

COMP 250

INTRODUCTION TO COMPUTER SCIENCE

Assignment Project Exam Help

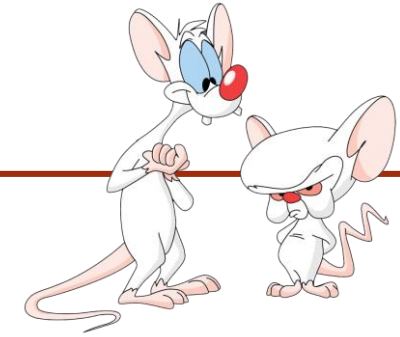
<https://powcoder.com>

Week 7-2: Queues

Giulia Alberini, Fall 2020

Slides adapted from Michael Langer's

WHAT ARE WE GOING TO DO IN THIS VIDEO?



- **Queues**

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

ADT (ABSTRACT DATA TYPE)

- List

`add(i, e), remove(i), get(i), set(i), ..`

Assignment Project Exam Help

<https://powcoder.com>

- Stack

`push(e), pop(), ..`

Add WeChat powcoder

- Queue

`enqueue(e), dequeue()`

QUEUE

dequeue
(remove from front)

enqueue
(add at back)

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder



e.g. Server



clients

EXAMPLES

- keyboard buffer

- CPU processes

Assignment Project Exam Help
(applications do not run in parallel)

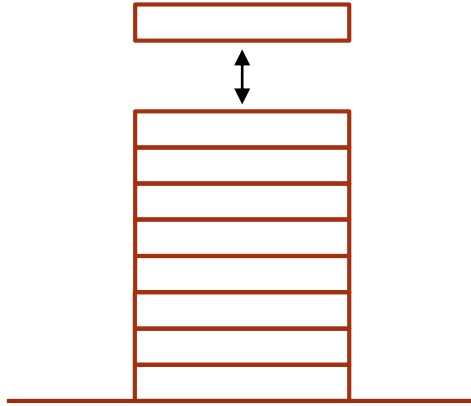
<https://powcoder.com>

- web server

Add WeChat powcoder

- students in the zoom waiting room

- ...



Stack

Assignment Project Exam Help

<https://powcoder.com>

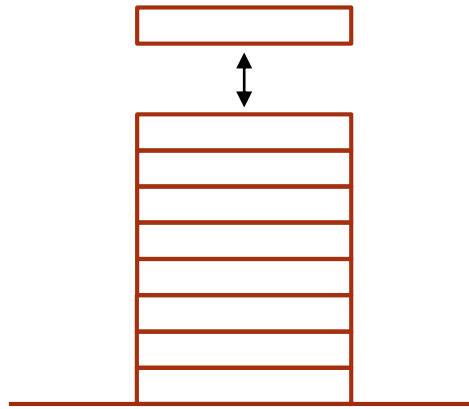
push(e)

Add WeChat powcoder

pop()

LIFO

(last in, first out)



Stack

push(e)

pop()

LIFO

(last in, first out)



Queue

enqueue(e)

dequeue()

FIFO

(first in, first out)

“first come, first serve”

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

QUEUE EXAMPLE

enqueue(a)

enqueue(b)

dequeue()

a

a b

b

returns a

time

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

QUEUE EXAMPLE

enqueue(a)

enqueue(b)

dequeue()

enqueue(c)

enqueue(d)

enqueue(e)

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

returns a

a

ab

b

bc

bcd

bcde

time

QUEUE EXAMPLE

enqueue(a)

enqueue(b)

dequeue()

enqueue(c)

enqueue(d)

enqueue(e)

dequeue()

enqueue(f)

enqueue(g)

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

a

ab

b

bc

bcd

bcde

cde

cdef

cdefg

returns a

returns b

time

HOW TO IMPLEMENT A QUEUE?

enqueue(e)

dequeue()

singly linked list

doubly linked list

array list

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

HOW TO IMPLEMENT A QUEUE?

enqueue(e)

dequeue()

singly linked list

addLast(e)

removeFirst()

<https://powcoder.com>

doubly linked list

Add WeChat powcoder

array list

HOW TO IMPLEMENT A QUEUE?

enqueue(e)

dequeue()

singly linked list

addLast(e)

removeFirst()

<https://powcoder.com>

doubly linked list

Add WeChat powcoder

(same, or addFirst() & removeLast())

array list

HOW TO IMPLEMENT A QUEUE?

enqueue(e)

dequeue()

singly linked list

addLast(e)

removeFirst()

<https://powcoder.com>

doubly linked list

Add WeChat powcoder

(same, or addFirst() & removeLast())

array list

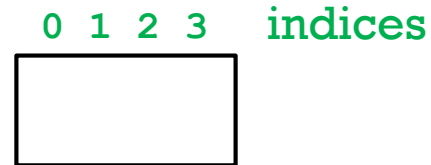
addLast(e)

removeFirst()

SLOW!

IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)

length = 4



enqueue (a)

enqueue (b)

dequeue ()

a---

ab--

b---

Assignment Project Exam Help

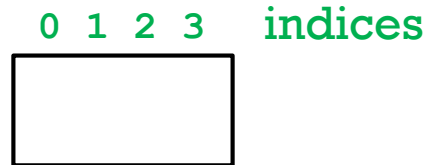
<https://powcoder.com>

Requires shift

Add WeChat powcoder

IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)

length = 4



enqueue (a)

a---

enqueue (b)

ab--

dequeue ()

b---

Requires shift

enqueue (c)

bc--

enqueue (d)

bcd-

enqueue (e)

bcde

dequeue ()

cde-

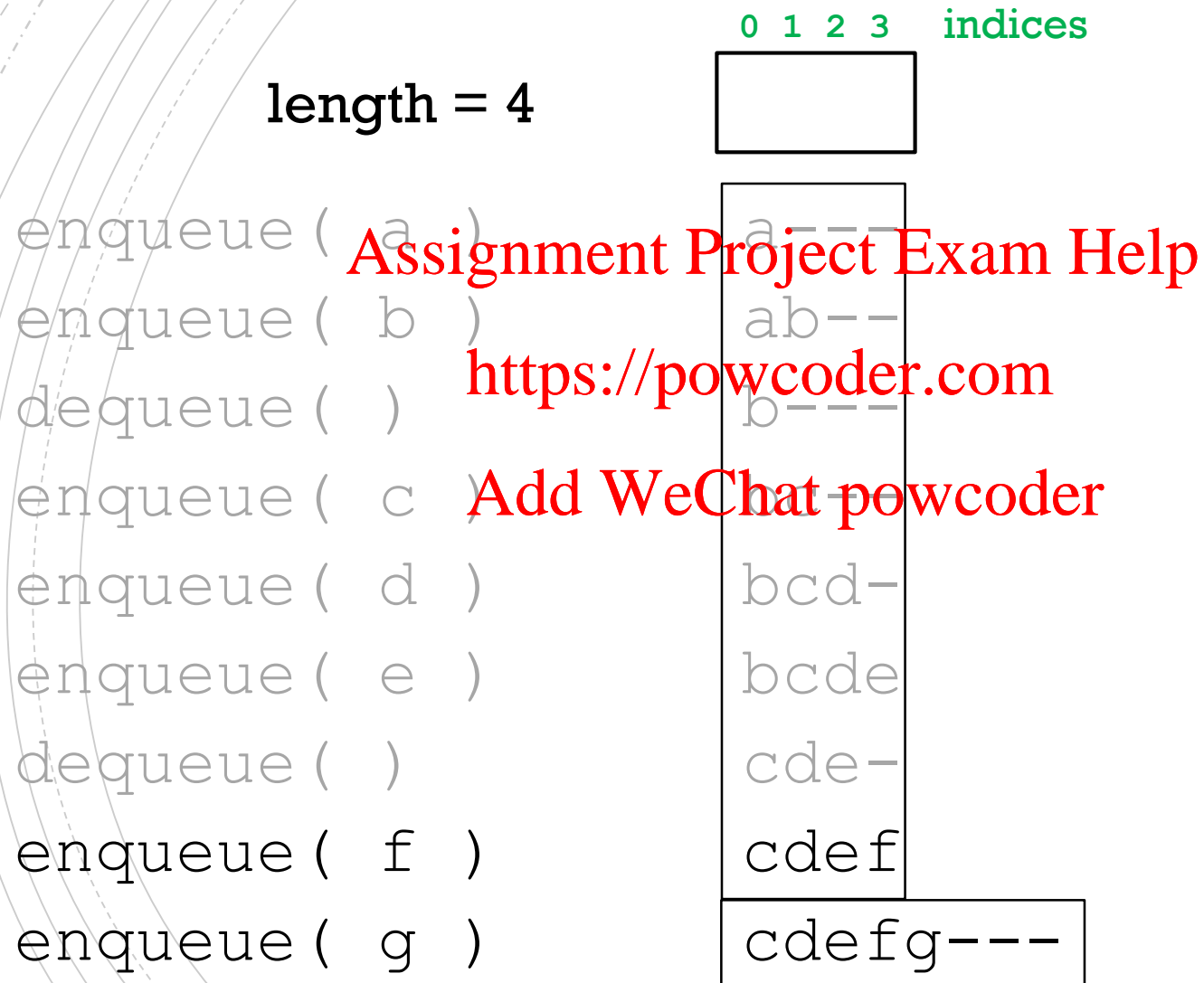
Requires shift

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

IMPLEMENTING A QUEUE WITH AN ARRAY LIST (BAD)



requires expansion

IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY (ALSO BAD)

Use **head** and **tail** indices

(**tail** = **head** + size - 1)

	0	1	2	3	
enqueue (a)	a	-	-	-	(0, 0)
enqueue (b)	a	b	-	-	(0, 1)
dequeue ()	-	b	-	-	(1, 1)
enqueue (c)	-	b	c	-	(1, 2)
enqueue (d)	-	b	c	d	(1, 3)
enqueue (e)				?	

Assignment Project Exam Help
<https://powcoder.com>
Add WeChat powcoder

IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY (ALSO BAD)

Use **head** and **tail** indices

(**tail** = **head** + size - 1)

	0	1	2	3				
enqueue (a)	a	-	-	-	(0, 0)			
enqueue (b)	a	b	-	-	(0, 1)			
dequeue ()	-	b	-	-	(1, 1)			
enqueue (c)	-	b	c	-	(1, 2)			
enqueue (d)	-	b	c	d	(1, 3)			
enqueue (e)	-	b	c	d	e	(1, 4)		
dequeue ()	-	-	c	d	e	(2, 4)		
enqueue (f)	-	-	c	d	e	f	(2, 5)	
enqueue (g)	-	-	c	d	e	f	g	(2, 6)

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

Make
bigger
array and
copy to it.

IMPLEMENTING A QUEUE WITH AN EXPANDING ARRAY

- to dequeue: retrieve the element at head and increase the index head

Assignment Project Exam Help

<https://powcoder.com>

- to enqueue: add the element at tail + 1

Add WeChat powcoder

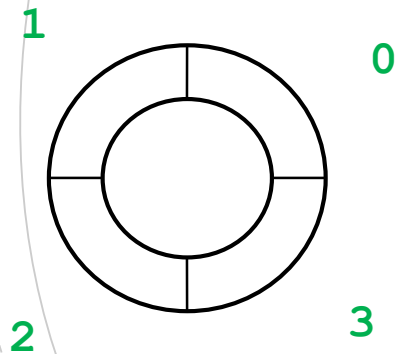
An expanding array is an inefficient usage of space!

A better idea is...

CIRCULAR ARRAY

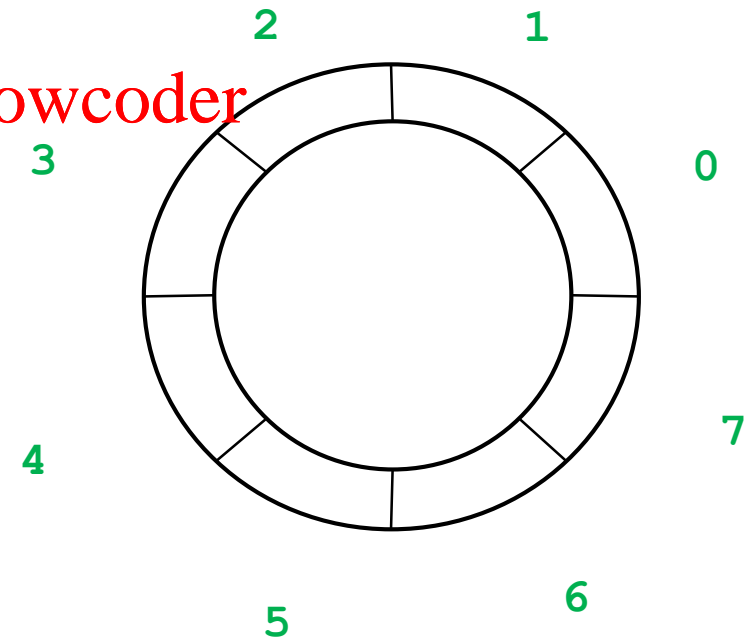
length = 4

0123



length = 8

01234567



Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$

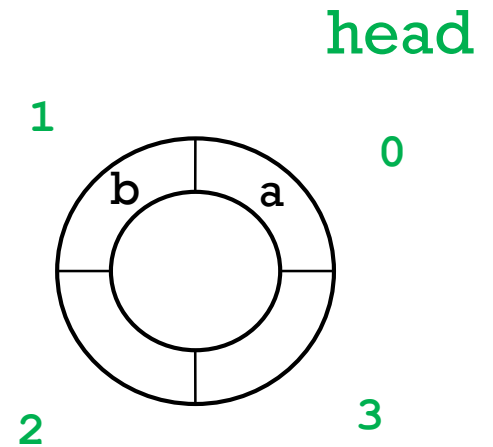
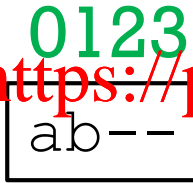
```
enqueue( a )  
enqueue( b )  
dequeue() ?
```

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

head=0 tail=1



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$

```
enqueue ( a )  
enqueue ( b )  
dequeue ()  
enqueue ( c ) ?
```

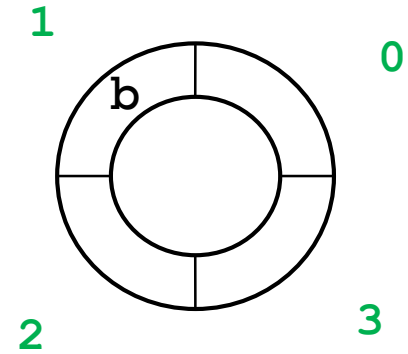
Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

head=1 tail=1

head
tail



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$$

```
enqueue ( a )  
enqueue ( b )  
dequeue ()  
enqueue ( c )  
enqueue ( d ) ?
```

Assignment Project Exam Help

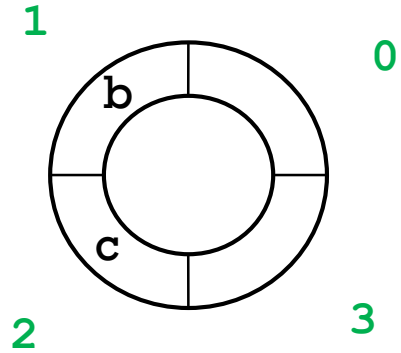
<https://powcoder.com>

Add WeChat powcoder

head=1 tail=2

head

tail



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$$

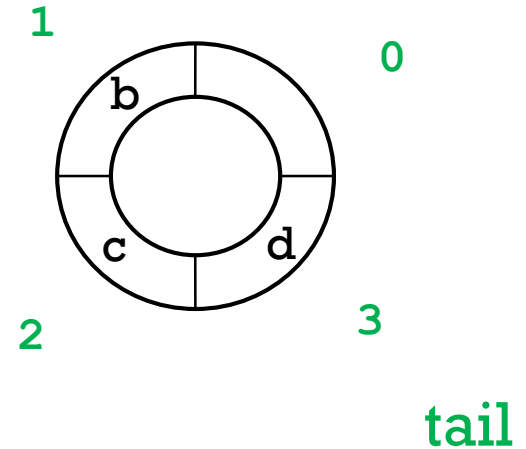
```
enqueue ( a )  
enqueue ( b )  
dequeue ( )  
enqueue ( c )  
enqueue ( d )  
enqueue ( e ) ?
```

Assignment Project Exam Help

0123
<https://powcoder.com>

Add WeChat powcoder

head=1 tail=3



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$$

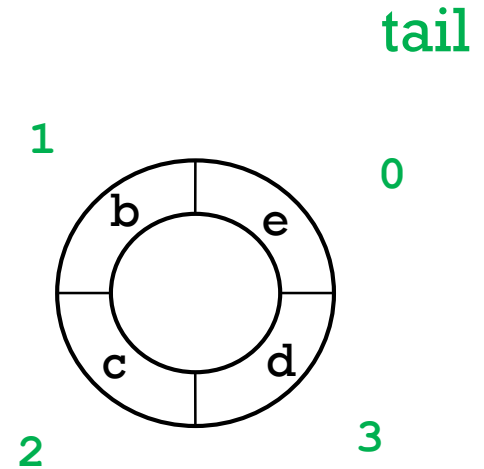
```
enqueue ( a )  
enqueue ( b )  
dequeue ()  
enqueue ( c )  
enqueue ( d )  
enqueue ( e )  
dequeue () ?
```

Assignment Project Exam Help

0123
<https://powcoder.com>

Add WeChat powcoder

head=1 tail=0



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$$

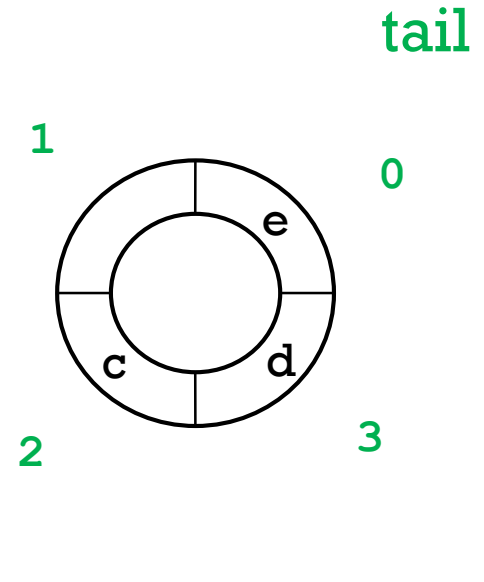
```
enqueue ( a )  
enqueue ( b )  
dequeue ()  
enqueue ( c )  
enqueue ( d )  
enqueue ( e )  
dequeue ()
```

Assignment Project Exam Help

0123
<https://powcoder.com>

Add WeChat powcoder

head=2 tail=0



IMPLEMENTING A QUEUE WITH A CIRCULAR ARRAY (GOOD)

$\text{tail} = (\text{head} + \text{size} - 1) \bmod \text{length}$

```
enqueue ( a )  
enqueue ( b )  
dequeue ()  
enqueue ( c )  
enqueue ( d )  
enqueue ( e )  
dequeue ()  
enqueue ( f )  
enqueue ( g ) ?
```

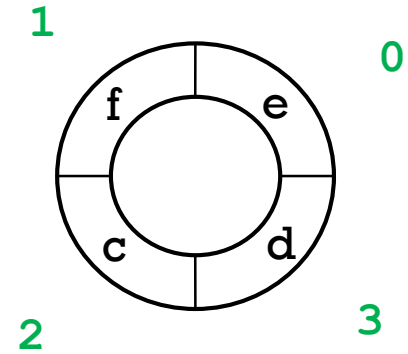
Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

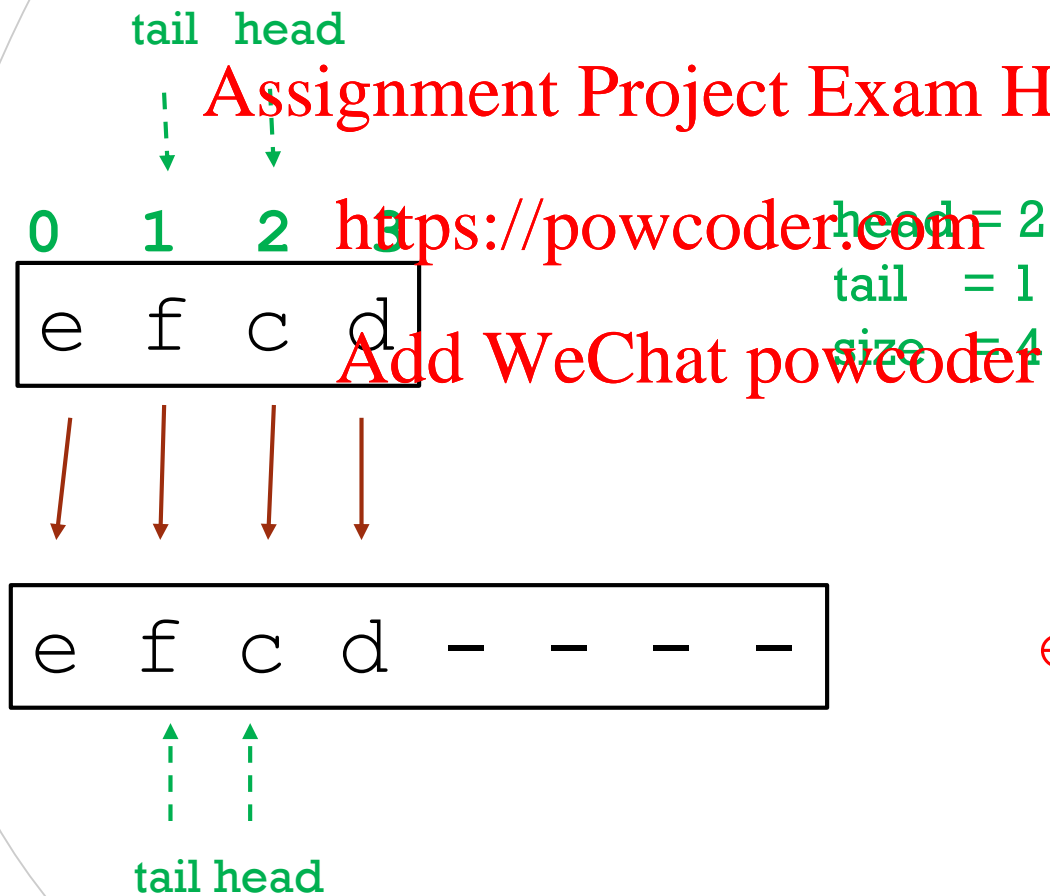
head=2 tail=1

head



INCREASE THE LENGTH OF THE ARRAY AND COPY

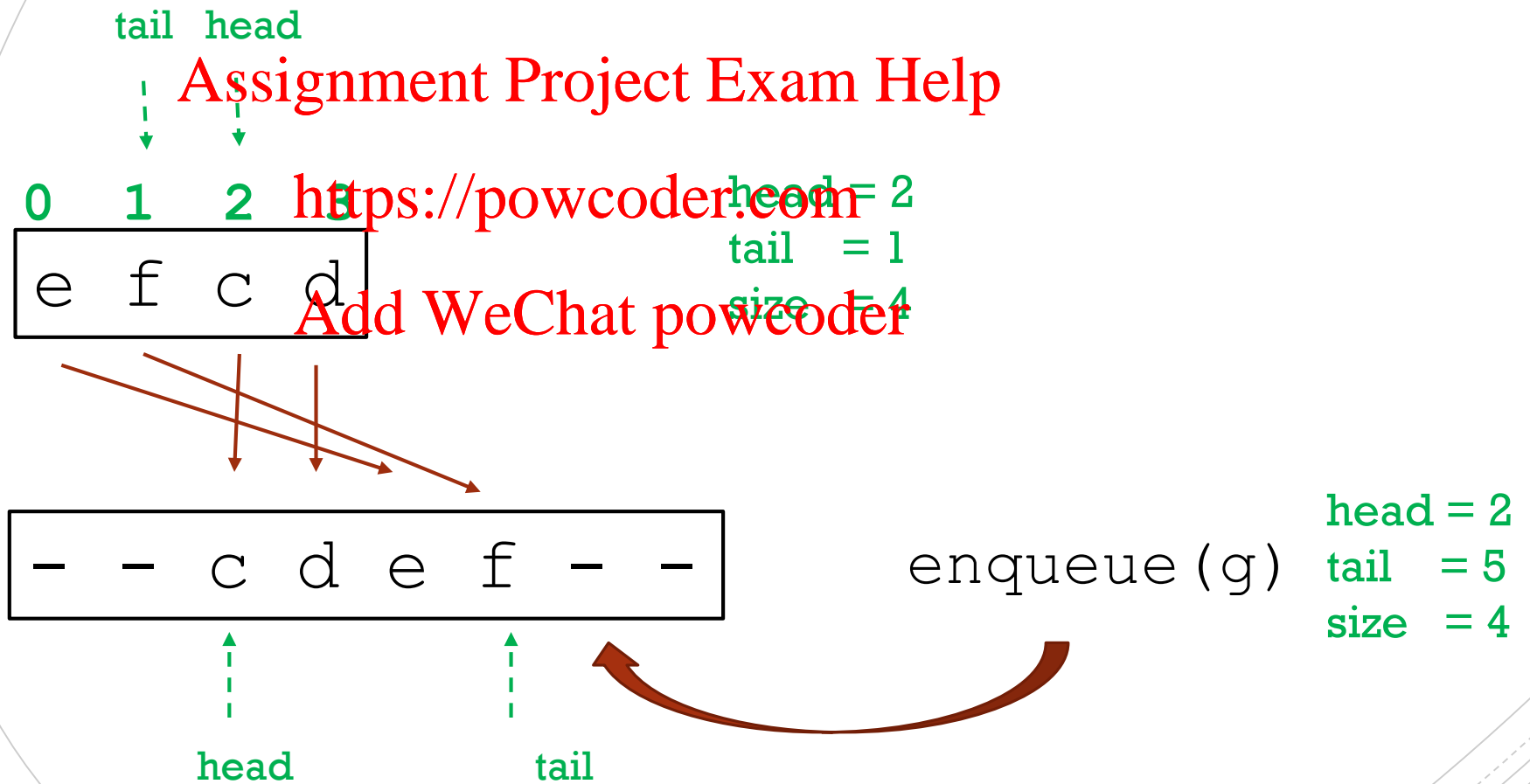
Be careful, on how you copy! The following would not work:



enqueue(g) ?

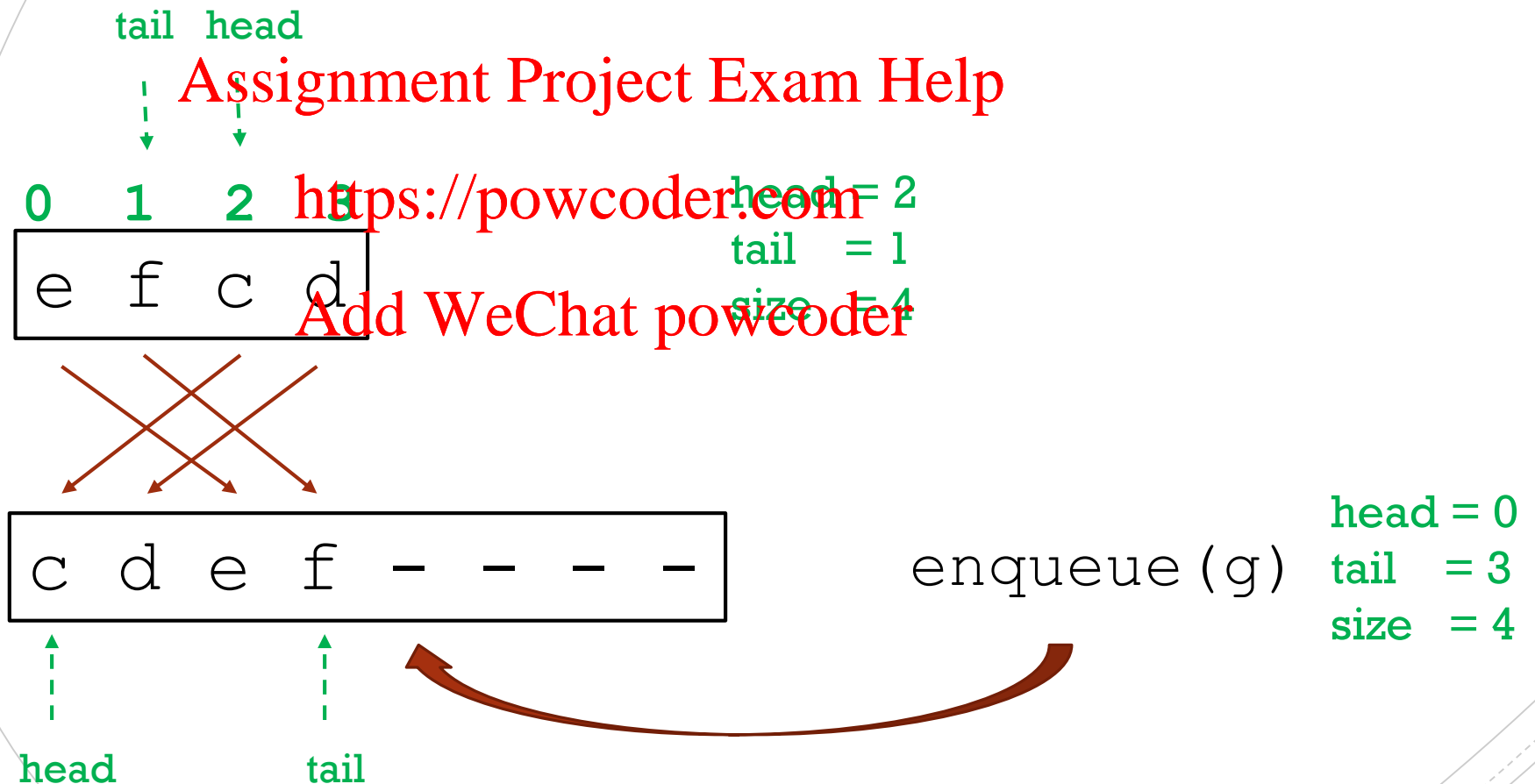
INCREASE THE LENGTH OF THE ARRAY AND COPY

Instead you can copy so that the head remains in the same position.



INCREASE THE LENGTH OF THE ARRAY AND COPY

OR you can copy so that the head moves to position 0.



ENQUEUE(e)

```
enqueue( element ){
    if (size == queue.length) {
        // increase length of array
        create a bigger array tmp[ ] // e.g. 2*length
        for i = 0 to queue.length - 1
            tmp[i] = queue[(head + i) mod queue.length]
        head = 0
        queue = tmp
    }
    queue[(head + size) mod length] = element
    size++
}
```

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

Note that we don't have a tail variable here. Instead, recall that $tail = (head + size - 1) \bmod length$, and note that the new element is added in position $(tail + 1) \bmod length$.

DEQUEUE()

```
def dequeue():  
    if size <= 0:  
        raise error  
  
    element = queue[head]  
    size = size - 1  
    head = (head + 1) % length  
    return element  
}
```

Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

WHAT IF SIZE IS 0?

What is the relation between `head` and `tail` when size is equal to 0?

`tail = (head + size - 1) mod length`

`array = (head, tail, size)`

Initial state `-- (0, 3, 0)`

Add WeChat powcoder

WHAT IF SIZE IS 0?

What is the relation between **head** and **tail** when size is equal to 0?

Assignment Project Exam Help
 $\text{tail} = (\text{head} + \text{size} - 1) \% \text{length}$

https://powcoder.com
 $\text{array} = (\text{head}, \text{tail}, \text{size})$

Add WeChat powcoder

Initial state	----	(0, 3, 0)
enqueue (a)	a---	(0, 0, 1)
enqueue (b)	ab--	(0, 1, 2)
dequeue ()	-b--	(1, 1, 1)
dequeue ()	--	(2, 1, 0)

tail **head**

ADT (ABSTRACT DATA TYPE)

Defines a data type by the values and operations from the user's perspective only. It ignores the details of the implementation.

Assignment Project Exam Help

Examples:

<https://powcoder.com>

Add WeChat powcoder

- list
- stack
- queue
- ...



Coming Soon

Assignment Project Exam Help

In the next videos:

- <https://powcoder.com>
Back to Java: interfaces!

Add WeChat powcoder