Lecture 05: Indexed Variables: Arrays

Course : Introduction to Programming

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Outline

1. Indexed Variables
2. Array Fundamentals
   - Definition and Terminologies
   - Characteristics
3. Array Declaration
4. Types of Arrays
   - One-Dimensional Arrays
5. Storing Values in Arrays
   - Three Methods
   - Initialization Methods
   - Assignment Method
   - Input Method
6. Accessing Array Elements
7. Arrays and Pointers
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Why Arrays?

The Problem

So far we have used only single variable names with different types where each variable is associated with a single memory space for storing one data item.

Real Example

Storing marks of 200 students would require 200 separate variables: mark1, mark2, ..., mark200

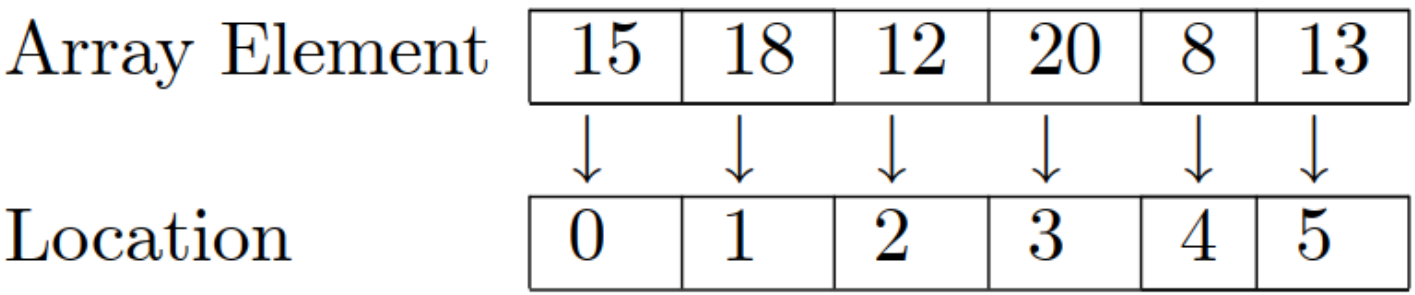
The Solution: Arrays

Arrays allow us to store multiple data items of the same type under one variable name in contiguous memory locations.

Definition of Arrays

Definition

An array is a linear and homogeneous (similar) data structure that can store a fixed-size sequential collection of elements of the same type.



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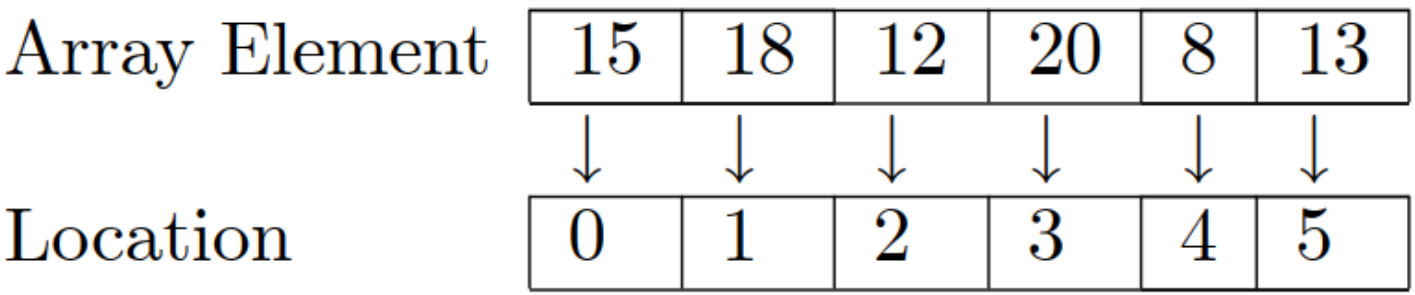

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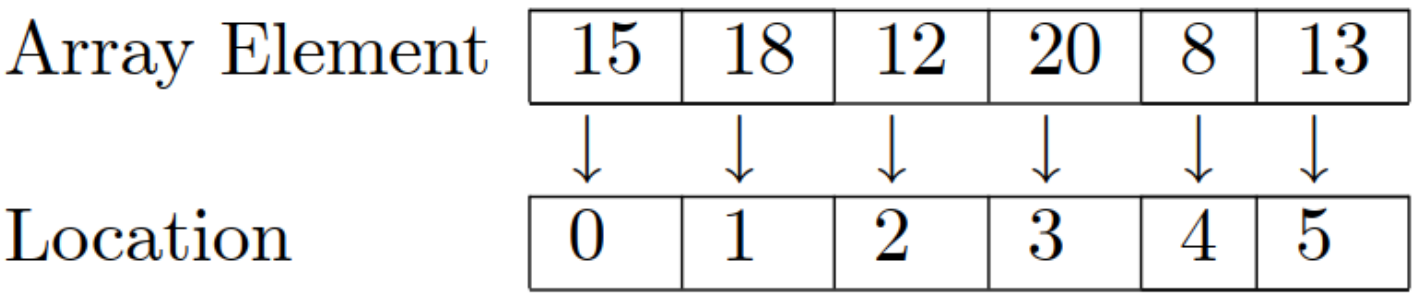

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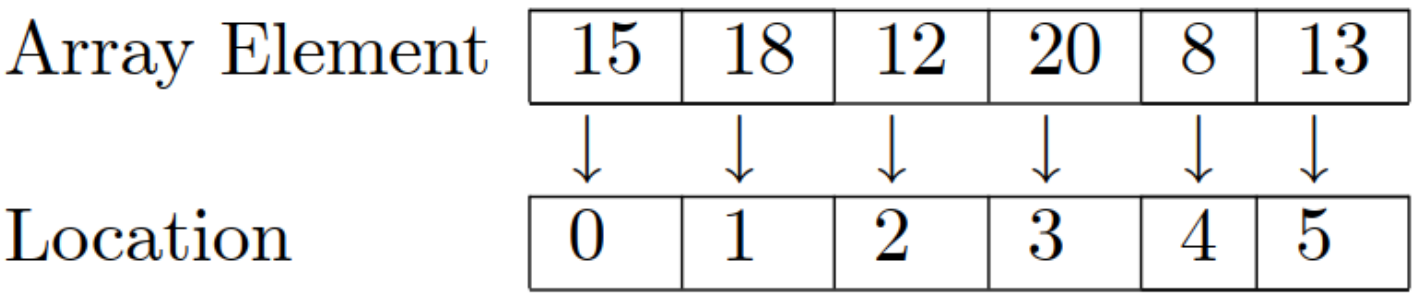

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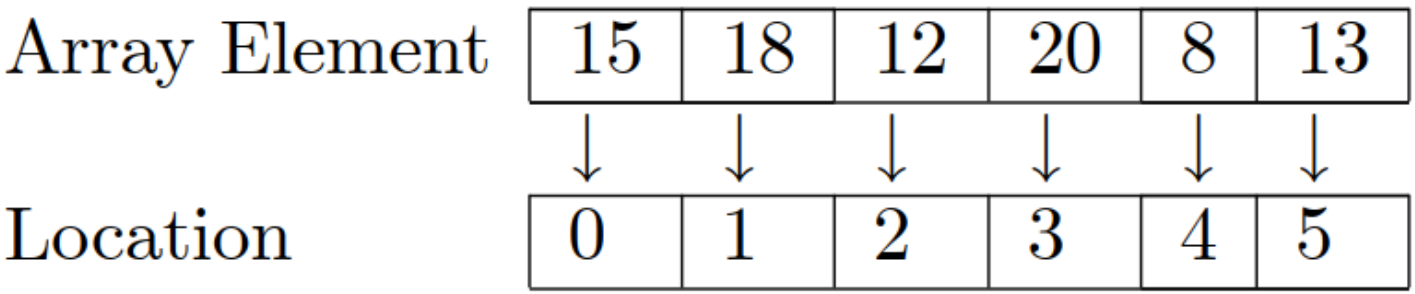

- Elements are stored **contiguously** in memory
- All elements share the same **variable name**
- Each element is accessed using an **index**
- Index always starts from **0**

Array Terminologies

Size

Number of elements or capacity to store elements in an array.
Indicated in square brackets [].

Type

Data type of elements stored in the array. Determines memory allocation.

Index

Used to refer to array elements.
For example: `arr[i]`

Important

Index value is always an integer beginning from 0.

Characteristics of Arrays

- `int arr[5]` creates five integer-type variables in memory

Example

```
int arr[5] = {10, 20, 30, 40, 50};
arr[2] = 35;    // Changes only the third element
```

Characteristics of Arrays

- `int arr[5]` creates five integer-type variables in memory
- All elements share the same name, distinguished by index

Example

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int arr[5] = {10, 20, 30, 40, 50};
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Characteristics of Arrays

- `int arr[5]` creates five integer-type variables in memory
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- Elements can be modified individually without affecting others

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int arr[5] = {10, 20, 30, 40, 50};
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Characteristics of Arrays

- `int arr[5]` creates five integer-type variables in memory
- All elements share the same name, distinguished by index
- Elements can be modified individually without affecting others
- Array name represents the base address in memory

Example

```
int arr[5] = {10, 20, 30, 40, 50};
arr[2] = 35;    // Changes only the third element
```

Declaring Arrays

Syntax

```
<data type> arrayName[size1][size2]....[sizen];
```

Examples

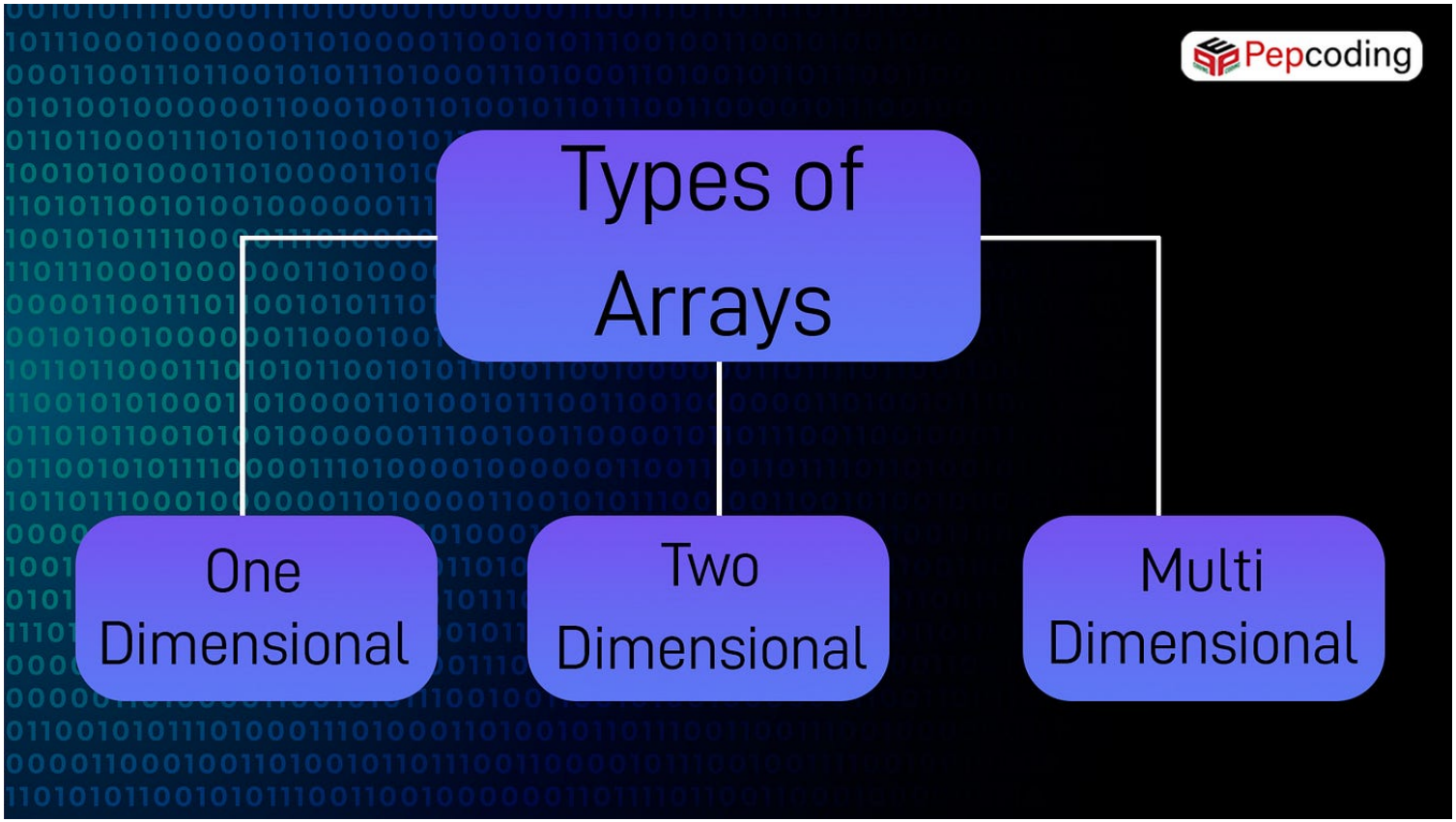
```
1 int arr_1[10];     // Array of 10 integers
2 char arr_2[15];    // Array of 15 characters
3 float arr_3[4];    // Array of 4 floating-point numbers
```

Compiler Information

The declaration tells the compiler:

1. Type and Name of the Array
2. Number of Array Dimensions
3. Number of Elements in Each Dimension

Types of Arrays



- **One-Dimensional Array (1D)**: Linear array with one index
- **Two-Dimensional Array (2D)**: Array with rows and columns
- **Multi-Dimensional Array**: Arrays with more than two dimensions

One-Dimensional Array (Linear Array)

Definition

Array having only one subscript variable (one index) is called One-Dimensional (1-D) array.

Declaration Syntax

```
<data type> <array name> [size];
```

```
1 int arr_1[10];     // 1D array of integers
2 char arr_2[15];    // 1D array of characters
3 float arr_3[4];    // 1D array of floats
```

Methods to Store Values in Arrays

1. **Initialization** - Assign values at declaration

Important

Declaration only allocates memory. Values must be stored explicitly.

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Methods to Store Values in Arrays

1. **Initialization** - Assign values at declaration
2. **Assignment** - Assign values to individual elements
3. **Input** - Read values from keyboard using scanf()

Important

Declaration only allocates memory. Values must be stored explicitly.

Initialization of Arrays

Syntax

```
<data type> <array name> [size] = {val1, val2, ..., valn};
```

Examples

```
1 int arr_1[10] = {2, 3, 4, 13, 1, 2, 12, 14, 20, 89};
2 char arr_2[15] = "welcome";
3 float arr_3[4] = {1.5, 3.5, 14.5, 20.2};
```

Full Array Initialization

Initializing All Elements

```
1 int arr[6] = {10, 11, 13, 39, 50};
```

$$\text{int arr}[6]=\{10,11,13,20,39,50\};$$

10	11	13	20	39	50

Partial Array Initialization

Initializing Some Elements

```
1 int arr[6] = {10, 11, 13};
```

$$\text{int arr}[6]=\{10,11,13\};$$

10	11	13	0	0	0

Note

Remaining elements are initialized to zero automatically by the compiler.

Initialization Without Size

Compiler Determines Size

```
1 int arr[] = {10, 11, 13, 20, 39, 50};
```

Result

Compiler counts the number of elements (6) and sets the array size accordingly.

Complete Program Example

```c
#include <stdio.h>
int main() {
    int vec[] = {10, 11, 13, 20, 39, 50};
    int i;

    for (i = 0; i < 6; i++) {
        printf("\n Array Element vec[%d] = %d", i, vec[i]);
    }
    return 0;
}
```

Output

```
Array Element vec[0] = 10
Array Element vec[1] = 11
Array Element vec[2] = 13
Array Element vec[3] = 20
Array Element vec[4] = 39
Array Element vec[5] = 50
```

String Initialization

Character Array (String)

```
1 char str[] = "Welcome";
```

Important

String length is 7, but array size is 8 because of NULL character (\0).

W	e	l	c	o	m	e	\0
str[0]	str[1]	str[2]	str[3]	str[4]	str[5]	str[6]	str[7]

Assigning Values to Arrays

Individual Element Assignment

```
1 int vect[4];
2 vect[0] = 10;
3 vect[1] = 11;
4 vect[2] = 30;
5 vect[3] = 40;
```

Reading Array Elements from Keyboard

Using scanf()

```
1 // Reading individual elements
2 scanf("%d", &arr[0]);
3 scanf("%d", &arr[1]);
4
5 // Reading in a loop
6 for (i = 0; i < n; i++) {
7     printf("Enter element %d: ", i);
8     scanf("%d", &arr[i]);
9 }
```

Accessing and Printing Array Elements

Using printf()

```
// Printing individual elements
printf("%d", arr[0]);

// Printing in a loop
for (i = 0; i < n; i++) {
    printf("\n arr[%d] = %d", i, arr[i]);
}
```

Complete Program: Read and Print Array

```c
#include <stdio.h>
int main() {
    int i, N, arr[10];
    printf("Enter number of elements: ");
    scanf("%d", &N);

    if (N < 10) {
        printf("Enter array elements:\n");
        for(i = 0; i < N; i++) {
            scanf("%d", &arr[i]);
        }

        printf("Array elements are:\n");
        for(i = 0; i < N; i++) {
            printf("arr[%d] = %d\n", i, arr[i]);
        }
    }
    else {
        printf("Error: Array size exceeded!\n");
    }
    return 0;
}
```

Program Output

Run 1 - Valid Input

```
Enter number of elements: 3
Enter array elements:
2
3
5
Array elements are:
arr[0] = 2
arr[1] = 3
arr[2] = 5
```

Run 2 - Invalid Input

```
Enter number of elements: 15
Error: Array size exceeded!
```

Relationship Between Arrays and Pointers

Key Concept

In C, arrays and pointers are closely related. The array name is a constant pointer to the first element.

Example Array

```
int vect[] = {10, 11, 13, 20, 39};
```

Accessing Array Elements Using Pointers

Expression	Description	Value
`vect`	Base address	2293296
`*vect`	First element	10
`*(vect+0)`	First element	10
`*(vect+1)`	Second element	11

Important Formula

`arr[i]` is equivalent to `*(arr + i)`

Demonstration Program

```c
#include <stdio.h>
#include <conio.h>

void main() {
    int vec[] = {10, 11, 13, 20, 39};
    int i;

    for(i = 0; i < 5; i++) {
        printf("%d %d %d %d %d %d\n",
               vec, &vec[i], vec[i],
               *(i+vec), *(vec+i), i[vec]);
    }

    getch();
}
```

Program Output Explained

Expression	Meaning
`vec`	Base address (constant)
`&vec[i]`	Address of element i
`vec[i]`	Value at index i (standard notation)
`*(i+vec)`	Value using pointer arithmetic
`*(vec+i)`	Value using pointer arithmetic
`i[vec]`	Alternative notation (works in C)

Key Insight

All expressions except the first two return the same value - the element at position i!

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- `arr[i]` is equivalent to `*(arr + i)`