

Array-Based Implementation



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Announcements

Sign up for the **CUNY 2X Newsletter**:

<http://eepurl.com/gkK8TD>

Comments: reference in project specification

- copy/paste and adapt
(e.g. name of parameter should appear after @param)
- use same format when you write helper functions

Project 1 due tonight at 11pm

- **NO LATE SUBMISSIONS — Don't abuse tutoring on the due date!**

Next: get started on Project 2 ASAP!!!

- **Better finish early than stress out about a last minute bug!!!**



Announcements

Can we change the name or parameters or returns of a function in the project?

NO

Why?

Because you'd be writing a different program, not what is being requested / assigned

- Unit testing cannot correctly call your functions
- Your project manager would not be happy!

If you provide default arguments to undocumented parameters no one will ever know about them so no one will ever use them.

Recap

We designed a Bag



ADT:

- A collection of data
- A set of operations on the data
- Specifies **what** ADT operations do **not how (interface)**

Templates

- A place holder for type

Today's Plan



Let's implement that Bag!!!

Bag



Implementation

First step: Choose Data Structure

So what is a Data Structure???

A data organization and storage format that enables "efficient" access and modification.

In this course we will encounter

Arrays

Vectors

Lists

Trees

Relative to the application
You must choose the right
data structure for your solution

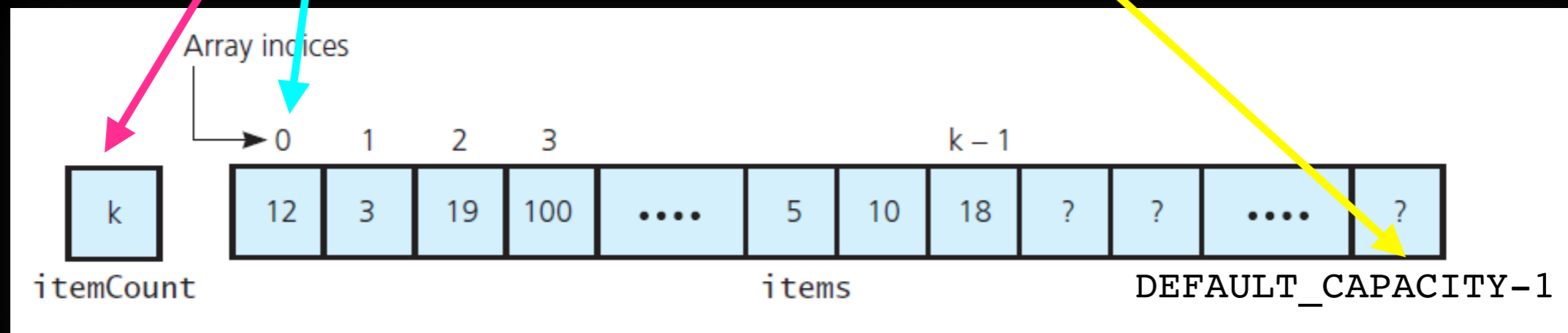
ADT defines the logical form
Data structure is the physical implementation

Array

A **fixed-size** container

Direct access to indexed location

Need to **keep track** of the number of elements in it



ArrayBag

Name ArrayBag only for pedagogical purposes:

- You would normally just call it a Bag and implement it as you wish
- Because we will try different implementations, we are going to explicitly use the name of the data structure in the name of the ADT
- Violates information hiding - wouldn't do it in "real life"

Implementation Plan

Write the header file (`ArrayBag.hpp`) -> straightforward from design phase

Incrementally write/test implementation (`ArrayBag.cpp`)

Identify core methods / implement / test

- Create container (constructors)

- Add items

- Remove items...

E.g. you may want to add items before implementing and testing

`getCurrentSize`

Use *stubs* when necessary

```
//STUB  
  
int ArrayBag::getCurrentSize() const  
{  
    return 4; //STUB dummy value  
}
```

The Header File

```
#ifndef ARRAY_BAG_H_  
#define ARRAY_BAG_H_  
  

```

```
#endif
```

Include Guard: used during linking to check that same header is not included multiple times.

The Header File

```
#ifndef ARRAY_BAG_H_  
#define ARRAY_BAG_H_
```

```
#include "ArrayBag.cpp"  
#endif
```

Include ArrayBag.cpp because this is a template. Remember not to include the .cpp file in the project or compilation command

The Header File

```
#ifndef ARRAY_BAG_H_
#define ARRAY_BAG_H_
```

```
template<class T>
class ArrayBag
{
```

```
}; //end ArrayBag
```

```
#include "ArrayBag.cpp"
#endif
```

The class definition:
define class ArrayBag as a **template**

Don't forget that *semicolon* at the end of your class definition!!!

The Header File

```
#ifndef ARRAY_BAG_H_
#define ARRAY_BAG_H_

template<class T>
class ArrayBag
{

public:

private:

}; //end ArrayBag

#include "ArrayBag.cpp"
#endif
```

The public interface: specifies the operations clients can call on objects of this class

The private implementation: specifies data and methods accessible only to members of this class. Invisible to clients

The Header File

```
#ifndef ARRAY_BAG_H_
#define ARRAY_BAG_H_

template<class T>
class ArrayBag
{
public:
    ArrayBag();
    int getCurrentSize() const;
    bool isEmpty() const;
    bool add(const T& new_entry);
    bool remove(const T& an_entry);
    void clear();
    bool contains(const T& an_entry) const;
    int getFrequencyOf(const T& an_entry) const;
    std::vector<T> toVector() const;

private:

};    //end ArrayBag

#include "ArrayBag.cpp"
#endif
```

This use of `const` means “I promise that this function doesn’t change the object”

This use of `const` means “I promise that this function doesn’t change the argument”

The public member functions of the `ArrayBag` class. These can be called on objects of type `ArrayBag`. Member functions are declared in the class definition. They will be implemented in the implementation file `ArrayBag.cpp`.

The Header File

```
#ifndef ARRAY_BAG_H_
#define ARRAY_BAG_H_

template<class T>
class ArrayBag
{
public:
    ArrayBag();
    int getCurrentSize() const;
    bool isEmpty() const;
    bool add(const T& new_entry);
    bool remove(const T& an_entry);
    void clear();
    bool contains(const T& an_entry) const;
    int getFrequencyOf(const T& an_entry) const;
    std::vector<T> toVector() const;

private:
    static const int DEFAULT_CAPACITY = 200 // Maximum Bag size
    T items_[DEFAULT_CAPACITY];           // Array of Bag items
    int item_count_;                       // Current count of Bag items
    /** @return index of target or -1 if target not found*/
    int getIndexof(const T& target) const;
}; //end ArrayBag

#include "ArrayBag.cpp"
#endif
```

The private data members and helper functions of the ArrayBag class. These can be called only within the ArrayBag implementation.

More than one public method will need to know the index of a target so we separate it out into a private helper function

Implementation

```
#include "ArrayBag.hpp"
```

Include header: declaration of the methods this file implements

```
template<class T>  
ArrayBag<T>::ArrayBag(): item_count_(0)  
{  
} // end default constructor
```

Member Initializer List

Implementation

```
#include "ArrayBag.hpp"

template<class T>
ArrayBag<T>::ArrayBag(): item_count_(0)
{
    // end default constructor
}

template<class T>
int ArrayBag<T>::getCurrentSize() const
{
    ???
} // end getCurrentSize

template<class T>
bool ArrayBag<T>::isEmpty() const
{
    ???
} // end isEmpty
```

Implementation

```
#include "ArrayBag.hpp"

template<class T>
ArrayBag<T>::ArrayBag(): item_count_(0)
{
    // end default constructor
}

template<class T>
int ArrayBag<T>::getCurrentSize() const
{
    return item_count_;
} // end getCurrentSize

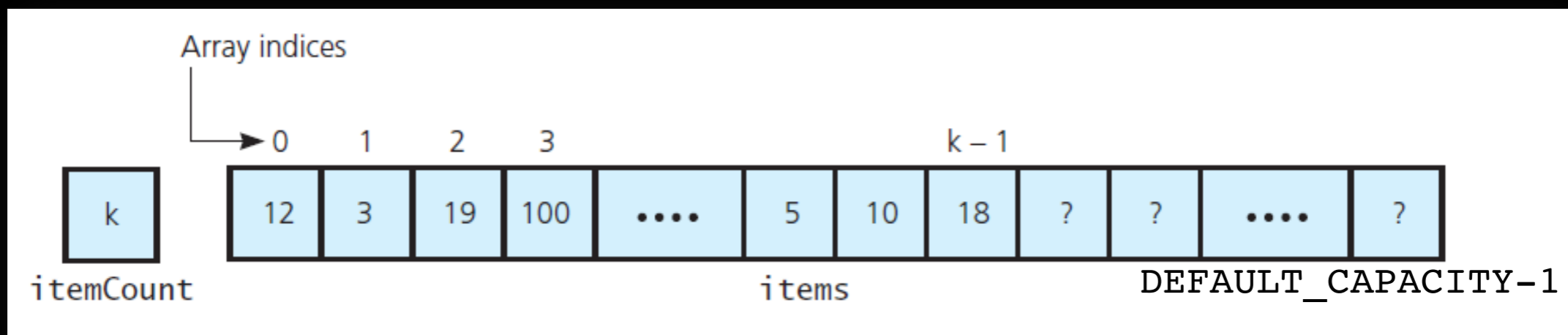
template<class T>
bool ArrayBag<T>::isEmpty() const
{
    return item_count_ == 0;
} // end isEmpty
```

Implementation

```
#include "ArrayBag.hpp"
```

```
...
```

```
template<class T>  
bool ArrayBag<T>::add(const T& new_entry)  
{  
    What do we need to do?  
} // end add
```

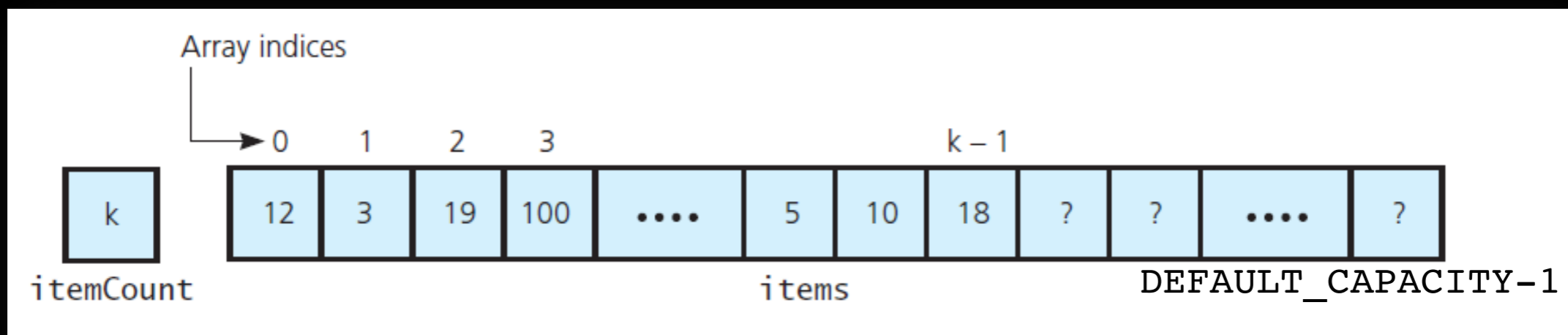


Implementation

```
#include "ArrayBag.hpp"
```

```
...
```

```
template<class T>  
bool ArrayBag<T>::add(const T& new_entry)  
{  
    Check if there is room  
    Add new_entry.. Where???  
} // end add
```



Implementation

```
#include "ArrayBag.hpp"
```

```
...
```

```
template<class T>
```

```
bool ArrayBag<T>::add(const T& new_entry)
```

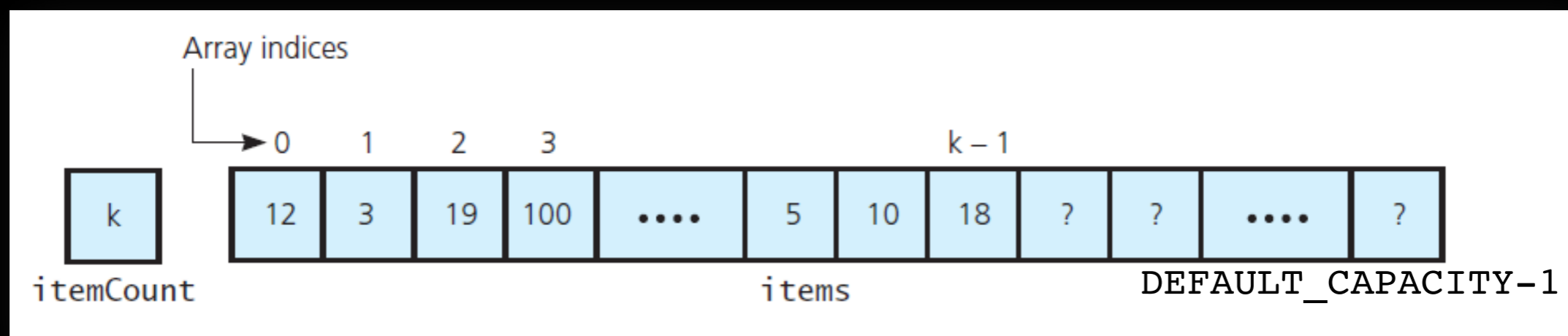
```
{
```

```
    Check if there is room
```

```
    Add new_entry.. At the end: index = item_count_
```

```
    Increment item_count_
```

```
} // end add
```

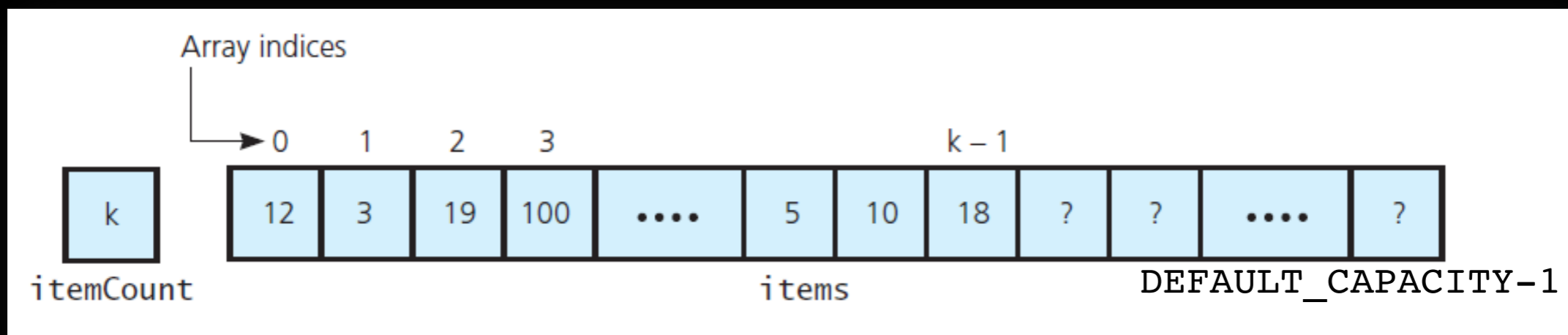


Implementation

```
#include "ArrayBag.hpp"

...

template<class T>
bool ArrayBag<T>::add(const T& new_entry)
{
    bool has_room_to_add = (item_count_ < DEFAULT_CAPACITY);
    if (has_room_to_add)
    {
        items_[item_count_] = new_entry;
        item_count_++;
    } // end if
    return has_room_to_add;
} // end add
```



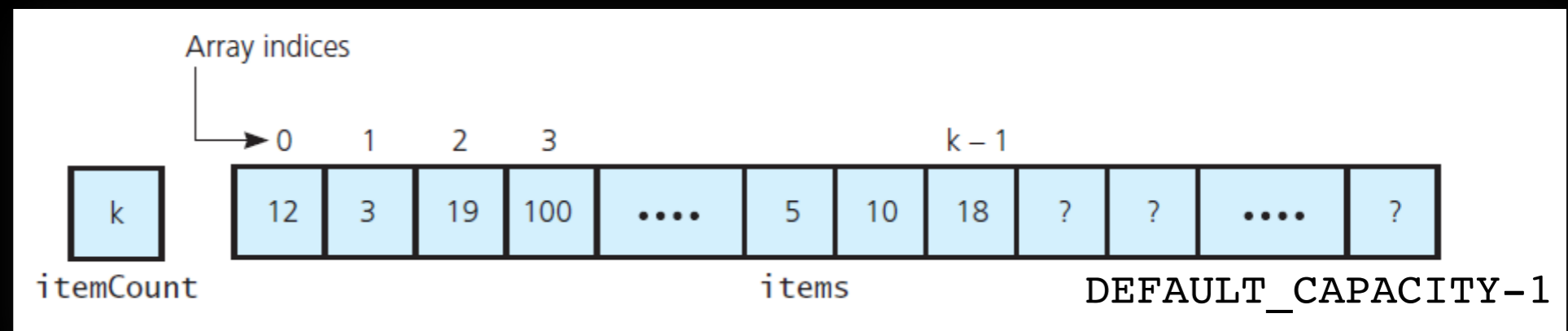
Lecture Activity

Write Pseudocode for
remove()

```
template<class T>
bool ArrayBag<T>::remove(const T& an_entry)
{
```

What do we need to do?

```
} //end remove
```



Lecture Activity

Write Pseudocode for
remove()

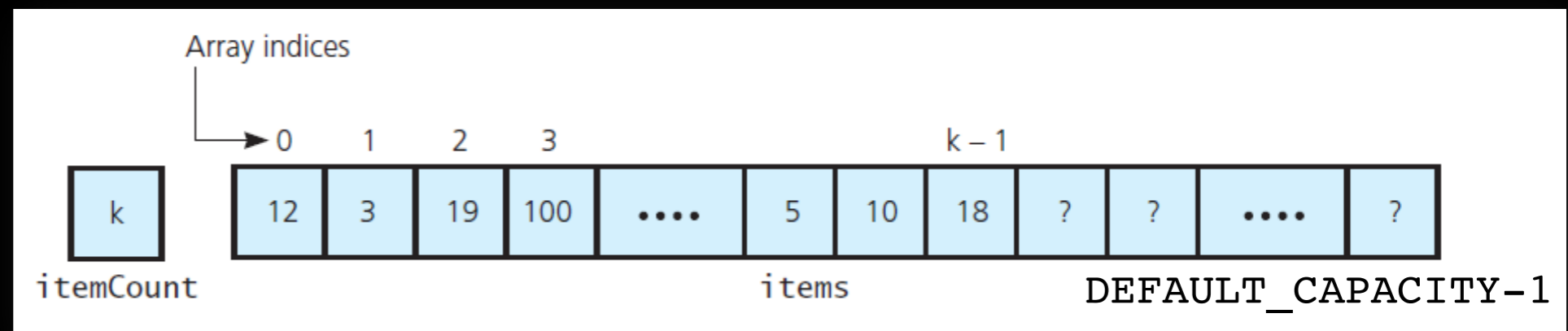
```
template<class T>
bool ArrayBag<T>::remove(const T& an_entry)
{
```

What do we need to do?

Hints:

- to add we looked if there was room in the bag. To remove what do we need to check first?

```
} //end remove
```



Lecture Activity

Write Pseudocode for
remove()

```
template<class T>
bool ArrayBag<T>::remove(const T& an_entry)
{
```

Lecture 4 Assignment on Gradescope

What do we need to do?

Login and submit NOW!!!

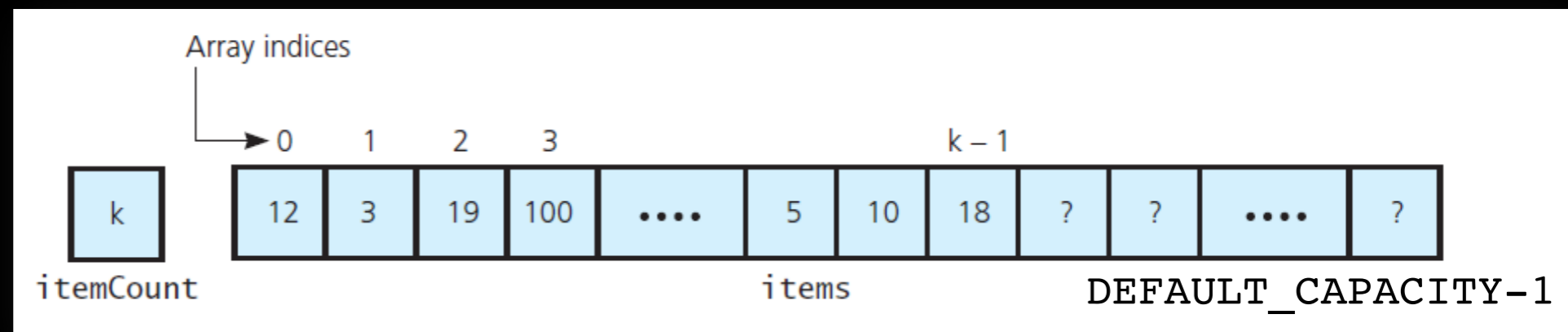
Hints:

- to add we looked if there was room in the bag. To remove what do we need to check first?

Tricky 🤔

- we always strive for efficiency: think of how to remove with minimal "movement" / minimal number of operations and remember in a Bag ORDER DOES NOT MATTER

```
} //end remove
```

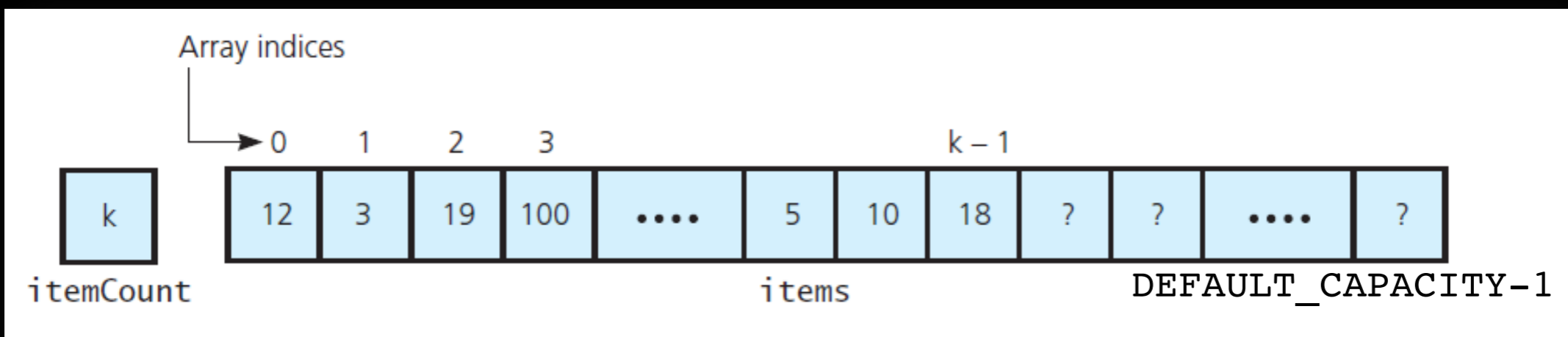


Implementation

```
#include "ArrayBag.hpp"

...

template<class T>
bool ArrayBag<T>::remove(const T& an_entry)
{
    int located_index = getIndexof(an_entry);
    bool can_remove_item = !isEmpty() && (located_index > -1);
    if (can_remove_item)
    {
        item_count--;
        items_[located_index] = items_[item_count_]; // copy last item in place of
                                                    // item to be removed
    } // end if
    return can_remove_item;
} // end remove
```



Implementation

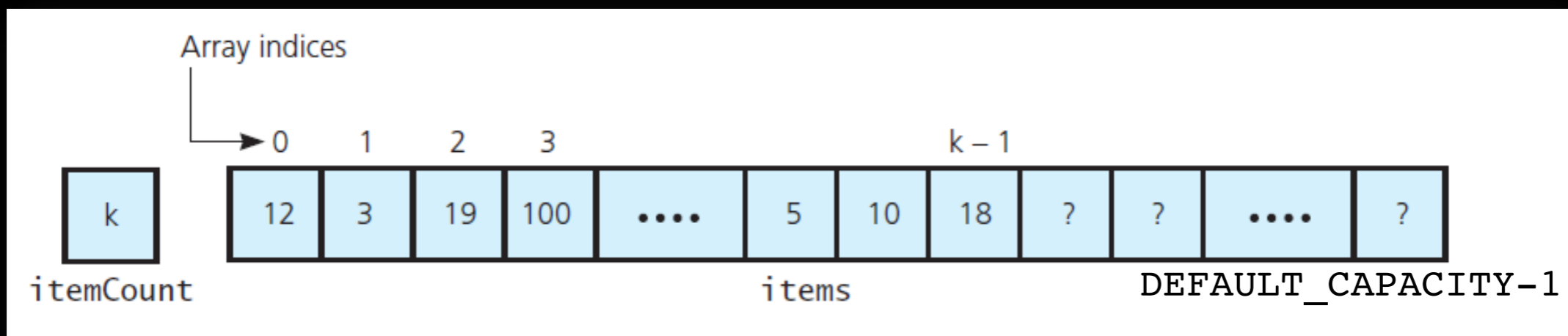
```
#include "ArrayBag.hpp"
```

```
...
```

```
template<class T>
bool ArrayBag<T>::remove(const T& an_entry)
{
    int located_index = getIndexof(an_entry);
    bool can_remove_item = !isEmpty() && (located_index > -1);
    if (can_remove_item)
    {
        item_count--;
        items_[located_index] = items_[item_count_]; // copy last item in place of
                                                    // item to be removed
    } // end if
    return can_remove_item;
} // end remove
```

This is a messy Bag
Order does not matter

What if we need
to retain the order?



Implementation

```
#include "ArrayBag.hpp"
```

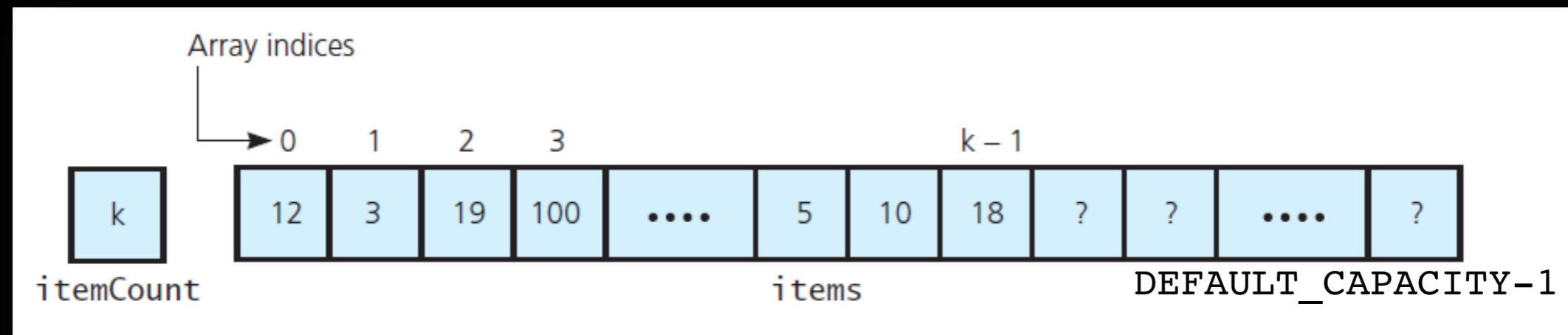
```
template<class T>
```

```
int ArrayBag<T>::getFrequencyOf(const T& an_entry) const
```

```
{
```

```
    What do we need to do???
```

```
} // end getFrequencyOf
```



Implementation

```
#include "ArrayBag.hpp"
```

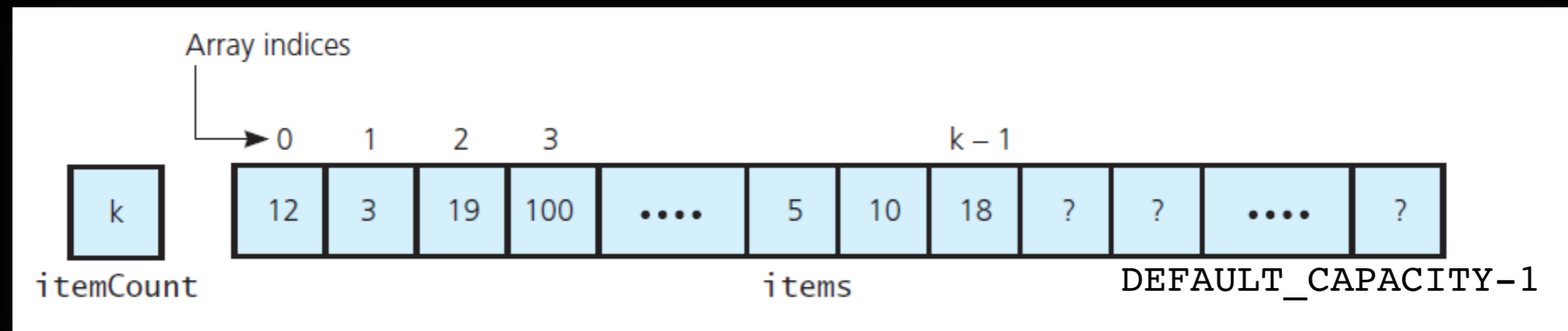
```
template<class T>
```

```
int ArrayBag<T>::getFrequencyOf(const T& an_entry) const
```

```
{
```

```
    Look at every array location, if == an_entry count it!
```

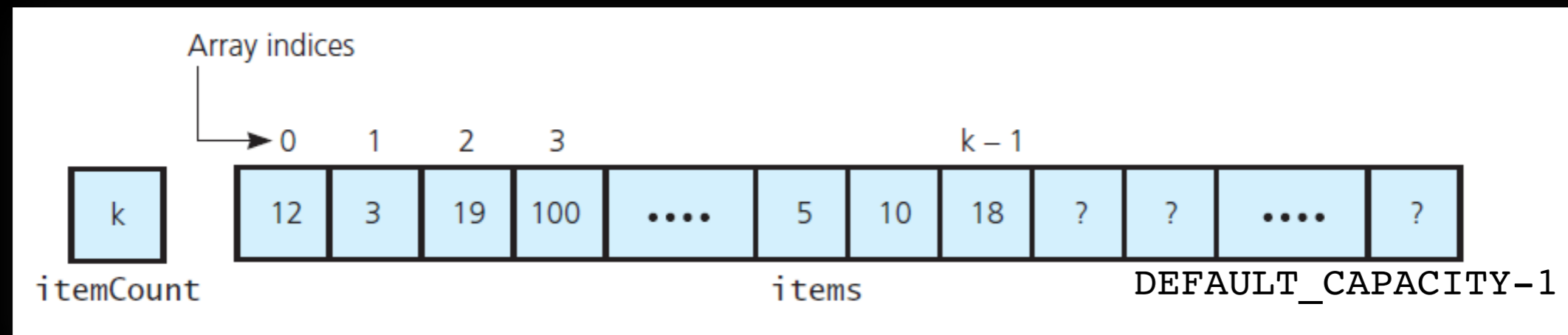
```
} // end getFrequencyOf
```



Implementation

```
#include "ArrayBag.hpp"

template<class T>
int ArrayBag<T>::getFrequencyOf(const T& an_entry) const
{
    int frequency = 0;
    int current_index = 0; // array index currently being inspected
    while (current_index < item_count_)
    {
        if (items_[current_index] == an_entry)
        {
            frequency++;
        } // end if
        current_index++; // increment to next entry
    } // end while
    return frequency;
} // end getFrequencyOf
```



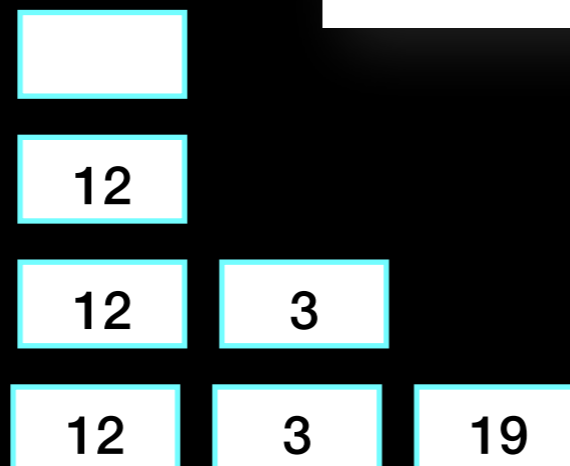
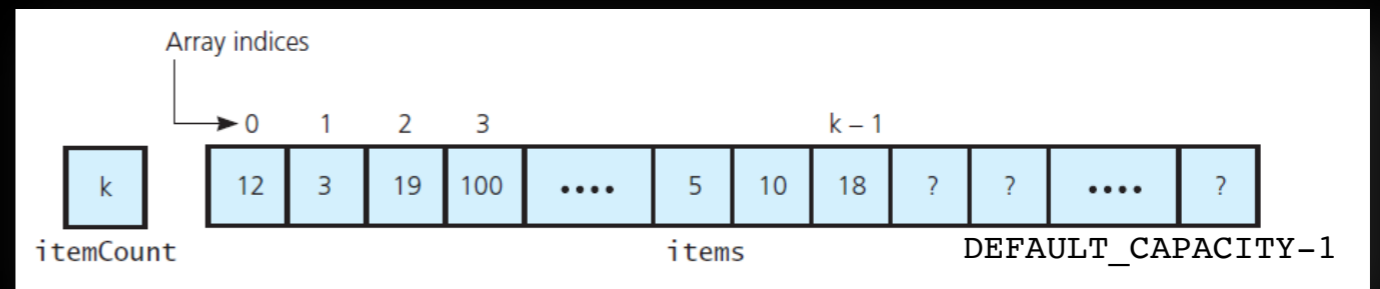
Implementation

```
#include "ArrayBag.hpp"
```

Return type

```
template<class T>
std::vector<T> ArrayBag<T>::toVector() const
{
    std::vector<T> bag_contents;
    for (int i = 0; i < itemCount ; i++)
        bag_contents.push_back(items_[i]);

    return bag_contents;
} // end toVector
```



```
bag_contents.push_back(items_[0])
```

```
bag_contents.push_back(items_[1])
```

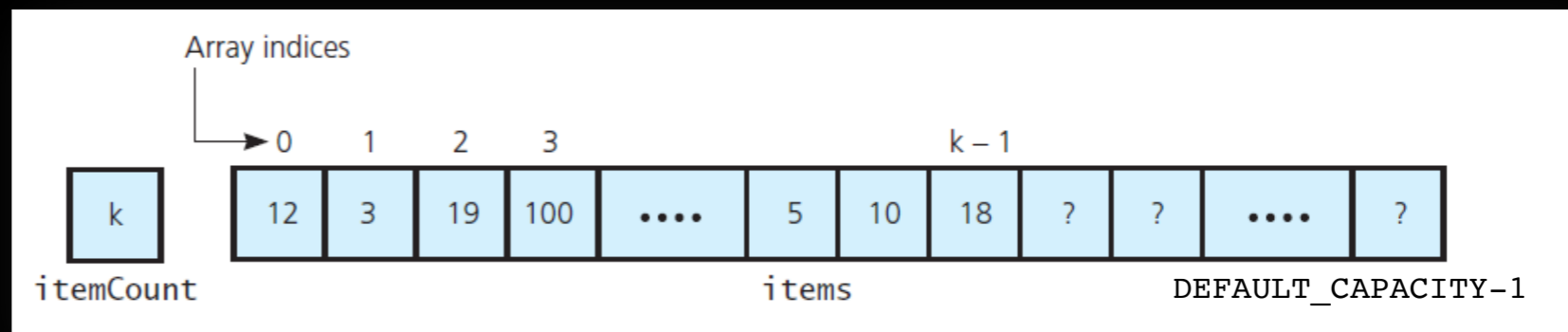
```
bag_contents.push_back(items_[2])
```

...

Implementation

```
#include "ArrayBag.hpp"

// private
template<class T>
int ArrayBag<T>::getIndexOf(const T& target) const
{
    Look at every array location,
    if == target return that location's index
} // end getIndexOf
```

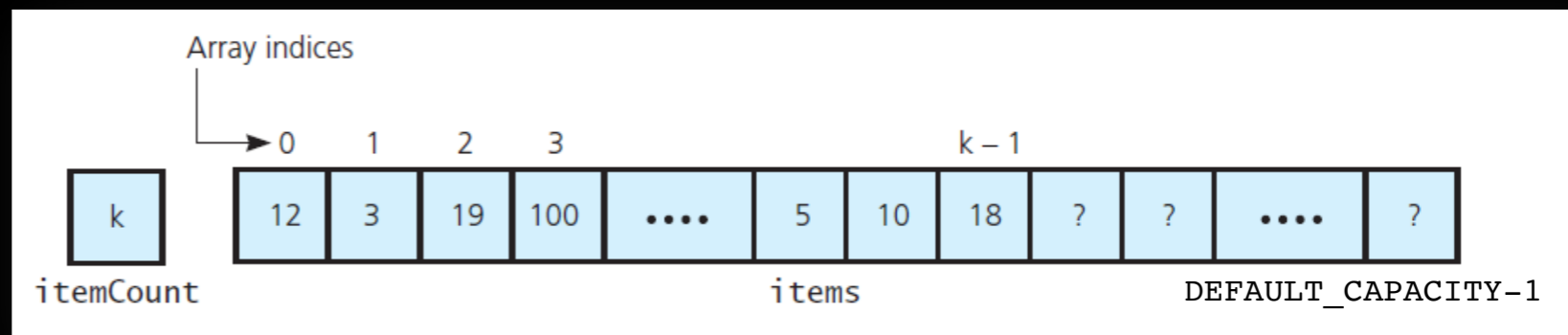


Implementation

```
#include "ArrayBag.hpp"

// private
template<class T>
int ArrayBag<T>::getIndexOf(const T& target) const
{
    bool found = false;
    int result = -1;
    int search_index = 0;

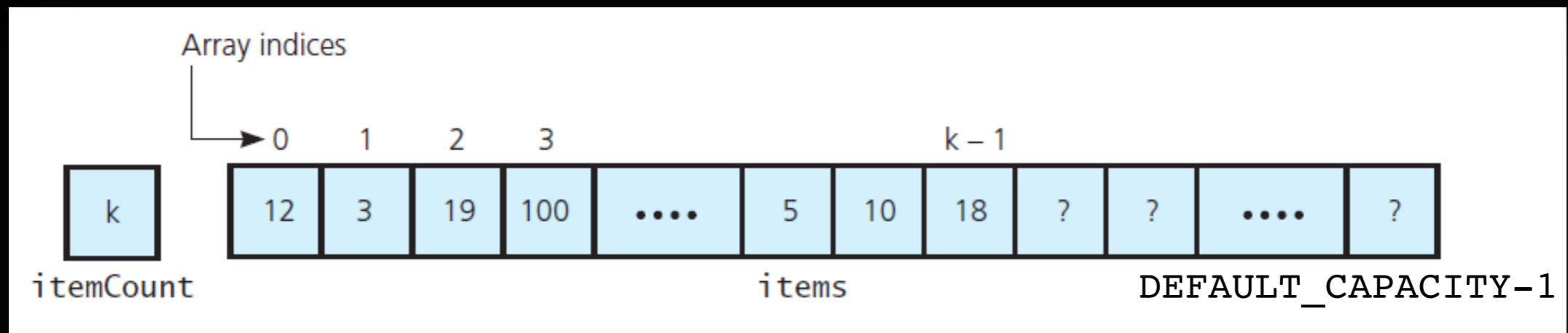
    // If the bag is empty, item_count_ is zero, so loop is skipped
    while (!found && (search_index < item_count_))
    {
        if (items_[search_index] == target)
        {
            found = true;
            result = search_index;
        }
        else
        {
            search_index ++;
        } // end if
    } // end while
    return result;
} // end getIndexOf
```



Implementation

```
#include "ArrayBag.hpp"

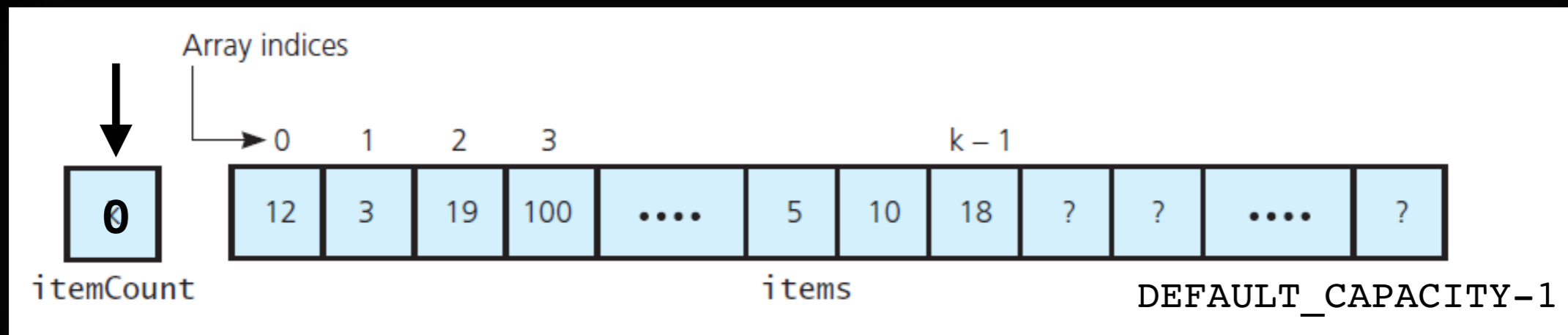
template<class T>
void ArrayBag<T>::clear()
{
    ???
} // end clear
```



Implementation

```
#include "ArrayBag.hpp"
```

```
template<class T>  
void ArrayBag<T>::clear()  
{  
    item_count_ = 0;  
} // end clear
```



Implementation

```
#include "ArrayBag.hpp"

template<class T>
bool ArrayBag<T>::contains(const T& an_entry) const
{
    return getIndexOf(an_entry) > -1;
} // end contains
```

We have a working Bag!!!