Queues

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- Like stacks, queues are an Abstract Data Type with more than one implementation.

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  - `integer size()`: returns the number of elements stored.
  - `boolean isEmpty()`: indicates whether no elements are stored.

Example

Operation	Return value	Queue
`enqueue(5)`	-	(5)
`enqueue(3)`	-	(5, 3)
`dequeue()`	5	(3)
`enqueue(7)`	-	(3, 7)
`dequeue()`	3	(7)
`first()`	7	(7)
`dequeue()`	7	()
`dequeue()`	`null`	()
`isEmpty()`	`true`	()
`enqueue(9)`	-	(9)
`enqueue(7)`	-	(9, 7)
`size()`	2	(9, 7)
`enqueue(3)`	-	(9, 7, 3)
`enqueue(5)`	-	(9, 7, 3, 5)
`dequeue()`	9	(7, 3, 5)

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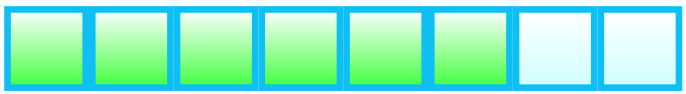
- Two variables keep track of the front and size:
  - `front`: index of the front element
  - `size`: number of stored elements
- When the queue has fewer than `N` elements, array location $back = (front + size) \bmod N$ is the first empty slot past the rear of the queue.

Array-backed Queue

Example of a queue implemented with an array using a "wraparound" technique.



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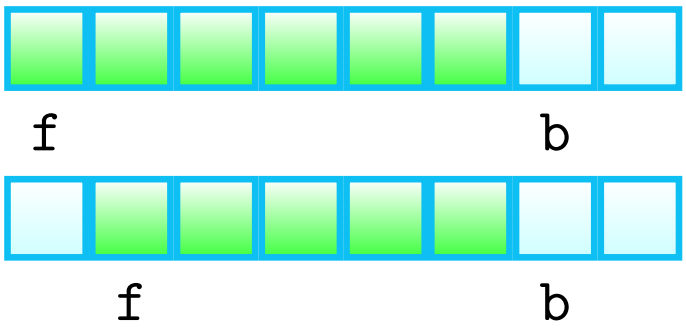

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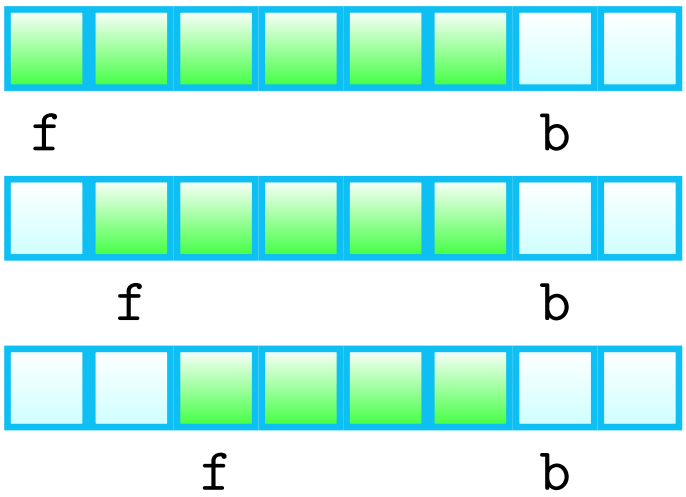

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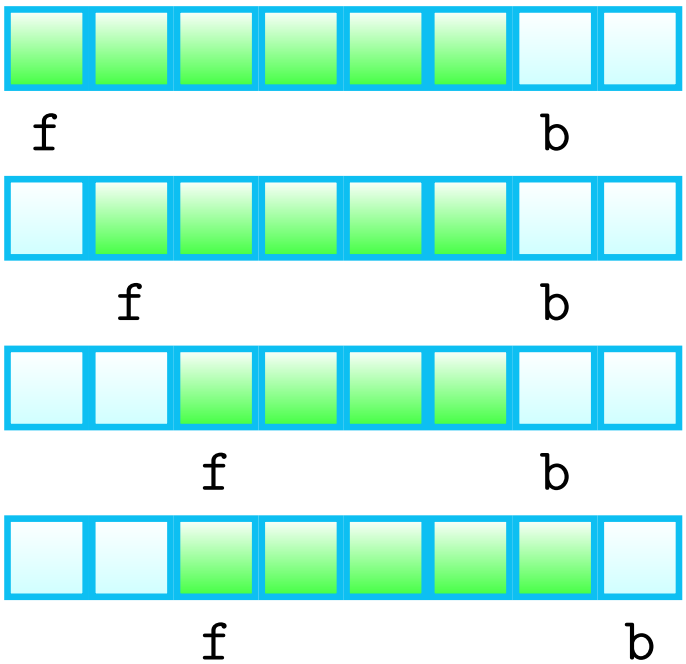

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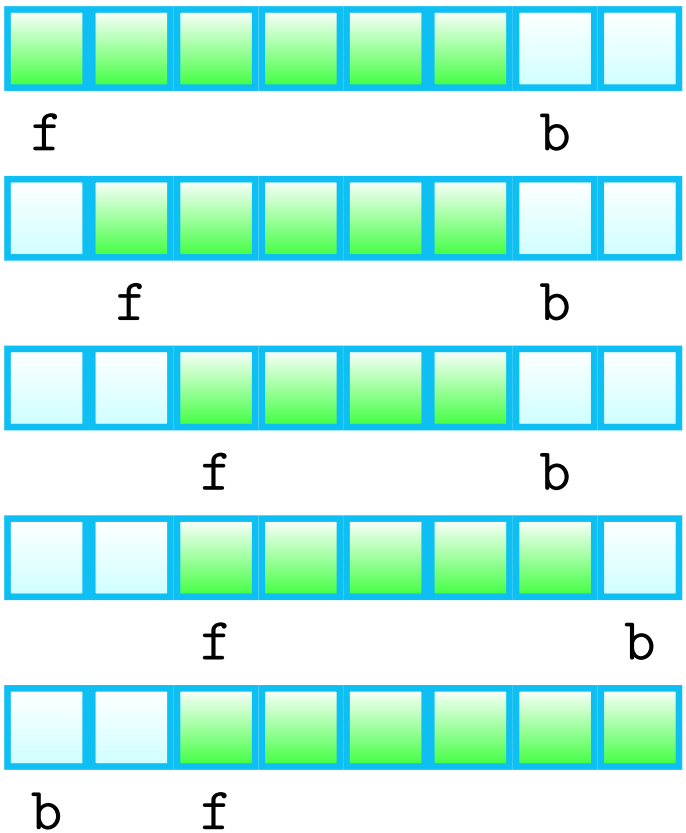

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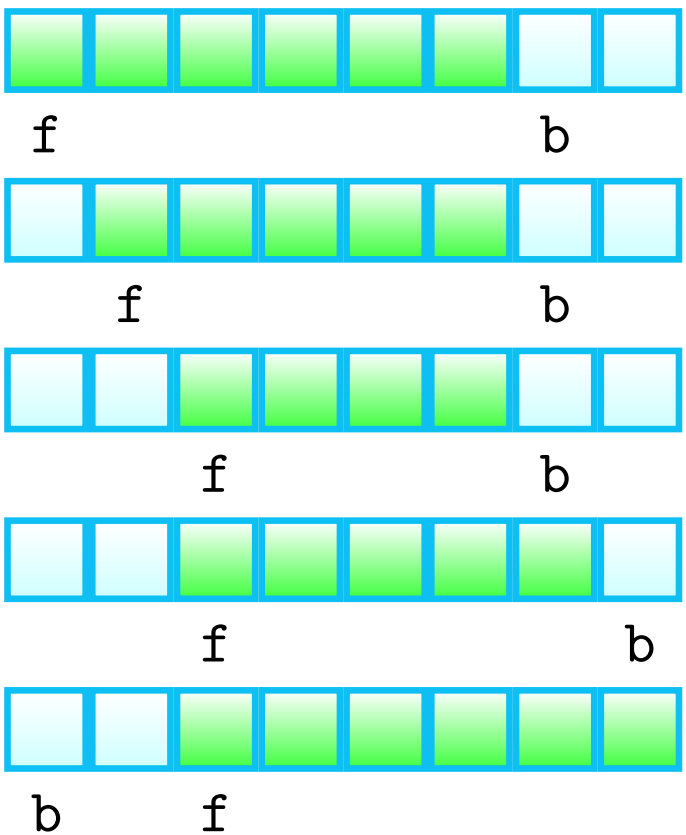

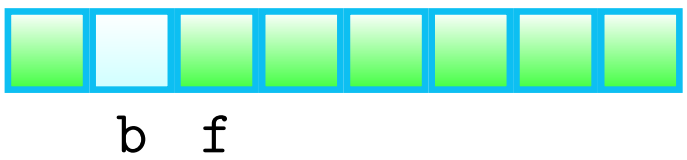

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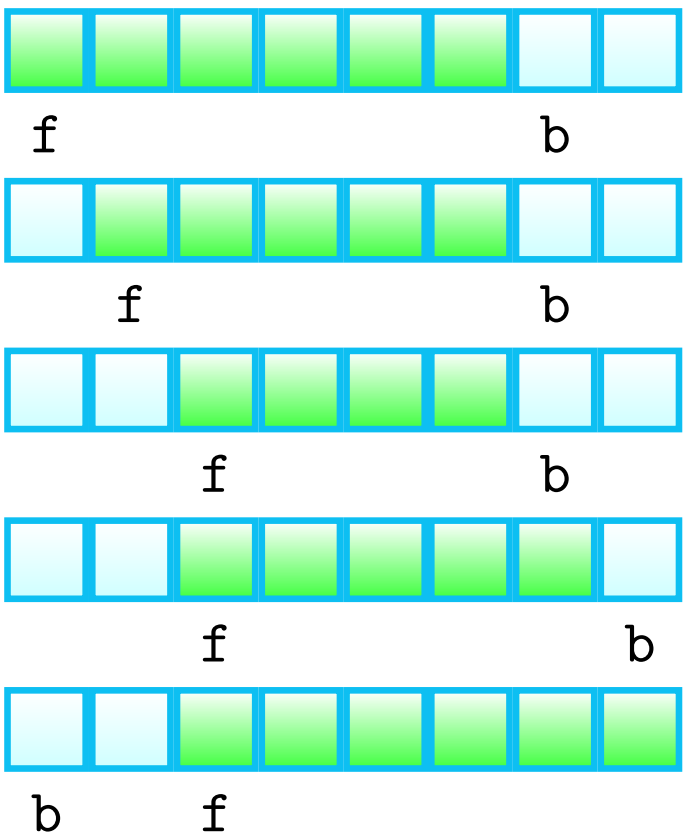

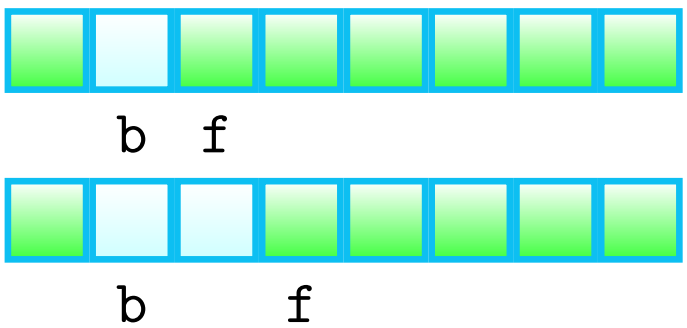

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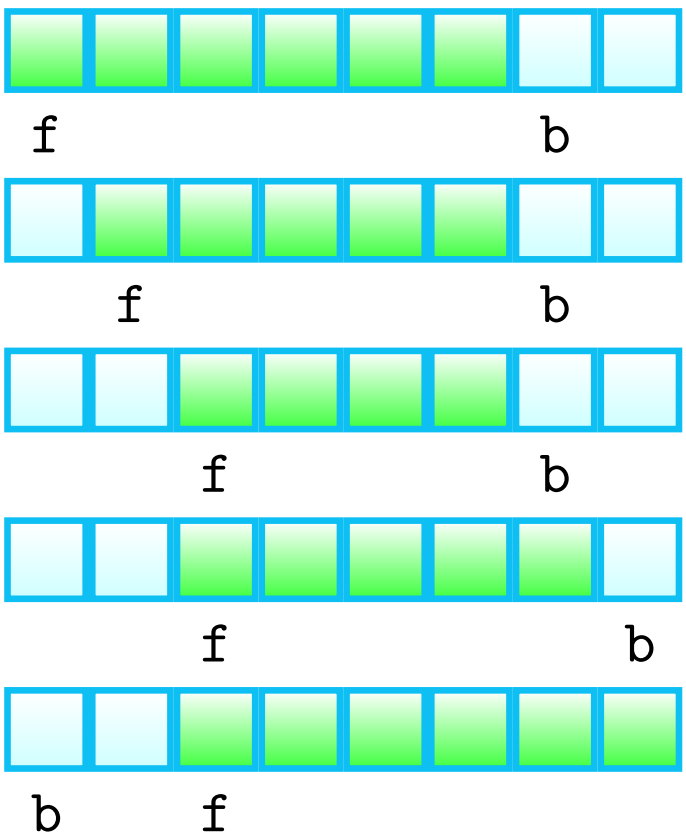

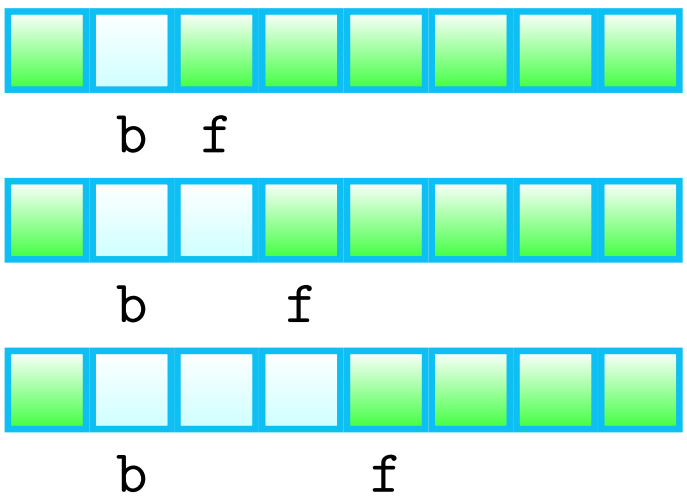

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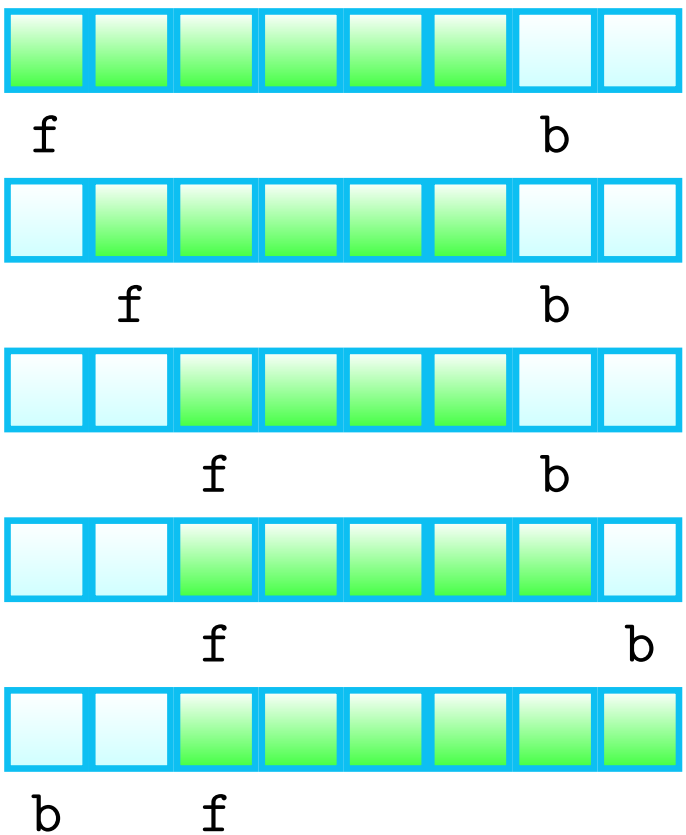

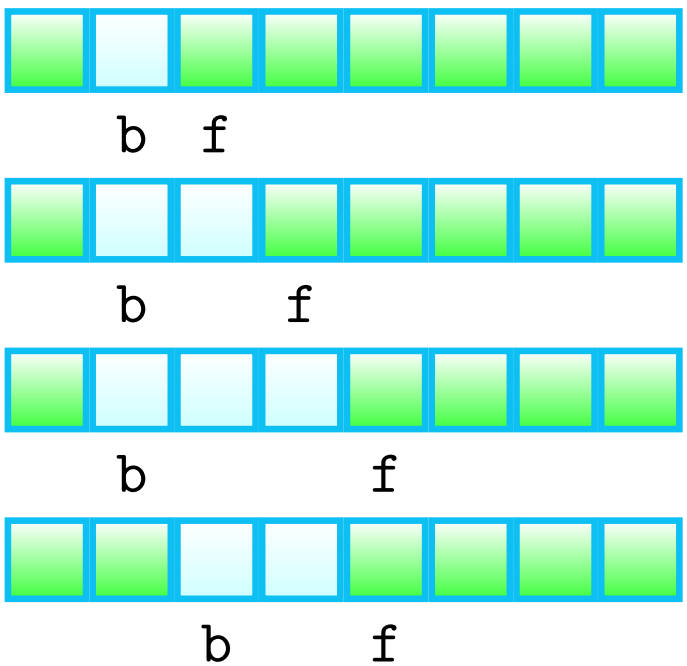

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procedure ENQUEUE(o)
    $back \leftarrow (front + size) \bmod N$
    $arr[back] \leftarrow o$
    $size \leftarrow size + 1$
end procedure

Keep in mind that you need to consider the case when the queue is full and how to handle it.

Array-backed Queue

procedure DEQUEUE
    $item \leftarrow arr[f]$
    $front \leftarrow (front + 1) \bmod N$
    $size \leftarrow size - 1$
    return *item*
end procedure

Notice that the cell in the array, $arr[f]$ is not set to *null* after it is dequeued. Consider the case, when the queue is empty and you attempt to dequeue.

Linked List-backed Queue

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- Elements would be added and removed to opposite ends of the list. The most efficient way to do this would depend on the list.

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  - Each operations runs in time $O(1)$.

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  - Linked list-backed queue do not have either of the above two limitations.

Applications of Queues

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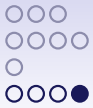
  - Auxillary data structure for algorithms
  - Component of other data structures



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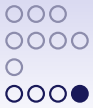

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  3. `processes.enqueue(process)`