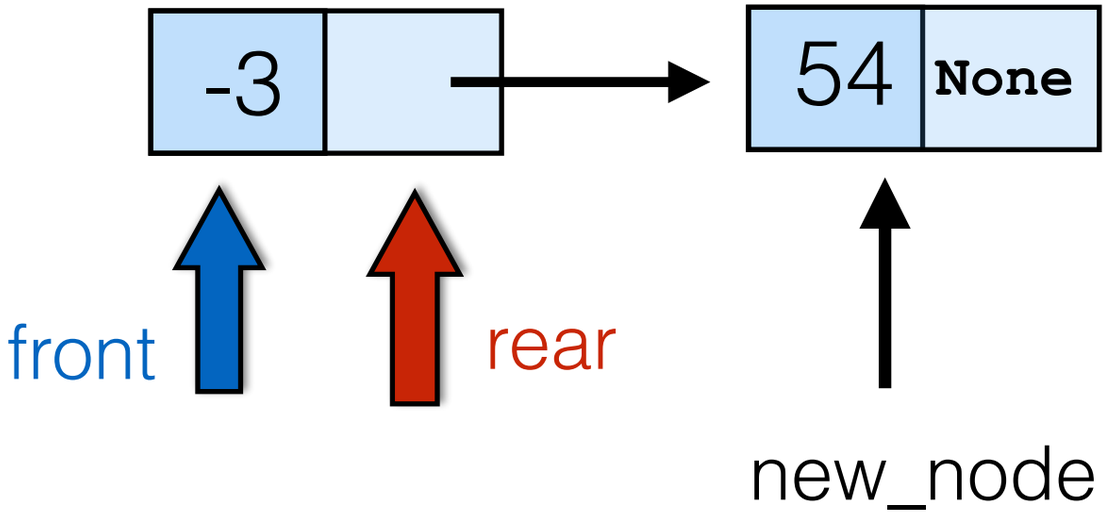


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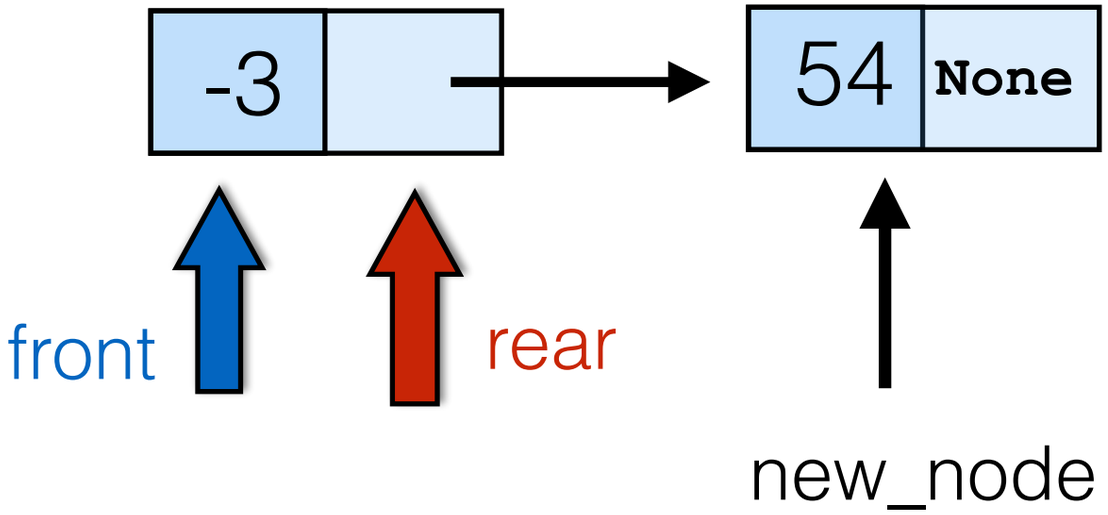
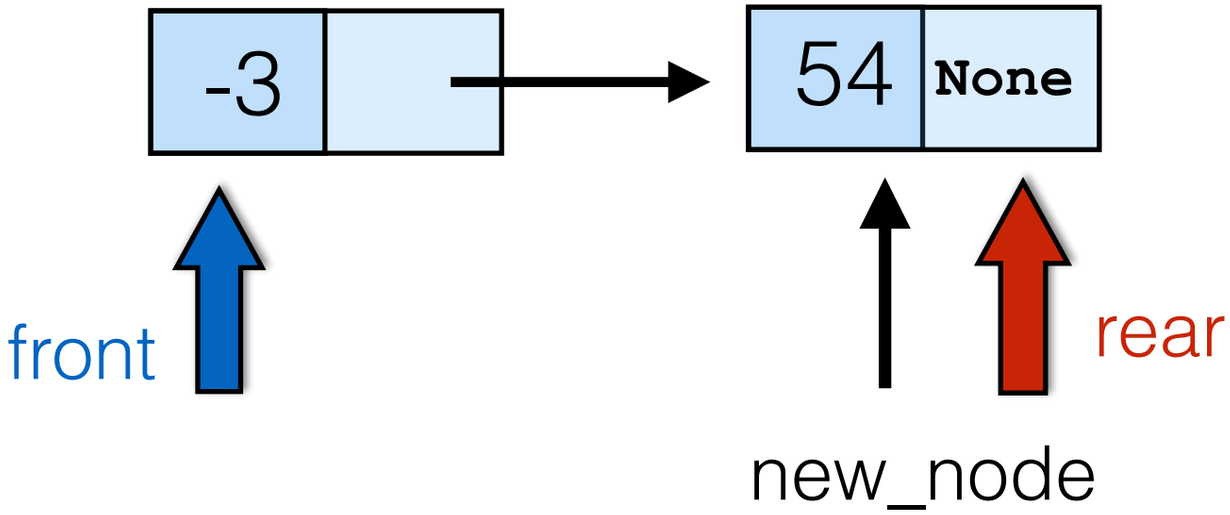



```
if q.front is q.rear
```

```
q.append(54)
```

```
def append(self, item):
    new_node = Node(item, None)
    if self.is_empty():
        self.front = new_node
    else:
        self.rear.next = new_node
    self.rear = new_node
```

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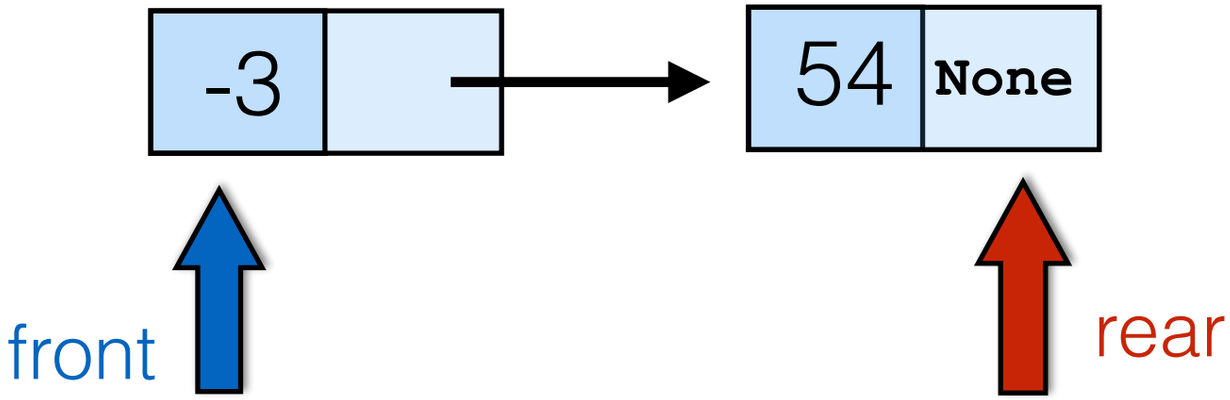


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```

Useful to check cases

- A few nodes.

- Empty.

- Single node.

Serve: algorithm

Circular array implementation:

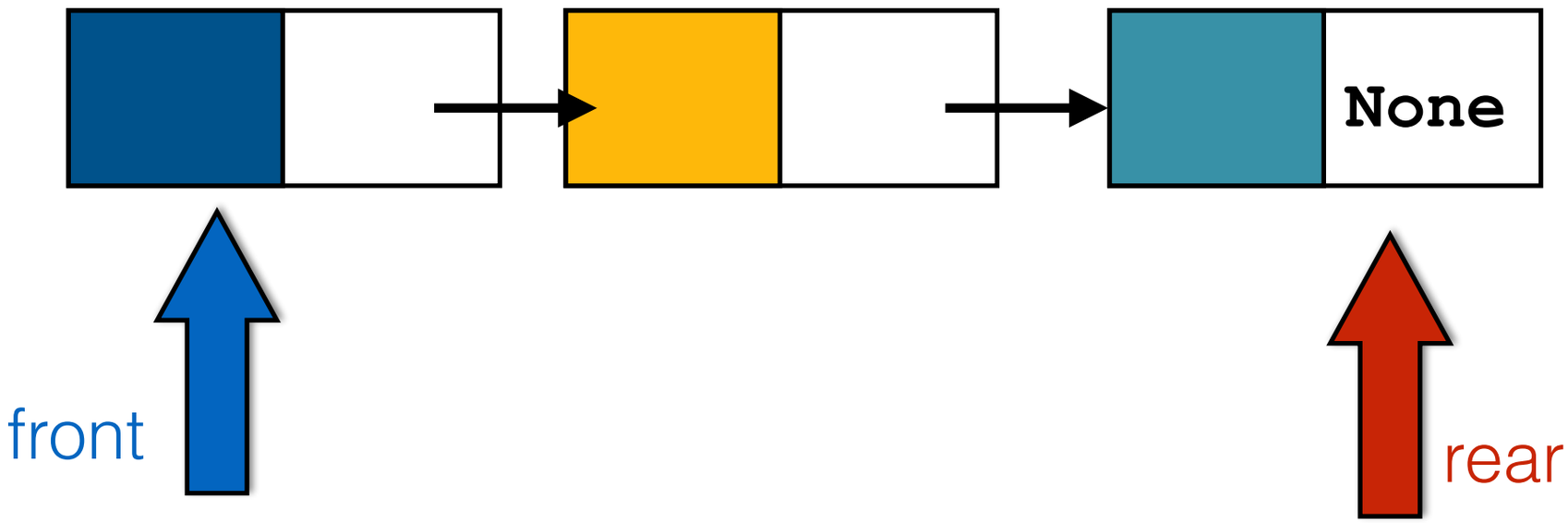
- If the array is empty raise exception
- Else
  - Remember item to return
  - Increase front % length of the array
  - Return the item

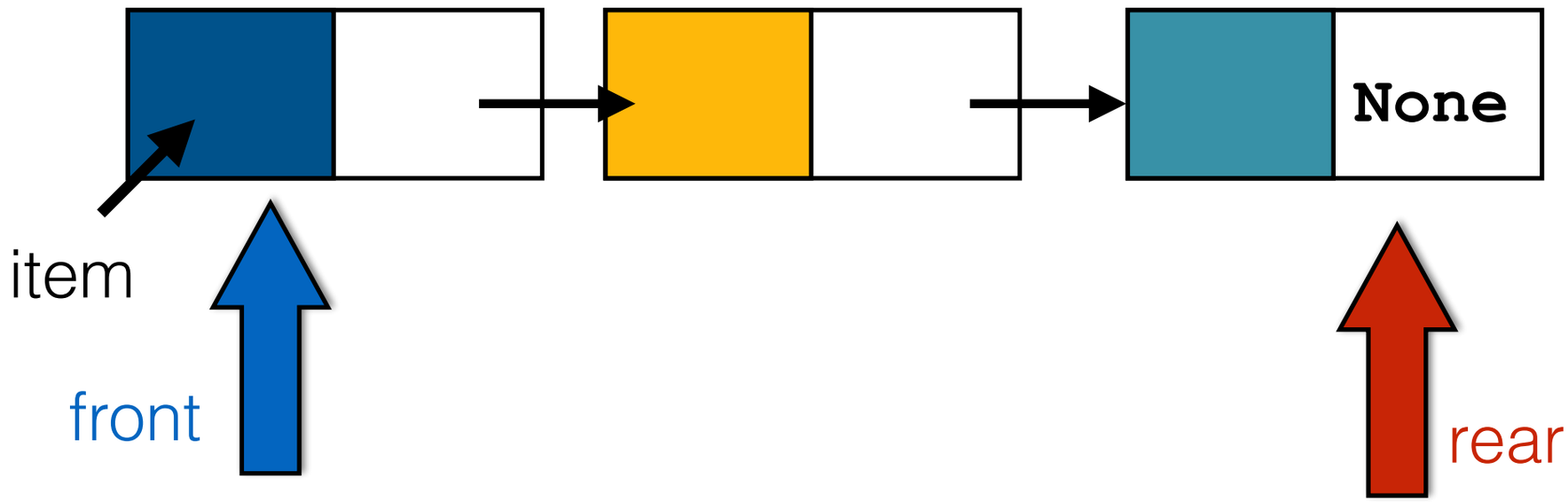
Linked implementation:

- If the array is empty raise exception
- Else
  - Remember item to return
  - Change front to point to the next node
  - Return the item

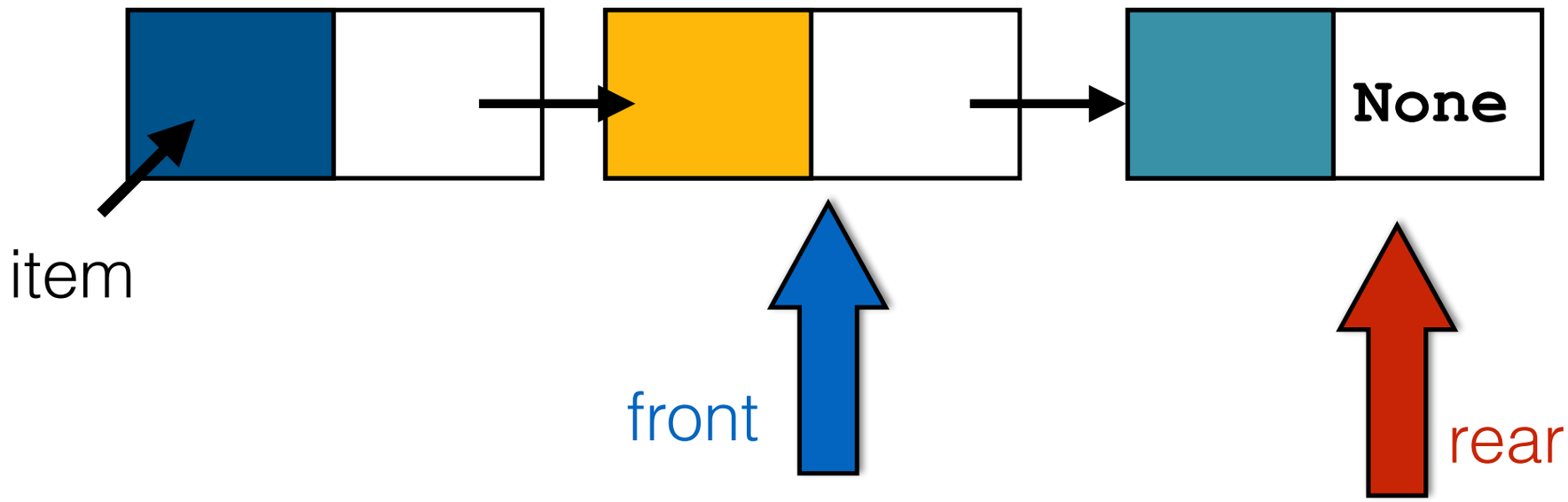
Would this work?

```
def serve(self):
    item = self.front.item
    self.front = self.front.next
    return item
```

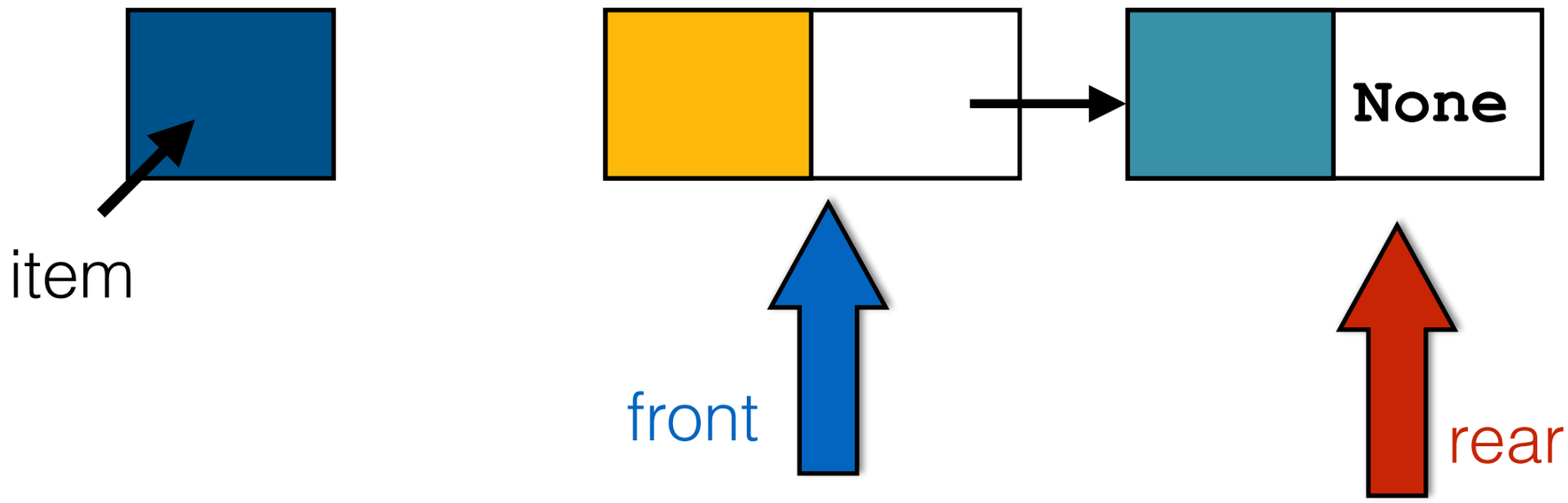

None
front
rear



- Remember the item in the front node.

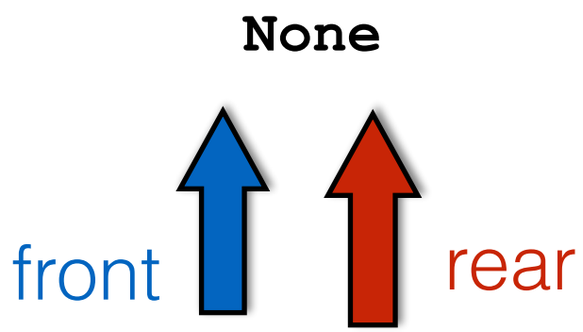


- Remember the item in the front node.
- Make the next node the new front

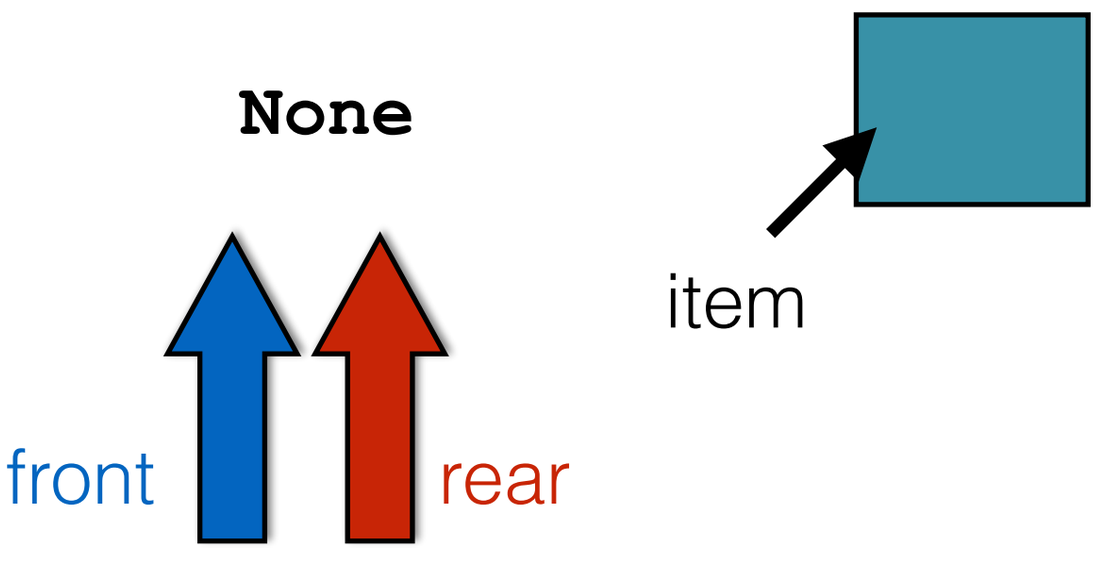


- Remember the item in the front node.
- Make the next node the new front
- Return the item

Boundary cases…



If the queue is empty we need to raise an Exception



- If the queue is empty we raise an Exception
- Remember the item in the front node.
- Make the next node the new front
- If front is pointing to None (i.e., queue is <u>now</u> empty)
    - Point rear to None
- Return the item

```
def serve(self):
    assert not self.is_empty(), " The queue is empty"
    temp = self.front.item
    self.front = self.front.next
    if self.is_empty():
        self.rear = None
    return temp
```

- If the queue is empty we raise an Exception
- Remember the item in the front node.
- Make the next node the new front
- If front is pointing to None (i.e., queue is now empty)
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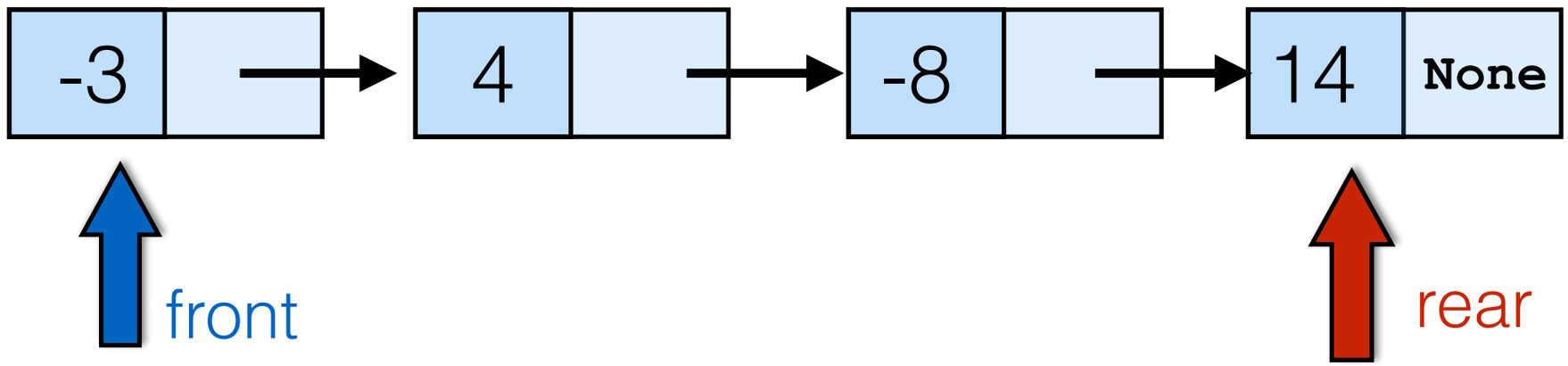

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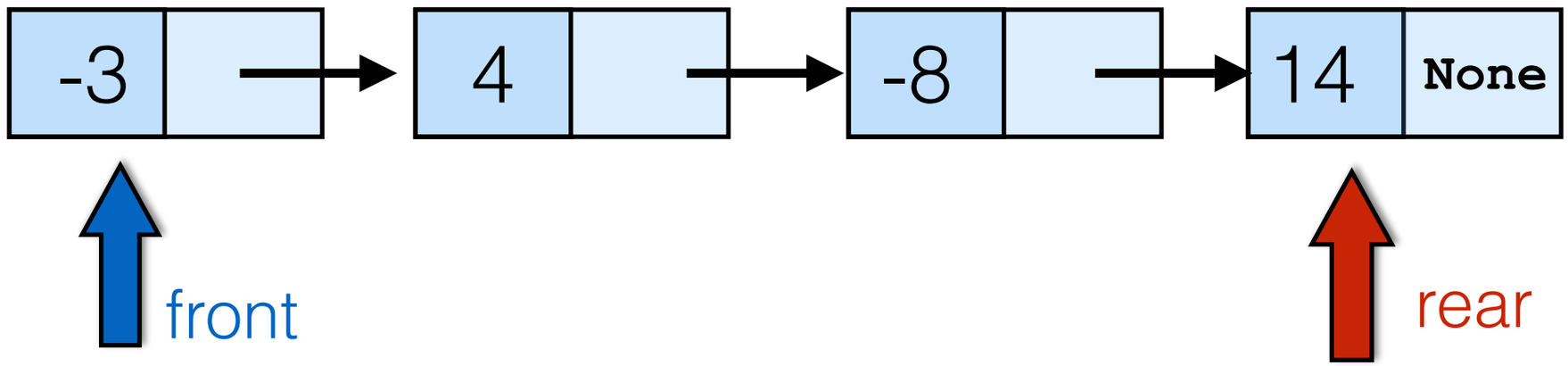

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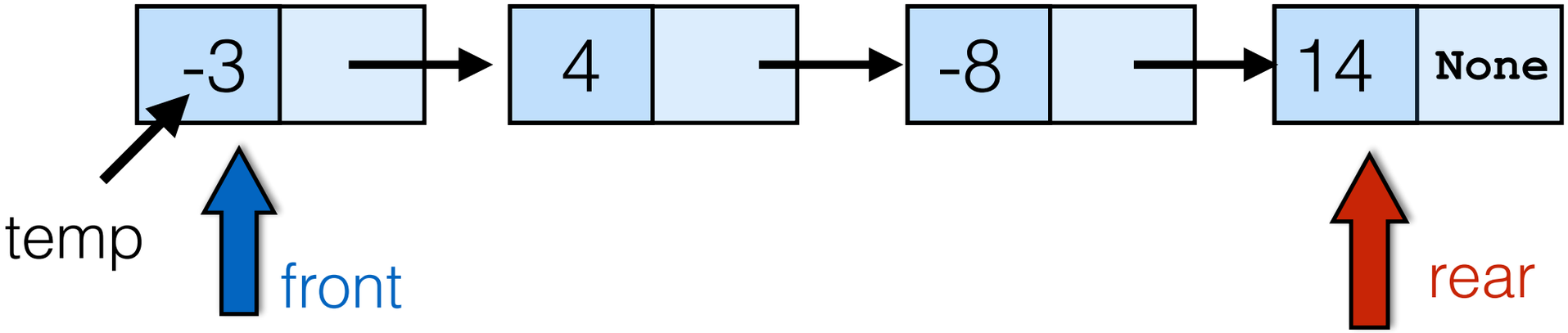

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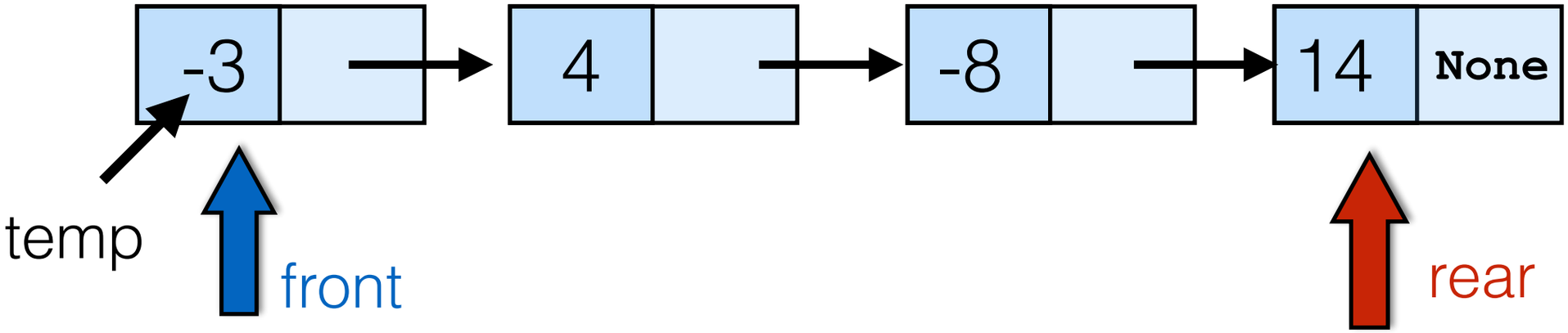

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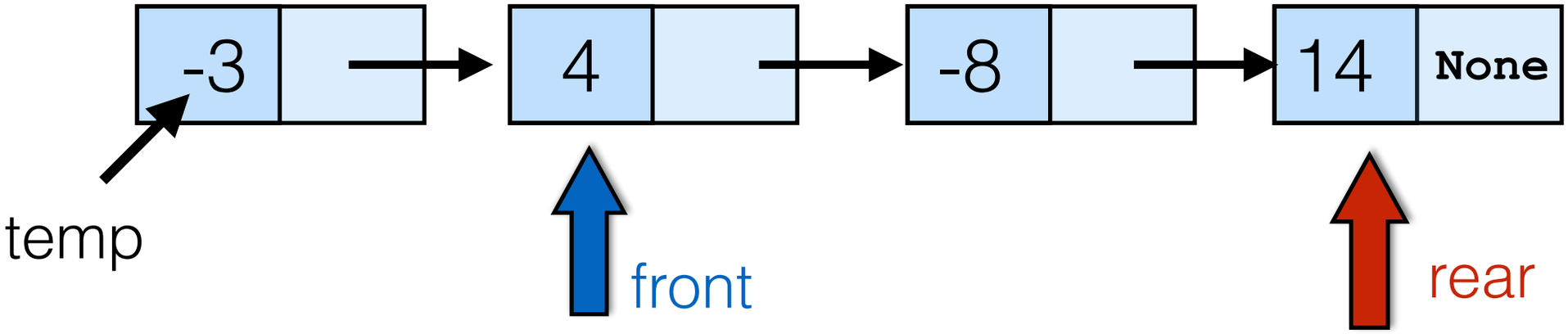

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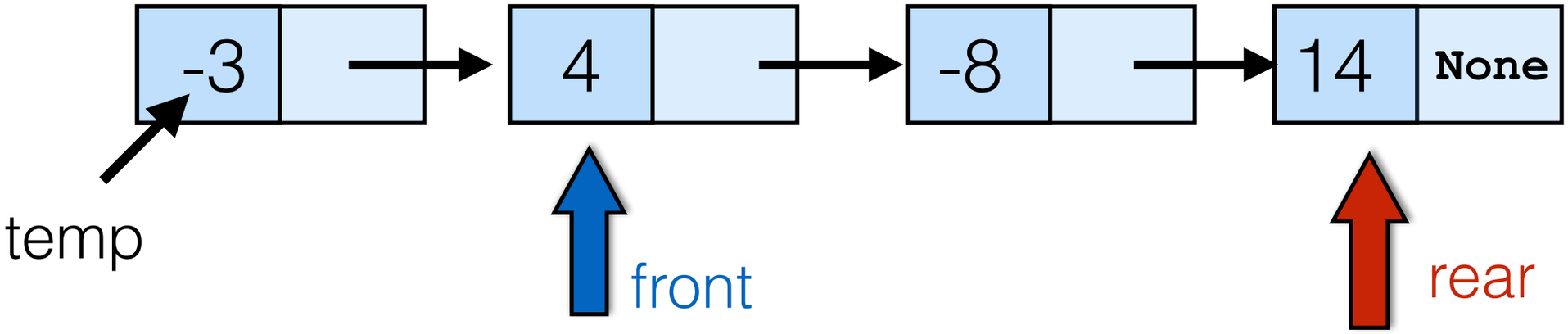

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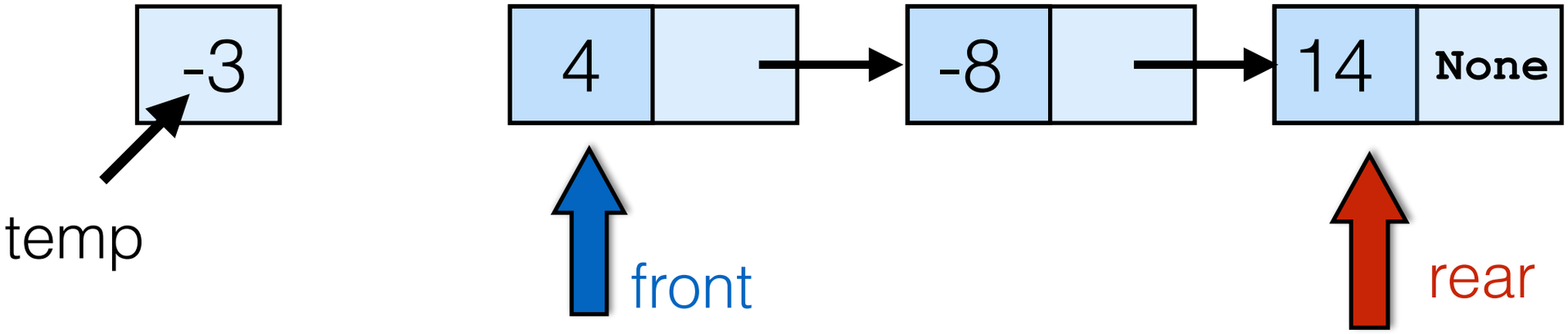

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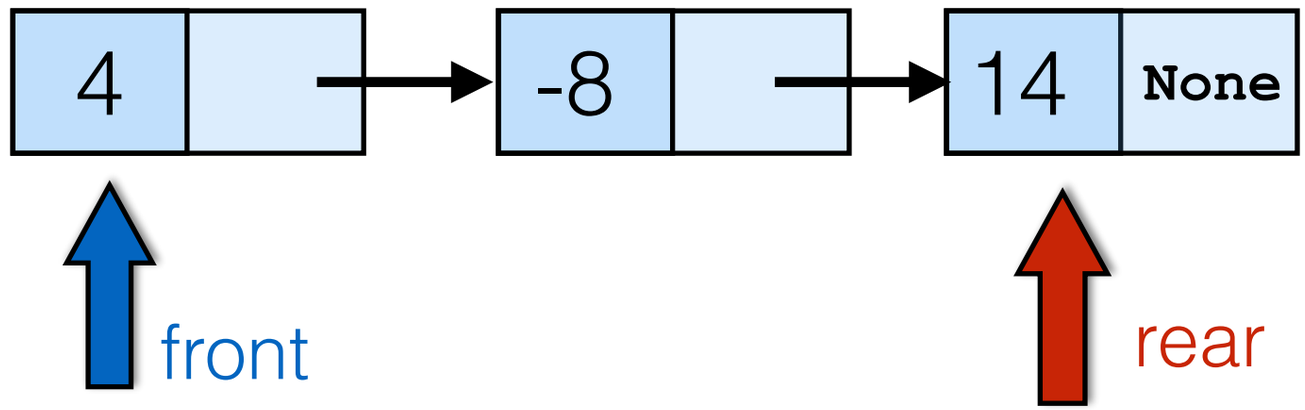

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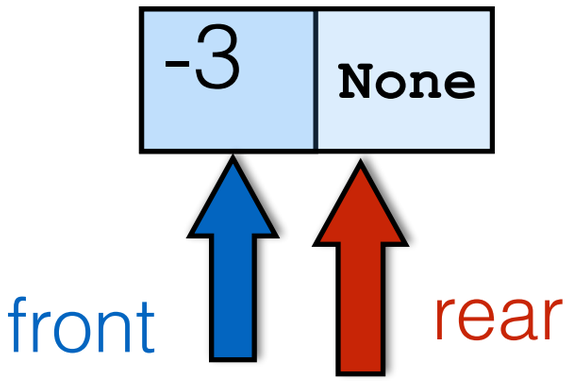


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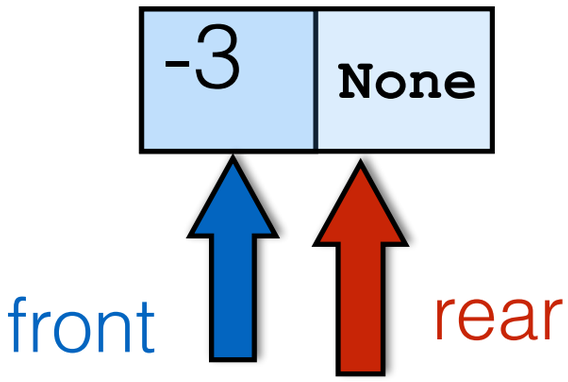

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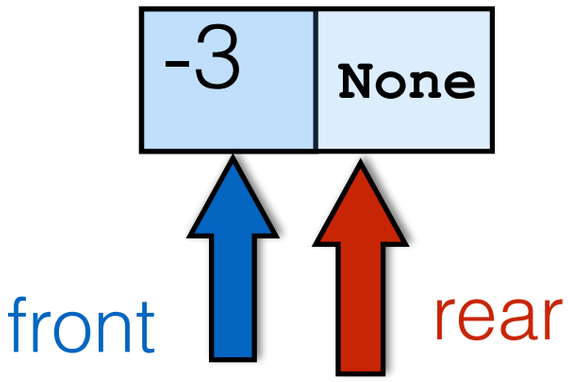

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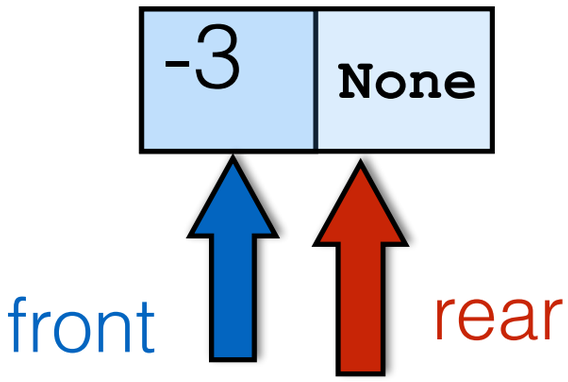

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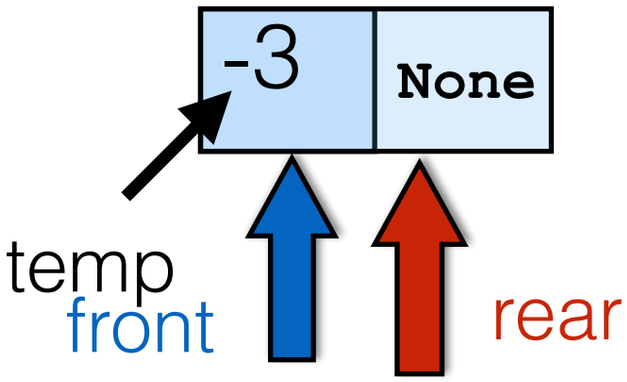

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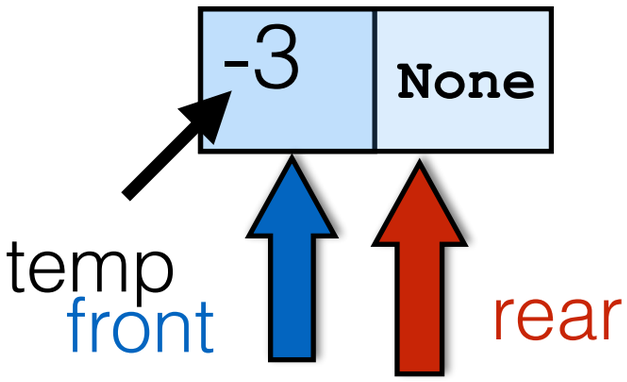

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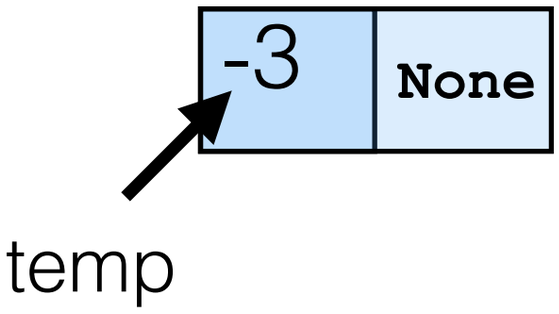

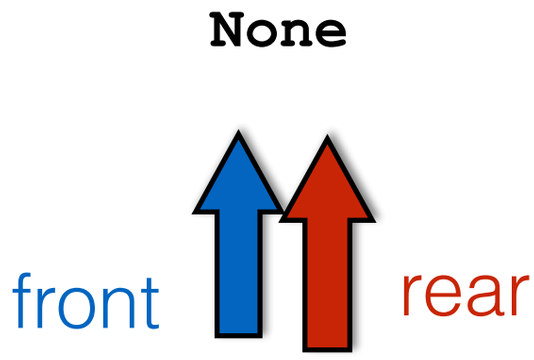

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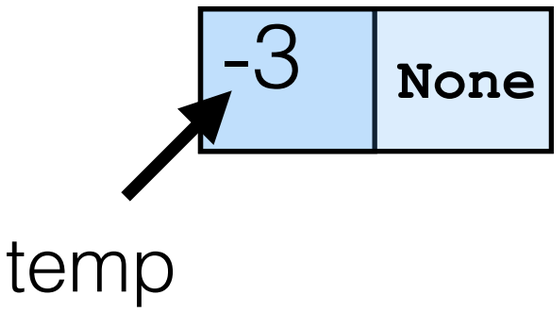

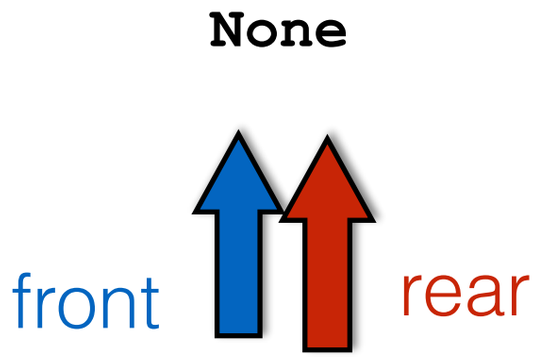

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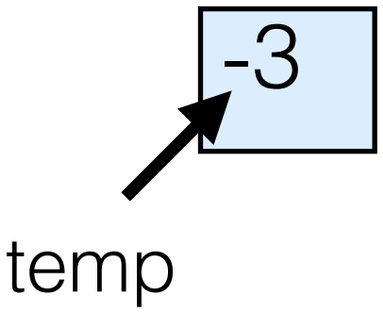
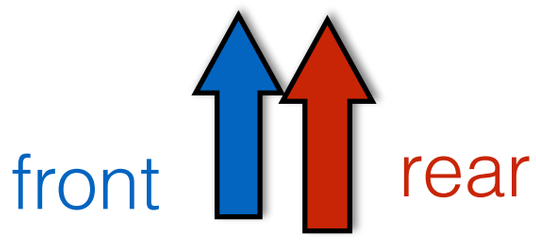


None



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Summary

- Queues implemented with linked data structures