

Array Data Structure

What is an Array?

An array is a type of linear data structure that is defined as a collection of elements with same or different data types. They exist in both single dimension and multiple dimensions. These data structures come into picture when there is a necessity to store multiple elements of similar nature together at one place.

The diagram illustrates an array as a horizontal sequence of five cells. To the left of the cells, three labels with arrows point to the rows: 'Memory Address' points to the top row, 'Array Values' points to the middle row, and 'Array Index' points to the bottom row. The top row contains memory addresses 2391, 2392, 2393, 2394, and 2395. The middle row contains values 12, 34, 68, 77, and 43 in red text. The bottom row contains indices 0, 1, 2, 3, and 4.

Memory Address	→	2391	2392	2393	2394	2395
Array Values	→	12	34	68	77	43
Array Index	→	0	1	2	3	4

The difference between an array index and a memory address is that the array index acts like a key value to label the elements in the array. However, a memory address is the starting address of free memory available.

Following are the important terms to understand the concept of Array.

- **Element** – Each item stored in an array is called an element.
- **Index** – Each location of an element in an array has a numerical index, which is used to identify the element.

Syntax

Creating an array in **C** and **C++** programming languages –

```
data_type array_name[array_size]={elements separated by commas}  
or,  
data_type array_name[array_size];
```

Creating an array in **Java** programming language –

```
data_type[] array_name = {elements separated by commas}  
or,  
data_type array_name = new data_type[array_size];
```

Need for Arrays

Arrays are used as solutions to many problems from the small sorting problems to more complex problems like travelling salesperson problem. There are many data structures other than arrays that provide efficient time and space complexity for these problems, so what makes using arrays better? The answer lies in the random access lookup time.

Arrays provide **$O(1)$** random access lookup time. That means, accessing the 1st index of the array and the 1000th index of the array will both take the same time. This is due to the fact that array comes with a pointer and an offset value. The pointer points to the right location of the memory and the offset value shows how far to look in the said memory.

```
array_name[index]  
  |      |  
Pointer  Offset
```

Therefore, in an array with 6 elements, to access the 1st element, array is pointed towards the 0th index. Similarly, to access the 6th element, array is pointed towards the 5th index.

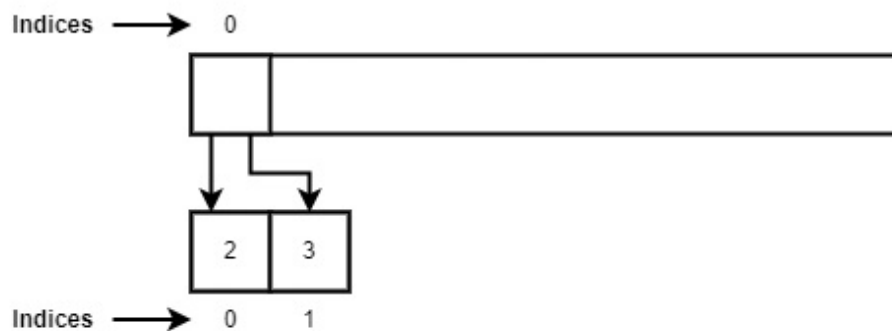
Array Representation

Arrays are represented as a collection of buckets where each bucket stores one element. These buckets are indexed from '0' to 'n-1', where n is the size of that particular array. For example, an array with size 10 will have buckets indexed from 0 to 9.

This indexing will be similar for the multidimensional arrays as well. If it is a 2-dimensional array, it will have sub-buckets in each bucket. Then it will be indexed as `array_name[m][n]`, where m and n are the sizes of each level in the array.



Single Dimensional Array



Multi Dimensional Array

As per the above illustration, following are the important points to be considered.

- Index starts with 0.
- Array length is 9 which means it can store 9 elements.
- Each element can be accessed via its index. For example, we can fetch an element at index 6 as 23.

Basic Operations in Arrays

The basic operations in the Arrays are insertion, deletion, searching, display, traverse, and update. These operations are usually performed to either modify the data in the array or to report the status of the array.

Following are the basic operations supported by an array.

- **Traverse** – print all the array elements one by one.
- **Insertion** – Adds an element at the given index.
- **Deletion** – Deletes an element at the given index.
- **Search** – Searches an element using the given index or by the value.
- **Update** – Updates an element at the given index.
- **Display** – Displays the contents of the array.

In C, when an array is initialized with size, then it assigns default values to its elements in following order.

Data Type	Default Value
bool	false
char	0
int	0
float	0.0
double	0.0f
void	
wchar_t	0

Array - Insertion Operation

In the insertion operation, we are adding one or more elements to the array. Based on the requirement, a new element can be added at the beginning, end, or any given index of array. This is done using input statements of the programming languages.

Algorithm

Following is an algorithm to insert elements into a Linear Array until we reach the end of the array –

1. Start
2. Create an Array of a desired datatype and size.
3. Initialize a variable 'i' as 0.
4. Enter the element at ith index of the array.
5. Increment i by 1.
6. Repeat Steps 4 & 5 until the end of the array.
7. Stop

Example

Here, we see a practical implementation of insertion operation, where we add data at the end of the array –

C

C++

Java

Python

```
#include <stdio.h>
int main(){
    int LA[3] = {}, i;
    printf("Array Before Insertion:\n");
    for(i = 0; i < 3; i++)
        printf("LA[%d] = %d \n", i, LA[i]);
    printf("Inserting Elements.. \n");
    printf("The array elements after insertion :\n"); // prints a
    for(i = 0; i < 3; i++) {
        LA[i] = i + 2;
        printf("LA[%d] = %d \n", i, LA[i]);
    }
    return 0;
}
```

Output

Array Before Insertion:
LA[0] = 0

```
LA[1] = 0
```

```
LA[2] = 0
```

Inserting elements..

Array After Insertion:

```
LA[0] = 2
```

```
LA[1] = 3
```

```
LA[2] = 4
```

```
LA[3] = 5
```

```
LA[4] = 6
```

For other variations of array insertion operation, [click here](#).

Array - Deletion Operation

In this array operation, we delete an element from the particular index of an array. This deletion operation takes place as we assign the value in the consequent index to the current index.

Algorithm

Consider LA is a linear array with N elements and K is a positive integer such that $K \leq N$. Following is the algorithm to delete an element available at the K^{th} position of LA.

1. Start
2. Set $J = K$
3. Repeat steps 4 and 5 while $J < N$
4. Set $LA[J] = LA[J + 1]$
5. Set $J = J + 1$
6. Set $N = N - 1$
7. Stop

Example

Following are the implementations of this operation in various programming languages –

C

C++

Java

Python

```
#include <stdio.h>
void main(){
    int LA[] = {1,3,5};
    int n = 3;
    int i;
    printf("The original array elements are :\n");
    for(i = 0; i<n; i++)
        printf("LA[%d] = %d \n", i, LA[i]);
    for(i = 1; i<n; i++) {
        LA[i] = LA[i+1];
        n = n - 1;
    }
    printf("The array elements after deletion :\n");
    for(i = 0; i<n; i++)
        printf("LA[%d] = %d \n", i, LA[i]);
}
```

Output

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

The array elements after deletion :

LA[0] = 1

LA[1] = 5

Array - Search Operation

Searching an element in the array using a key; The key element sequentially compares every value in the array to check if the key is present in the array or not.

Algorithm

Consider LA is a linear array with N elements and K is a positive integer such that $K \leq N$. Following is the algorithm to find an element with a value of ITEM using sequential search.

1. Start
2. Set $J = 0$
3. Repeat steps 4 and 5 while $J < N$
4. IF $LA[J]$ is equal ITEM THEN GOTO STEP 6
5. Set $J = J + 1$
6. PRINT J, ITEM
7. Stop

Example

Following are the implementations of this operation in various programming languages –

C

C++

Java

Python

```
#include <stdio.h>
void main(){
    int LA[] = {1,3,5,7,8};
    int item = 5, n = 5;
    int i = 0, j = 0;
    printf("The original array elements are :\n");
    for(i = 0; i<n; i++) {
        printf("LA[%d] = %d \n", i, LA[i]);
    }
    for(i = 0; i<n; i++) {
        if( LA[i] == item ) {
            printf("Found element %d at position %d\n", item, i+1);
        }
    }
}
```



```
}  
}
```

Output

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

Found element 5 at position 3

Array - Traversal Operation

This operation traverses through all the elements of an array. We use loop statements to carry this out.

Algorithm

Following is the algorithm to traverse through all the elements present in a Linear Array –

- 1 Start
2. Initialize an Array of certain size and datatype.
3. Initialize another variable 'i' with 0.
4. Print the ith value in the array and increment i.
5. Repeat Step 4 until the end of the array is reached.
6. End

Example

Following are the implementations of this operation in various programming languages –

C

C++

Java

Python

```
#include <stdio.h>
int main(){
    int LA[] = {1,3,5,7,8};
    int item = 10, k = 3, n = 5;
    int i = 0, j = n;
    printf("The original array elements are :\n");
    for(i = 0; i<n; i++) {
        printf("LA[%d] = %d \n", i, LA[i]);
    }
}
```

Output

The original array elements are :

LA[0] = 1
LA[1] = 3
LA[2] = 5
LA[3] = 7
LA[4] = 8

Array - Update Operation

Update operation refers to updating an existing element from the array at a given index.

Algorithm

Consider LA is a linear array with N elements and K is a positive integer such that $K \leq N$. Following is the algorithm to update an element available at the Kth position of LA.

1. Start
2. Set $LA[K-1] = \text{ITEM}$

3. Stop

Example

Following are the implementations of this operation in various programming languages –

C

C++

Java

Python

```
#include <stdio.h>
void main(){
    int LA[] = {1,3,5,7,8};
    int k = 3, n = 5, item = 10;
    int i, j;
    printf("The original array elements are :\n");
    for(i = 0; i<n; i++) {
        printf("LA[%d] = %d \n", i, LA[i]);
    }
    LA[k-1] = item;
    printf("The array elements after updation :\n");
    for(i = 0; i<n; i++) {
        printf("LA[%d] = %d \n", i, LA[i]);
    }
}
```

Output

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

The array elements after updation :

LA[0] = 1

LA[1] = 3

```
LA[2] = 10
```

```
LA[3] = 7
```

```
LA[4] = 8
```

Array - Display Operation

This operation displays all the elements in the entire array using a print statement.

Algorithm

Consider LA is a linear array with N elements. Following is the algorithm to display an array elements.

1. Start
2. Print all the elements in the Array
3. Stop

Example

Following are the implementations of this operation in various programming languages –

C

C++

Java

Python

```
#include <stdio.h>
int main(){
    int LA[] = {1,3,5,7,8};
    int n = 5;
    int i;
    printf("The original array elements are :\n");
    for(i = 0; i<n; i++) {
        printf("LA[%d] = %d \n", i, LA[i]);
    }
}
```

Output

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8