CSE101-Lec#17

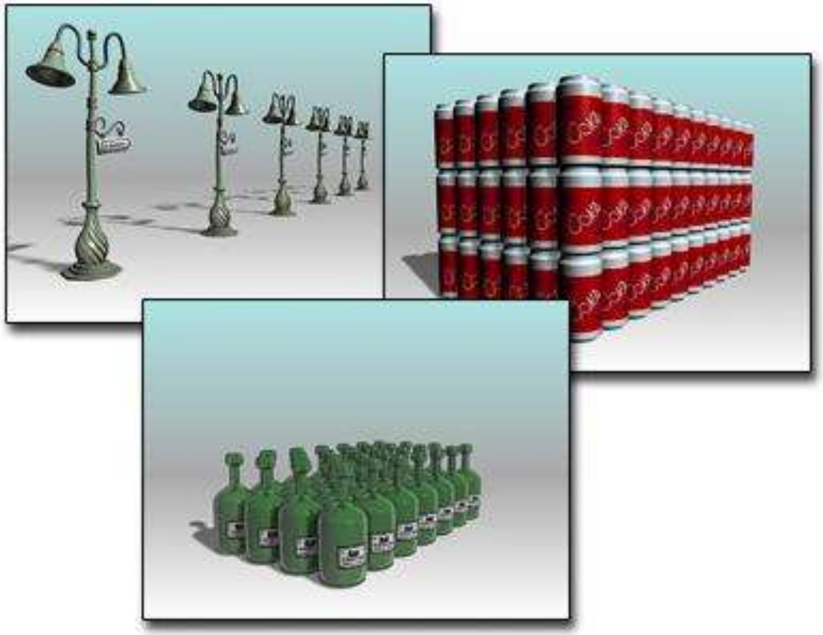
- Arrays
- (Arrays and Functions)

Outline

- To declare an array
- To initialize an array
- To pass an array to a function

Introduction

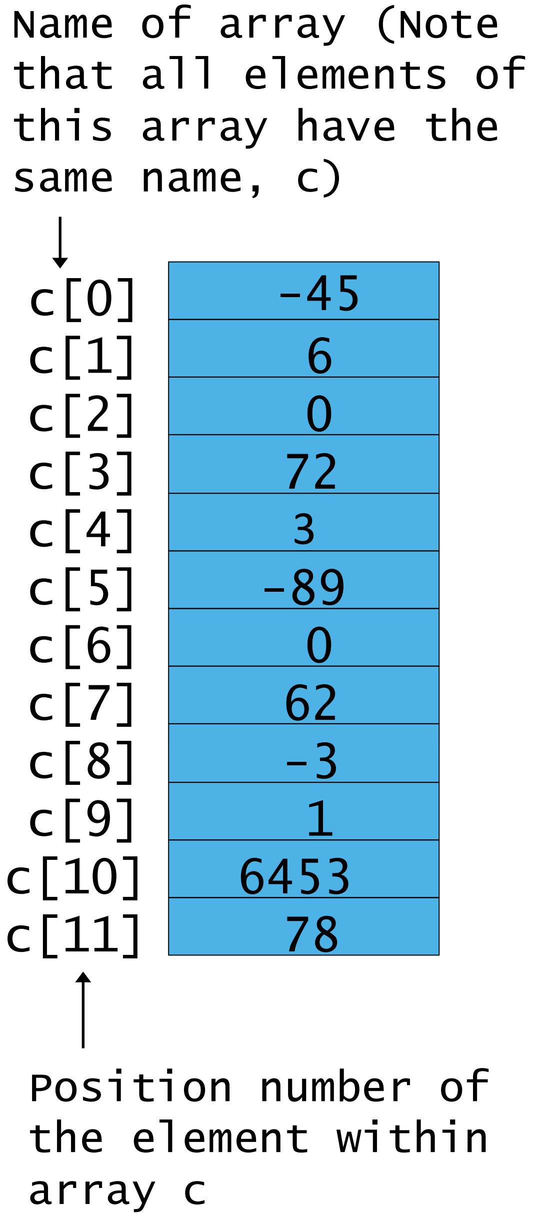
- Arrays
  - Collection of **related** data items of **same data type**.
  - Static entity – i.e. they remain the same size throughout program execution



Arrays

- Array
  - Group of consecutive memory locations
  - Same name and data type
- To refer to an element, specify:
  - Array name
  - Position number in square brackets([])
- Format:

  arrayname[position_number]
  - First element is always at position `0`
  - Eg. `n` element array named `c`:
    - `c[0], c[1]...c[n – 1]`



Name of array (Note that all elements of this array have the same name, c)

c[0]	-45
c[1]	6
c[2]	0
c[3]	72
c[4]	3
c[5]	-89
c[6]	0
c[7]	62
c[8]	-3
c[9]	1
c[10]	6453
c[11]	78

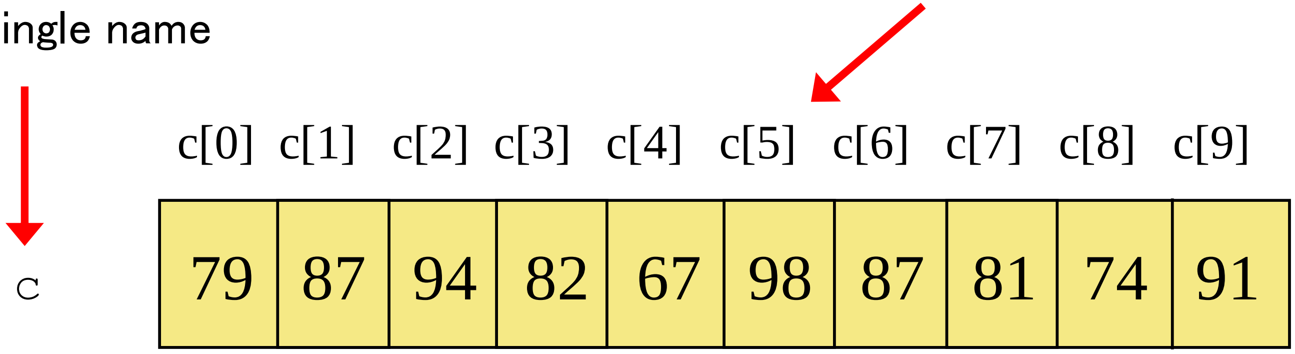
Position number of the element within array c

Arrays

- An *array* is an ordered list of values

The entire array
has a single name

Each value has a numeric *index*



c

c[0]	c[1]	c[2]	c[3]	c[4]	c[5]	c[6]	c[7]	c[8]	c[9]
79	87	94	82	67	98	87	81	74	91

An array of size **N** is indexed from **zero to N-1**

This array holds 10 values that are indexed from 0 to 9

Arrays

- Array elements are like normal variables

```
c[0] =  3;/*stores 3 to c[0] element*/
scanf (“%d”, &c[1]);/*reads c[1] element*/
printf (“%d, %d”, c[0], c[1]); /*displays
                                 c[0] & c[1] element*/
```

- The position number inside square brackets is called **subscript/index**.
- Subscript must be integer or an integer expression

```
c[5 - 2] = 7;  (i.e. c[3] = 7)
```

Defining Arrays

- When defining arrays, specify:
  - Name
  - Data Type of array
  - Number of elements

    ```
    datatype arrayName[numberOfElements];
    ```
  - Examples:

    ```
    int students[10];
    float myArray[3284];
    ```
- Defining multiple arrays of same data type
  - Format is similar to regular variables
  - Example:

    ```
    int b[100], x[27];
    ```

Initializing Arrays

- Initializers

  ```
  int n[5] = { 1, 2, 3, 4, 5 };
  ```

  - If not enough initializers given, then rightmost elements become 0
  - `int n[5] = { 0 };  //` initialize all elements to 0
  - C arrays have no bounds checking.
- If size is omitted, initializers determine it

  ```
  int n[] = { 1, 2, 3, 4, 5 };
  ```

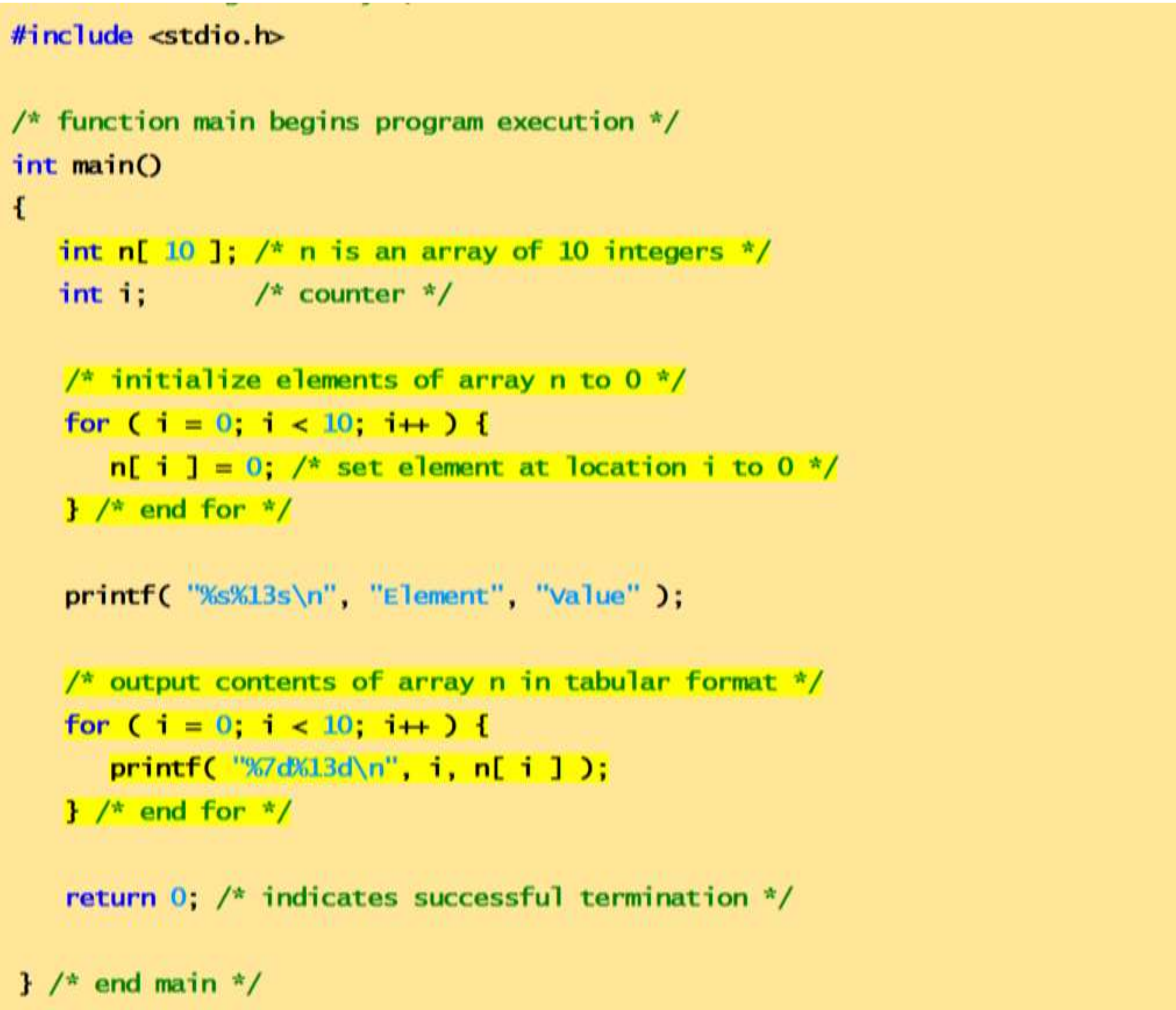
  - 5 initializers, therefore 5 element array.

Initializing Arrays

- Array is same as the variable can prompt for value from the user at run time.
- Array is a group of elements so we use **for** loop to get the values of every element instead of getting single value at a time.
- Example:

```
int array[5], i;  // array of size 5
for(i=0;i<5;i++){// loop begins from 0 to 4
   scanf(“%d”, &array[i]);
 }
```

Program of Initializing an array to zero using loop.



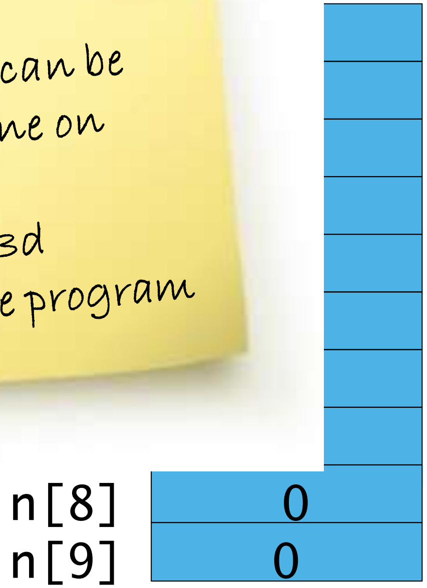
```
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int n[ 10 ]; /* n is an array of 10 integers */
   int i;       /* counter */

   /* initialize elements of array n to 0 */
   for ( i = 0; i < 10; i++ ) {
      n[ i ] = 0; /* set element at location i to 0 */
   } /* end for */

   printf( "%s%13s\n", "Element", "Value" );

   /* output contents of array n in tabular format */
   for ( i = 0; i < 10; i++ ) {
      printf( "%7d%13d\n", i, n[ i ] );
   } /* end for */

   return 0; /* indicates successful termination */

} /* end main */
```

```
Element          Value
      0              0
      1              0
      2              0
      3              0
      4              0
      5              0
      6              0
      7              0
      8              0
      9              0
```

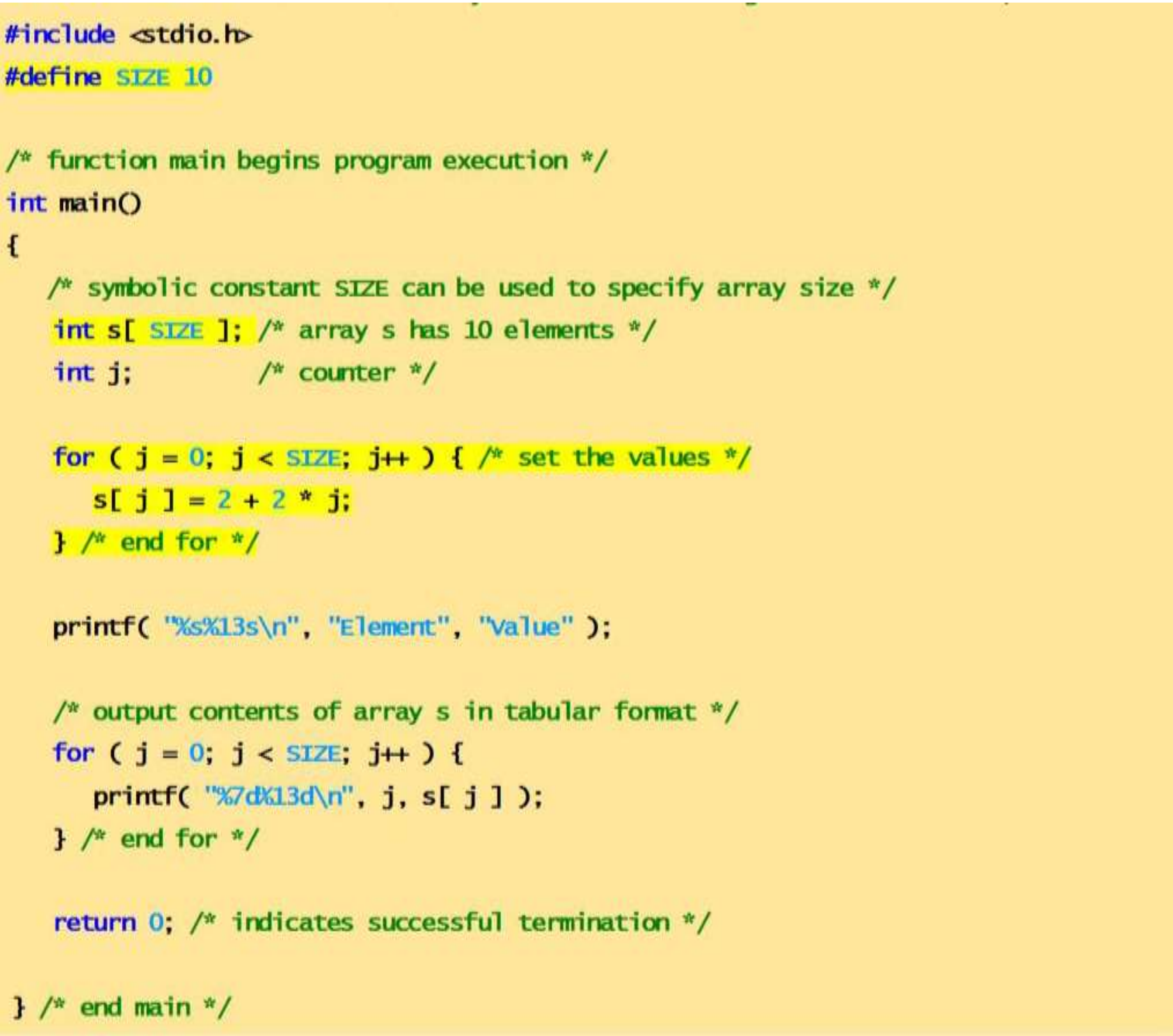
Quick yak:
Discussion can be quickly done on

- %s%13s
- %7d%13d

used in the program



Program of Initializing an array element with calculations using loop.



```
#include <stdio.h>
#define SIZE 10

/* function main begins program execution */
int main()
{
   /* symbolic constant SIZE can be used to specify array size */
   int s[ SIZE ]; /* array s has 10 elements */
   int j;         /* counter */

   for ( j = 0; j < SIZE; j++ ) { /* set the values */
      s[ j ] = 2 + 2 * j;
   } /* end for */

   printf( "%s%13s\n", "Element", "Value" );

   /* output contents of array s in tabular format */
   for ( j = 0; j < SIZE; j++ ) {
      printf( "%7d%13d\n", j, s[ j ] );
   } /* end for */

   return 0; /* indicates successful termination */

} /* end main */
```

```
Element          Value
      0              2
      1              4
      2              6
      3              8
      4             10
      5             12
      6             14
      7             16
      8             18
      9             20
```

n[0]	2
n[1]	4
n[2]	6
n[3]	8
n[4]	10
n[5]	12
n[6]	14
n[7]	16
n[8]	18
n[9]	20

Program to compute sum of elements of array

```c
#include <stdio.h>
#define SIZE 12

/* function main begins program execution */
int main()
{
   /* use initializer list to initialize array */
    int a[ SIZE ] = { 1, 3, 5, 4, 7, 2, 99, 16, 45, 67, 89, 45 };
    int i;          /* counter */
    int total = 0; /* sum of array */

    /* sum contents of array a */
    for ( i = 0; i < SIZE; i++ ) {
       total += a[ i ];
    } /* end for */

    printf( "Total of array element values is %d\n", total );

    return 0; /* indicates successful termination */

 } /* end main */
```

```
Total of array element values is 383
```

Program to explain the address of array

```c
#include <stdio.h>

/* function main begins program execution */
int main()
{
   char array[ 5 ]; /* define an array of size 5 */

   printf( "    array = %p\n&array[0] = %p\n"
      "   &array = %p\n",
      array, &array[ 0 ], &array );

   return 0; /* indicates successful termination */

} /* end main */
```

```
    array = 0012FF78
&array[0] = 0012FF78
   &array = 0012FF78
```

Character Arrays

- Character arrays
  - Character arrays can be initialized using string literals

    ```
    char string1[] = "first";
    ```

    - It is equivalent to

    ```
    char string1[] = { 'f', 'i', 'r', 's', 't', '\0' };
    ```

    - Null character `'\0'` terminates strings
    - `string1` actually has **6 elements**
  - Can access individual characters

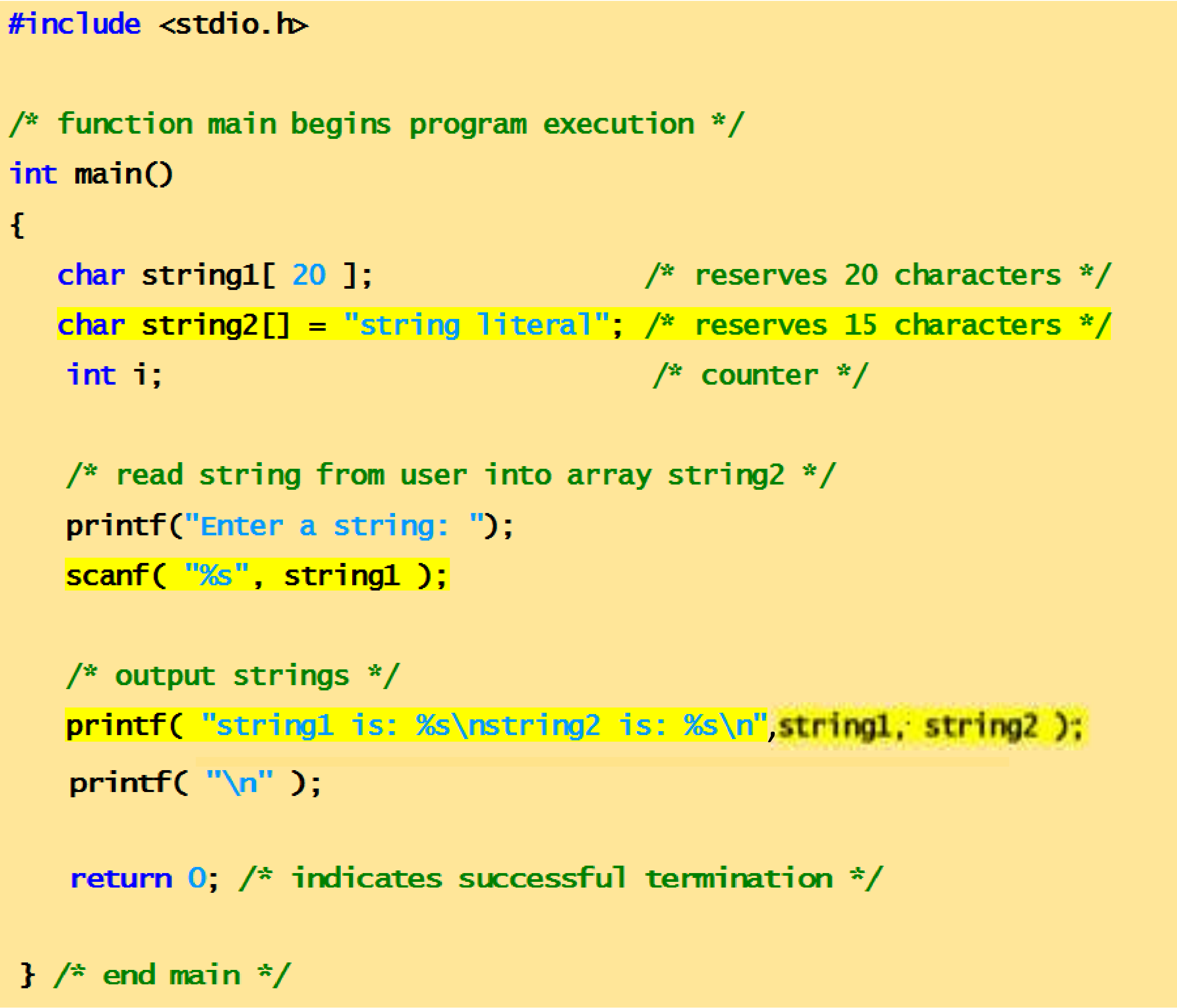
    ```
    string1[ 3 ] is character 's'
    ```

  - Array name is address of array, so **&** not needed for scanf

    ```
    scanf( "%s", string2 );
    ```

    - Reads characters until whitespace encountered

Program to print character array as strings.



```c
#include <stdio.h>

/* function main begins program execution */
int main()
{
   char string1[ 20 ];                     /* reserves 20 characters */
   char string2[] = "string literal";  /* reserves 15 characters */
    int i;                                 /* counter */

    /* read string from user into array string2 */
    printf("Enter a string: ");
    scanf( "%s", string1 );

    /* output strings */
    printf( "string1 is: %s\nstring2 is: %s\n",string1, string2 );
    printf( "\n" );

    return 0; /* indicates successful termination */

 } /* end main */
```

```
Enter a string: Hello
string1 is: Hello
string2 is: string literal
```

Passing Arrays to Function

- Arrays can be passed to functions in two ways:

1. **Pass entire array**
2. **Pass array element by element**

Pass entire array

- Here entire array can be passed as an argument to the function
- Function gets **complete access** to the original array
- While passing entire array Address of first element is passed to function, any changes made inside function, directly **affects the Original value.**

```
void modifyArray(int b[], int arraySize);
```

- Function passing method: “ **Pass by Address”**

Pass array element by element

- Here individual elements are passed to the function as argument
- Duplicate **carbon copy of Original variable** is passed to function
- So any changes made inside function **does not affects the original value**
- Function doesn’t get complete access to the original array element.

```
void modifyElement(int e);
```

- Function passing method: “ **Pass by Value”**

Passing Arrays to Functions

- Function prototype

```
void modifyArray(int b[], int arraySize);
```

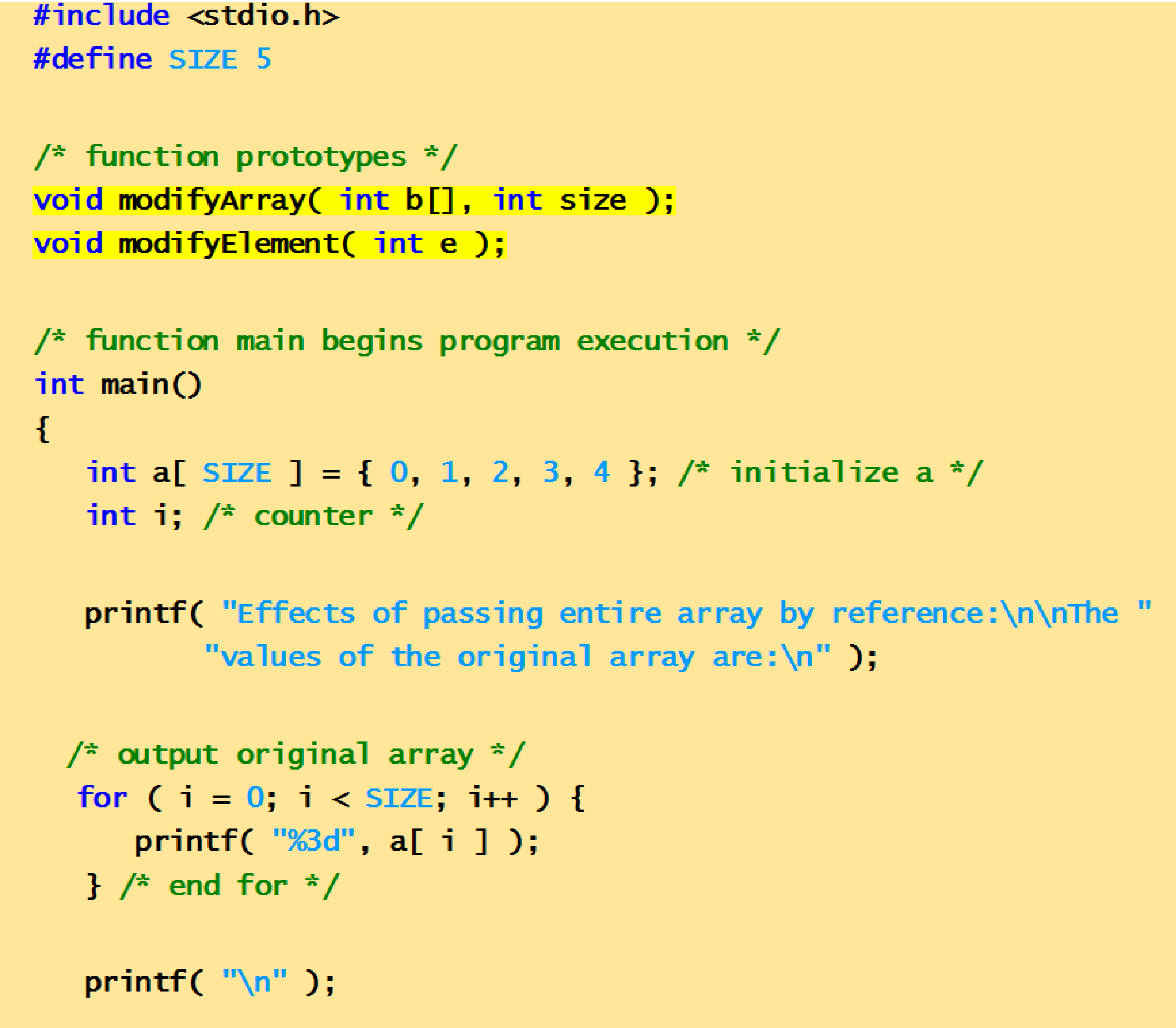
  - Parameter names optional in prototype
    - `int b[]` could be written `int []`
    - `int arraySize` could be simply `int`

```
 void modifyArray(int [], int);
```

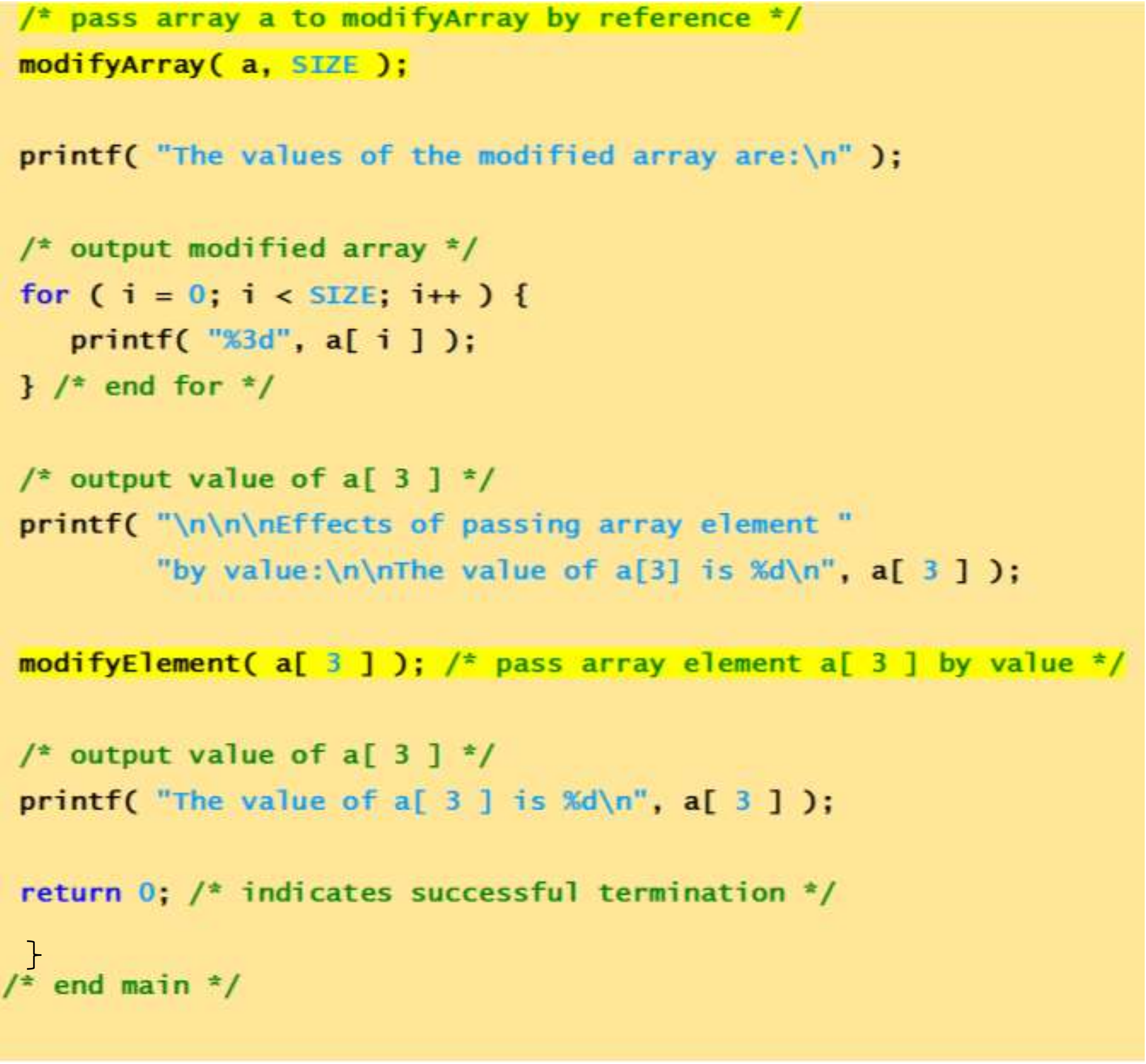
- Function call

```
    int a[SIZE];
    modifyArray(a, SIZE);
```

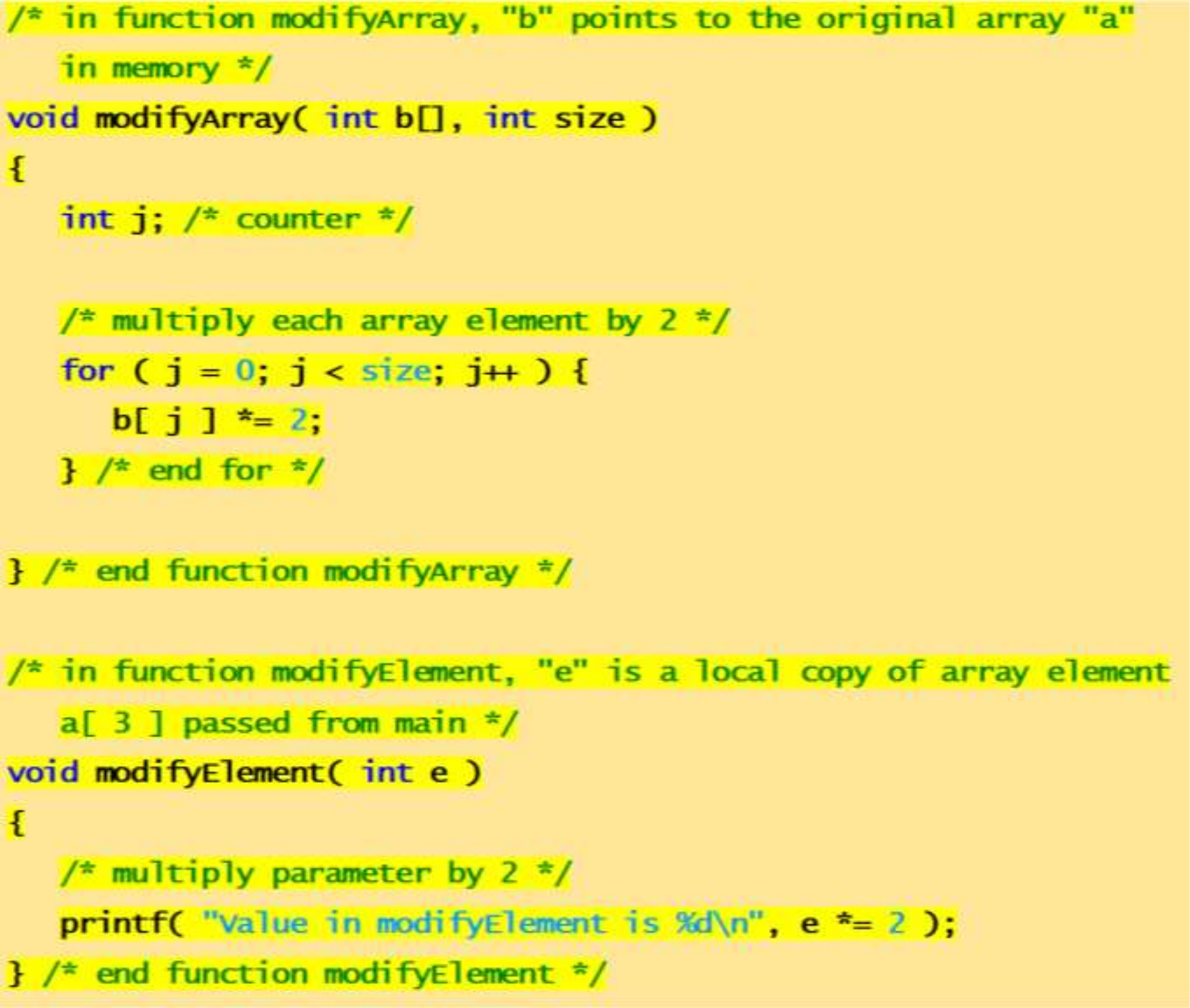
Passing arrays and individual array elements to functions



```
#include <stdio.h>
#define SIZE 5

/* function prototypes */
void modifyArray( int b[], int size );
void modifyElement( int e );

/* function main begins program execution */
int main()
{
   int a[ SIZE ] = { 0, 1, 2, 3, 4 }; /* initialize a */
   int i; /* counter */

   printf( "Effects of passing entire array by reference:\n\nThe "
          "values of the original array are:\n" );

  /* output original array */
  for ( i = 0; i < SIZE; i++ ) {
     printf( "%3d", a[ i ] );
   } /* end for */

   printf( "\n" );
```



```
/* pass array a to modifyArray by reference */
modifyArray( a, SIZE );

printf( "The values of the modified array are:\n" );

/* output modified array */
for ( i = 0; i < SIZE; i++ ) {
   printf( "%3d", a[ i ] );
} /* end for */

/* output value of a[ 3 ] */
printf( "\n\n\nEffects of passing array element "
        "by value:\n\nThe value of a[3] is %d\n", a[ 3 ] );

modifyElement( a[ 3 ] ); /* pass array element a[ 3 ] by value */

/* output value of a[ 3 ] */
printf( "The value of a[ 3 ] is %d\n", a[ 3 ] );

return 0; /* indicates successful termination */

 }
/* end main */
```



```
/* in function modifyArray, "b" points to the original array "a"
   in memory */
void modifyArray( int b[], int size )
{
   int j; /* counter */

   /* multiply each array element by 2 */
   for ( j = 0; j < size; j++ ) {
      b[ j ] *= 2;
   } /* end for */

} /* end function modifyArray */

/* in function modifyElement, "e" is a local copy of array element
   a[ 3 ] passed from main */
void modifyElement( int e )
{
   /* multiply parameter by 2 */
   printf( "Value in modifyElement is %d\n", e *= 2 );
} /* end function modifyElement */
```

```
Effects of passing entire array by reference:

The values of the original array are:
  0  1  2  3  4
The values of the modified array are:
  0  2  4  6  8



Effects of passing array element by value:

The value of a[3] is 6
Value in modifyElement is 12
The value of a[3] is 6
```

MCQ

Choose a correct statement about C language arrays.

A) An array address is the address of first element of array itself.

B) An array size must be declared if not initialized immediately.

C) Array size is the sum of sizes of all elements of the array.

D) All the above

MCQ

What is the output of C Program.?

```
 int main()
 {
 int a[] = {1,2,3,4};
 int b[4] = {5,6,7,8};
printf("%d,%d", a[0], b[0]);
 }
```

A) 1,5
B) 2,6
C) 0 0
D) Compiler error

MCQ

What is the output of C Program.?

```
 int main()
 {
 int a[3] = {10,12,14};
 a[1]=20;
int i=0;
while(i<3)
 {
 printf("%d ", a[i]); i++; }
 }
```

A) 20 12 14

B) 10 20 14

C) 10 12 20

D) Compiler error

MCQ

An array Index starts with.?

A) -1

B) 0

C) 1

D) 2

What is the minimum and maximum Indexes of this below array.?

```
int main()
{
 int ary[9];
 return 0;
 }
```

A) -1, 8

B) 0, 8

C) 1,9

D) None of the above

MCQ

Array can be considered as set of elements stored in consecutive memory locations but having __________.

A. Same data type
B. Different data type
C. Same scope
D. None of these

What is a multidimensional array in C Language.?

A) It is like a matrix or table with rows and columns

B) It is an array of arrays

C) To access 3rd tow 2nd element use ary[2][1] as the index starts from 0 row or column

D) All the above.

Find the output of the code?

```
#include <stdio.h>
  void main()
  {
     int a[2][3] = {1, 2, 3, 4, 5};
     int i = 0, j = 0;
     for (i = 0; i < 2; i++)
     {
        for (j = 0; j < 3; j++)
     printf("%d", a[i][j]);
     }
  }
```

a) 1 2 3 4 5 0   b) 1 2 3 4 5 junk   c) 1 2 3 4 5 5   d) Run time error

MCQ

Size of the array need not be specified, when

A.Initialization is a part of definition

B.It is a declaratrion

C.It is a formal parameter

D.All of these

MCQ

Consider the array definition

int num [10] = {3, 3, 3};

Pick the Correct answers

A.num [9] is the last element of the array num

B.The value of num [8] is 3

C.The value of num [3] is 3

D.None of the above

MCQ

Which of the following statements are correct about 6 used in the program?

```
int num[6];
num[6]=21;
```

A.In the first statement 6 specifies a particular element, whereas in the second statement it specifies a type.

B.In the first statement 6 specifies a array size, whereas in the second statement it specifies a particular element of array.

C.In the first statement 6 specifies a particular element, whereas in the second statement it specifies a array size.

D.In both the statement 6 specifies array size.

Point the correct statement

A. An array element may be an array by itself

B. Strictly speaking C supports 1-dimensional arrays only

C. Array elements need not occupy contiguous memory locations

MCQ

Where is linear searching used?

a) When the list has only a few elements

b) When performing a single search in an unordered list

c) Used all the time

d) When the list has only a few elements and When performing a single search in an unordered list

Next Class:
Applications of Arrays

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CSE101-Lec# 14,15, 16

- What are Arrays?
- To declare an array
- To initialize an array
- To display address of the array
- Basic program examples of 1D array
- To pass an array to a function(By reference and By value)
- Applications and Operations on 1D Array

Outline

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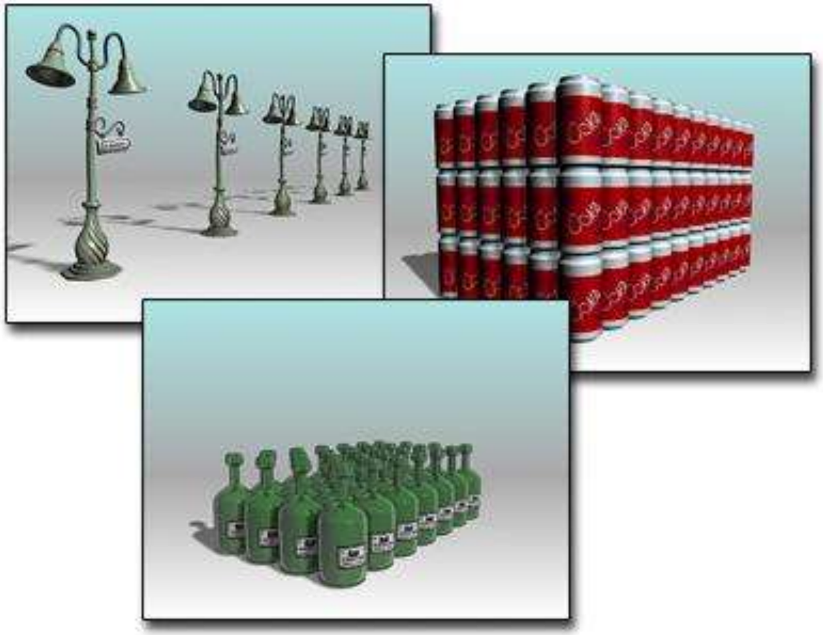
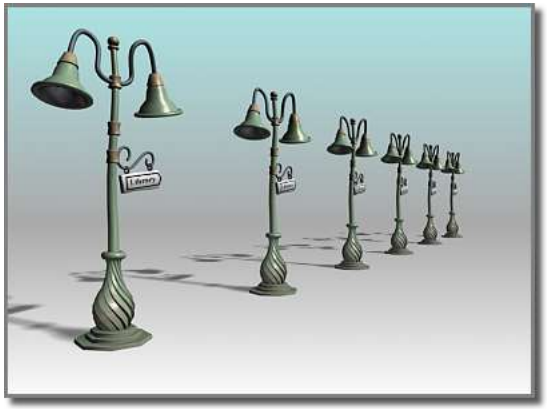


Types

- One Dimensional (e.g. int a[100])
- Multidimensional(2D,3D….)(e.g. int a[5][5], int a[5][5][5])

1-D array

- A single- dimensional or 1-D array consists of a fixed number of elements of the same data type organized as a single **linear** sequence.
- The elements of a single dimensional array can be accessed by using a single subscript
- The arrays we have studied till now were 1D array or linear array.
- Example: `int a[n];`

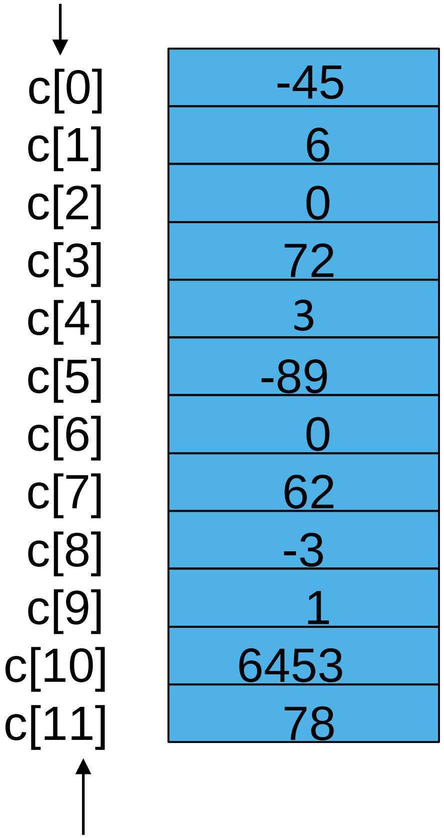


Arrays(1D)

- Array
  - Group of consecutive memory locations
  - Same name and data type
- To refer to an element, specify:
  - Array name
  - Position number in square brackets([])
- Format:

  `arrayname[position_number]`

  - First element is always at position 0
  - Eg. n element array named c:
    - c[0], c[1]...c[n – 1]



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c[8]	-3
c[9]	1
c[10]	6453
c[11]	78

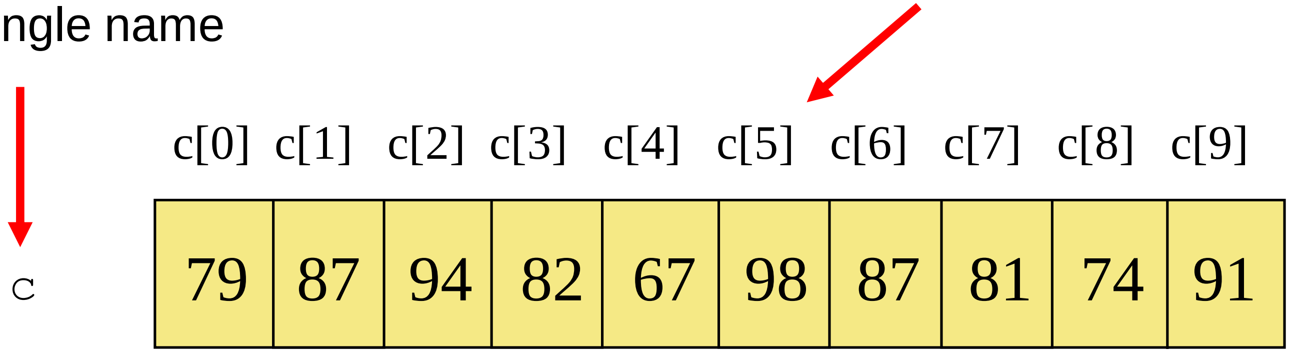
Position number of the element within array c

Arrays

- An *array* is an ordered list of values

The entire array
has a single name

Each value has a numeric *index*



c

c[0]	c[1]	c[2]	c[3]	c[4]	c[5]	c[6]	c[7]	c[8]	c[9]
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An array of size **N** is indexed from **zero to N-1**

This array holds 10 values that are indexed from 0 to 9

Arrays

- Array elements are like normal variables

```
c[0] =  3;/*stores 3 to c[0] element*/
scanf (“%d”, &c[1]);/*reads c[1] element*/
printf (“%d, %d”, c[0], c[1]); /*displays
                              c[0] & c[1] element*/
```

- The position number inside square brackets is called **subscript/index**.
- Subscript must be integer or an integer expression

```
c[5 - 2] = 7;  (i.e. c[3] = 7)
```

Defining Arrays

- When defining arrays, specify:
  - Name
  - Data Type of array
  - Number of elements

```
datatype arrayName[numberOfElements];
```

  - Examples:

```
int students[10];
float myArray[3284];
```

- Defining multiple arrays of same data type
  - Format is similar to regular variables
  - Example:

```
int b[100], x[27];
```

Initializing Arrays

Different ways of initializing ID Arrays

1) Initializing array at the point of declaration

- int a[5]={1,2,3,4,5};
- int a[]={1,2,3,4,5};//Here compiler will automatically depict the size:5
- int a[5]={1,2,3};//Partial initialization[Remaining elements will be initialized to default values for integer, i.e. 0]
- int a[5]={};//All elements will be initialized to zero
- int a[5]={1};//First element is one and the remaining elements are default values for integer, i.e. 0

Initializing Arrays

2) Initializing array after taking input from the user

- Array is same as the variable can prompt for value from the user at run time.
- Array is a group of elements so we use **for** loop to get the values of every element instead of getting single value at a time.
- Example: int array[5], i; // array of size 5

```
          for(i=0;i<5;i++){// loop begins from 0 to 4
               scanf("%d", &array[i]);
            }
```

Printing base address of the array and address of any array element

```
#include<stdio.h>
int main()
{
int a[5]={1,2,3,4,5};
int i;
printf("\n Printing base address of the array:");
printf("\n%u %u %u",&a[0],a,&a);
printf("\n Printing addresses of all array elements:");
for(i=0;i<5;i++)
{
printf("\n%u",&a[i]);
}
return 0;
}
```

Program example 1-WAP to read and display elements of 1D Array

```
#include<stdio.h>
int main()
{
        int a[100],n,i;
        printf("\n Enter number of elements:");
        scanf("%d",&n);
        printf("\n Enter array elements:");
        for(i=0;i<n;i++)
        {
                scanf("%d",&a[i]);
        }
        printf("\n Entered array elements are:");
        for(i=0;i<n;i++)
        {
                printf("\n%d",a[i]);
        }
        return 0;
}
```

Program example-2 WAP to find the sum of all 1D array elements

```
#include<stdio.h>
int main()
{
        int a[100],n,i,sum=0;
        printf("\n Enter number of elements:");
        scanf("%d",&n);
        printf("\n Enter array elements:");
        for(i=0;i<n;i++)
        {
                scanf("%d",&a[i]);
        }
        for(i=0;i<n;i++)
        {
                sum=sum+a[i];
        }
        printf("\n Sum of array elements is:%d",sum);
        return 0;

}
```

Program example 3-WAP to display the largest and smallest element from 1D array elements

```
#include<stdio.h>
int main()
{
        int n,a[10],i,max,min;
        printf("\n Enter number of elements:");
        scanf("%d",&n);
        for(i=0;i<n;i++)
        {
        scanf("%d",&a[i]);
        }
        min=a[0];
        for(i=1;i<n;i++)
        {
        if(a[i]<min)
        {
        min=a[i];
        }
        }
        max=a[0];
        for(i=1;i<n;i++)
        {
        if(a[i]>max)
        {
        max=a[i];
        }
        }
        printf("\nMaximum element is: %d",max);
        printf("\nMinimum element is: %d",min);
        return 0;
        }
```

Passing Arrays to Function

- Arrays can be passed to functions in two ways:

1. **Pass entire array**
2. **Pass array element by element**

Pass entire array

- Here entire array can be passed as an argument to the function
- Function gets **complete access** to the original array
- While passing entire array Address of first element is passed to function, any changes made inside function, directly **affects the Original value.**

```
void modifyArray(int b[], int arraySize);
```

- Function passing method: **“ Pass by Address”**

Passing array element by element

- Here individual elements are passed to the function as argument
- Duplicate **carbon copy of Original variable** is passed to function
- So any changes made inside function **does not affects the original value**
- Function doesn’t get complete access to the original array element.

```
void modifyElement(int e);
```

- Function passing method: **“ Pass by Value”**

Passing Arrays to Functions

- Function prototype

```
void modifyArray(int b[], int arraySize);
```

  - Parameter names optional in prototype
    - `int b[]` could be written `int []`
    - `int arraySize` could be simply `int`

```
void modifyArray(int [], int);
```

- Function call

```
int a[SIZE];
modifyArray(a, SIZE);
```

Program example-1 Passing Array to a function using by reference(or Passing entire array at once)

```
#include<stdio.h>
void reference(int[],int);
int main()
{
        int arr[100],n;
        int i;
        printf("\n Enter n:");
        scanf("%d",&n);
        printf("\n Enter array elements:");
        for(i=0;i<n;i++)
  {
        scanf("%d",&arr[i]);
  }
        printf("\n Elements by reference:");
        reference(arr,n);//Passing array by call by reference
        return 0;
}
```

```
void reference(int x[],int size)
{
        int i;
        for(i=0;i<size;i++)
        {
                printf("%d ",x[i]);
        }
}
```

Program example-2 Passing Array to a function using by value(or Passing element by element)

```
#include<stdio.h>
void value(int);
int main()
 {
          int arr[100],n;
          int i;
          printf("\n Enter n:");
          scanf("%d",&n);
          printf("\n Enter array elements:");
          for(i=0;i<n;i++)
          {
          scanf("%d",&arr[i]);
          }
          printf("\n Passing elements by value:");
          for(i=0;i<5;i++)
          {
          value(arr[i]);//Passing array value by Call by value
           }
          return 0;
}
```

```
void value(int u)
{
          printf("%d ",u);
}
```

Application Of Array :

Stores Elements of Same Data Type

- Array is used to store the number of elements that are of same data type.
- Eg: int students[30];
- array of marks of five subjects for single student.

  float marks[5];
- array of marks of five subjects for 30 students.

  float marks[30][5]
- Similarly if we declare the character array then it can hold only character.
- So in short character array can store character variables while floating array stores only floating numbers.

Array Used for Maintaining multiple variable names using single name

Suppose we need to store 5 roll numbers of students then without declaration of array we need to declare following -

int roll1,roll2,roll3,roll4,roll5;

1. Now in order to get roll number of first student we need to access roll1.
2. Guess if we need to store roll numbers of 100 students then what will be the procedure.
3. Maintaining all the variables and remembering all these things is very difficult.

- So we are using array which can store multiple values and we have to remember just single variable name.

Array Can be Used for Sorting Elements

- We can store elements to be sorted in an array and then by using different sorting technique we can sort the elements.

Different Sorting Techniques are :

1. Bubble Sort
2. Insertion Sort
3. Selection Sort

Array Can Perform Matrix Operation

Matrix operations can be performed using the array. We can use 2-D array

- To store the matrix.
- To perform all mathematical manipulations on matrix.
- Matrix can be multi-dimensional.

Searching in Arrays

- The process of finding a particular element of an array is called searching.
- Search an array for a *key* value.
- Two searching techniques:
  - Linear search
  - Binary search

Linear search

- Linear search
  - Simple
  - Compare each element of array with key value
  - Useful for small and unsorted arrays
- It simply examines each element sequentially, starting with the first element, until it finds the key element or it reaches the end of the array.

  Example: If you were looking for someone on a moving passenger train, you would use a sequential search.

Program example-WAP to implement linear search in 1D array element

```c
#include <stdio.h>
int main()
{
  int a[50];
  int i, loc = -1, key,n;
  printf("\n Enter value of n:");
  scanf("%d",&n);
  printf("\n Enter the elements:");

  for(i=0;i<n;i++)
  {
                scanf("%d",&a[i]);
  }
  printf("Enter integer value to search in array:");
  scanf( "%d", &key );
  // attempt to locate searchKey in array a
  for ( i = 0; i < n; i++ )
  {
   if ( a[i] == key )
   {
    loc = i; // location of key is stored
    break;
   } // end if
  } // end for
```

```c
 if(loc!= -1)
  {
   printf("Element found at %d",loc+1);
  }
  else
  {
   printf("Element not found");
  }
} // end main
```

Binary search

- Binary search
  - Applicable for **sorted** arrays
- The algorithm locates the **middle** element of the array and compares it to the key value.
  - Compares middle element with the key
    - If equal, match found
    - If key < middle, looks in left half of middle
    - If key > middle, looks in right half of middle
    - Repeat (the algorithm is repeated on **one-quarter** of the original array.)

Binary search

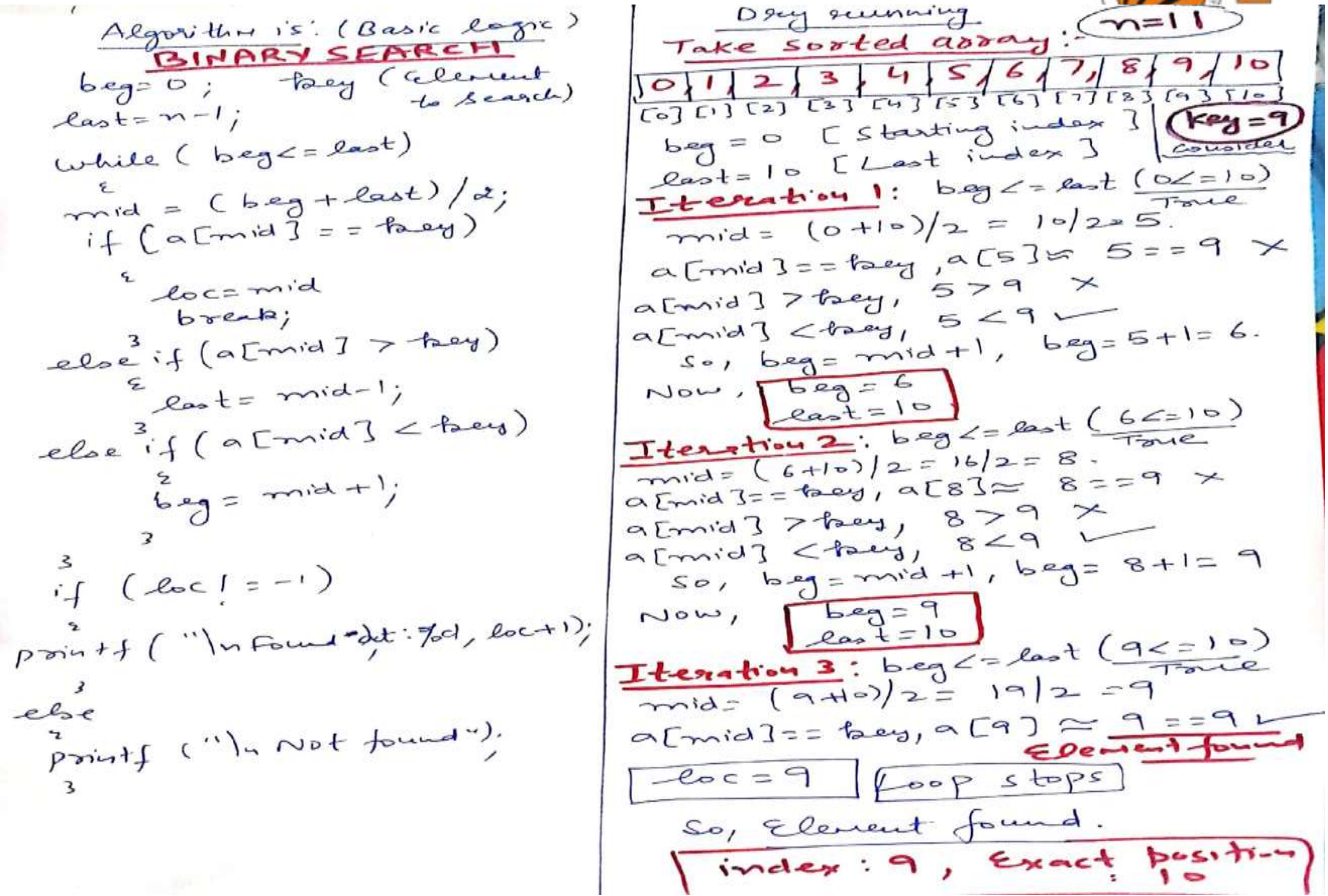
- It repeatedly divides the sequence in two, each time restricting the search to the half that would contain the element.
- This is a tremendous increase in performance over the linear search that required comparing the search key to an average of half of the array elements.
- You might use the binary search to look up a word in a dictionary

Program example-WAP to implement Binary Search in 1D array elements

```
#include<stdio.h>
int main()
{

  int a[50],n,loc=-1, key, beg,last,mid,i;
  printf("\n Enter number of array elements:");
  scanf("%d",&n);
  printf("\n Enter array elements:");
  for(i=0;i<n;i++)
  {
                scanf("%d",&a[i]);
  }
  beg=0;
  last=n-1;
  printf("Enter integer value to search in sorted array:");
  scanf( "%d", &key );
   while(beg<=last)//Loop will run until unless only one element is not
remaining
   {
    mid = (beg + last) / 2; // determine index of middle element
    if(a[mid]==key)
    {
      loc=mid; //save the location of element.
      break;
    }
    else if(a[mid]>key) //Middle element is greater than key
    {
      last=mid-1;//If middle element is greater than key, we
need to search left subarray
    }
    else if(a[mid]<key) //Middle element is less than key
    {
      beg=mid+1;//If middle element is less than key, we
need to search right subarray
    } //end of if else
   } //end of while
   if(loc!=-1)
   {
     printf("element found at %d", loc+1);//Location is
exact position, not index
   }
   else
   {
     printf("element not found");
   }
   return 0;
}
```

Dry running



Algorithm is: (Basic logic)

BINARY SEARCH

```
beg=0;        key (element
                  to search)
last=n-1;
while (beg<=last)
{
 mid = (beg+last)/2;
  if (a[mid] == key)
  {
     loc=mid
     break;
  }
 else if (a[mid] > key)
  {
     last= mid-1;
  }
 else if (a[mid] < key)
  {
     beg= mid+1;
  }
}
if (loc!=-1)
{
printf("\n Found at: %d", loc+1);
}
else
{
printf("\n Not found");
}
```

Dry running

Take sorted array: n=11

0	1	2	3	4	5	6	7	8	9	10
[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]

Key=9 consider

beg = 0 [Starting index]

last=10 [Last index]

Iteration 1: beg<=last (0<=10) True

mid= (0+10)/2 = 10/2=5.

a[mid]==key, a[5]≃ 5==9 ✗

a[mid] > key, 5>9 ✗

a[mid] < key, 5<9 ✓

So, beg= mid+1, beg= 5+1= 6.

Now, beg=6 last=10

Iteration 2: beg<=last (6<=10) True

mid= (6+10)/2 = 16/2= 8.

a[mid]==key, a[8]≃ 8==9 ✗

a[mid] > key, 8>9 ✗

a[mid] < key, 8<9 ✓

So, beg= mid+1, beg= 8+1= 9

Now, beg=9 last=10

Iteration 3: beg<=last (9<=10) True

mid= (9+10)/2 = 19/2 =9

a[mid]== key, a[9] ≃ 9==9 ✓

Element found

loc=9

Loop stops

So, Element found.

index : 9, Exact position : 10

Sorting

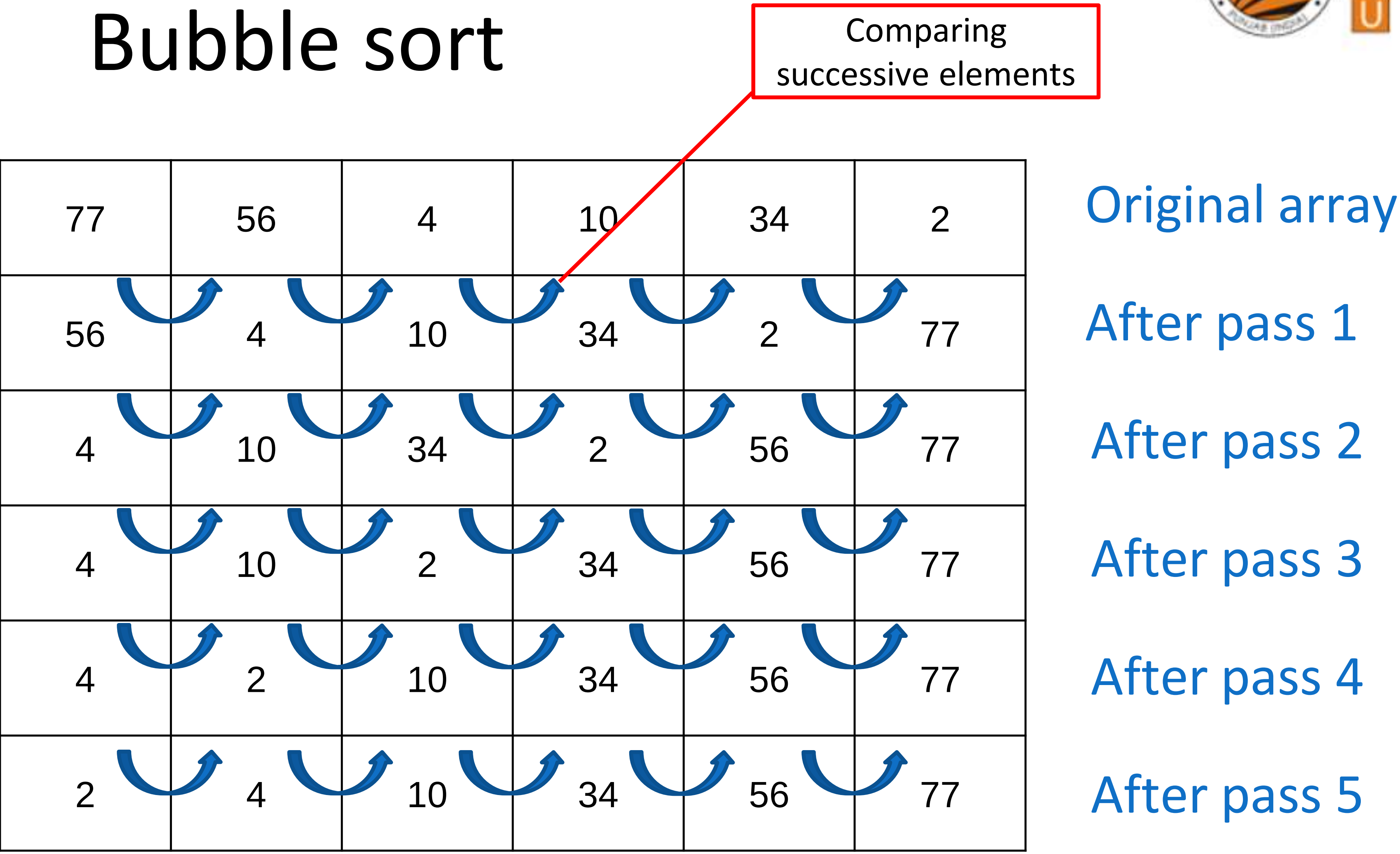
- Sorting data
  - Important computing application
  - Virtually every organization must sort some data

Bubble sort

Bubble sort (sinking sort)

- A simple but inefficient sorting technique.
  - Several passes through the array
  - Successive pairs of elements are compared
    - If increasing order (or identical), no change
    - If decreasing order, elements exchanged
  - Repeat

Bubble sort



Comparing successive elements

77	56	4	10	34	2	Original array
56	4	10	34	2	77	After pass 1
4	10	34	2	56	77	After pass 2
4	10	2	34	56	77	After pass 3
4	2	10	34	56	77	After pass 4
2	4	10	34	56	77	After pass 5

Total number of pass required for sorting: n-1

Bubble sort

- It’s called bubble sort or sinking sort because smaller values gradually “bubble” their way to the top of the array (i.e., toward the first element) like air bubbles rising in water, while the larger values sink to the bottom (end) of the array.
- The technique uses nested loops to make several passes through the array.
  - Each pass compares successive pairs of elements.
  - If a pair is in increasing order (or the values are equal), the bubble sort leaves the values as they are.
  - If a pair is in decreasing order, the bubble sort swaps their values in the array.

Bubble sort

- The first pass compares the first two elements of the array and swaps their values if necessary. It then compares the second and third elements in the array. The end of this pass compares the last two elements in the array and swaps them if necessary.
- After one pass, the largest element will be in the last index. After two passes, the largest two elements will be in the last two indices.

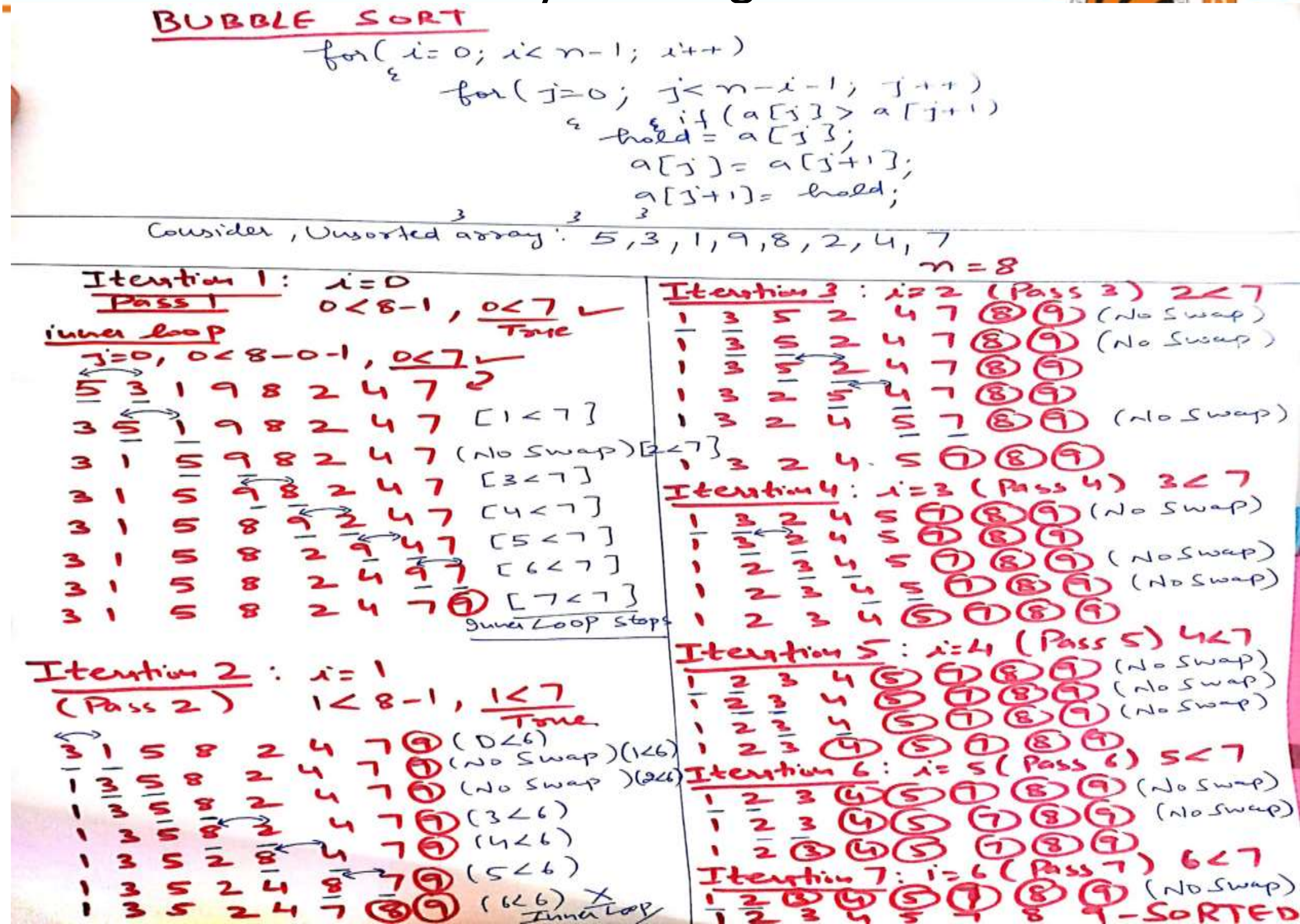
Program example-WAP to sort elements of 1D array in ascending order using Bubble sort

```
#include <stdio.h>
int main()
{
   int a[100];
   int hold,i,j,n;
   printf("\n Enter value of n:");
   scanf("%d",&n);
   printf("\n Enter elements:");
   for(i=0;i<n;i++)
   {
            scanf("%d",&a[i]);
   }
   printf( "Data items in original order" );
   for (i=0;i<n;i++ )
   {
      printf("%d ",a[i]);//Elements will
come with space
   } // end for
   // bubble sort
```

```
// loop to control number of passes(no. of passes are
always n-1)
  for (i=0;i<n-1;i++)
  {
   // loop to control number of comparisons per
pass(There is one comparison less)

                  for (j=0;j<n-i-1;j++)
                   {
       // compare adjacent elements and swap them if
first
       // element is greater than second element
       if (a[j]>a[j+1])
                                  {
         hold=a[j];
         a[j]=a[j+1];
         a[j+1]=hold;
       } // end if
     } // end inner for
  } // end outer for
  printf( "\nData items in ascending order" );
  for (i=0;i<n;i++)
  {
    printf("%d ",a[i]);
  } // end for
} // end main
```

Dry running



BUBBLE SORT

```
for( i= 0; i< n-1; i++)
{
    for( j=0; j< n-i-1; j++)
    {
        {if (a[j] > a[j+1])
            hold = a[j];
            a[j] = a[j+1];
            a[j+1]= hold;
```

Consider, Unsorted array: 5, 3, 1, 9, 8, 2, 4, 7

n = 8

Iteration 1: i=0
Pass 1 0<8-1, 0<7 ✓
True

inner loop

```
j=0, 0<8-0-1, 0<7 ✓
5 3 1 9 8 2 4 7
3 5 1 9 8 2 4 7 [1<7]
3 1 5 9 8 2 4 7 (No Swap)[2<7]
3 1 5 9 8 2 4 7 [3<7]
3 1 5 8 9 2 4 7 [4<7]
3 1 5 8 2 9 4 7 [5<7]
3 1 5 8 2 4 9 7 [6<7]
3 1 5 8 2 4 7 ⑨ [7<7]
                Inner Loop stops
```

Iteration 2 : i= 1
(Pass 2) 1< 8-1, 1<7
True

```
3 1 5 8 2 4 7 ⑨ (0<6)
1 3 5 8 2 4 7 ⑨ (No Swap)(1<6)
1 3 5 8 2 4 7 ⑨ (No Swap)(2<6)
1 3 5 8 2 4 7 ⑨ (3<6)
1 3 5 2 8 4 7 ⑨ (4<6)
1 3 5 2 4 8 7 ⑨ (5<6)
1 3 5 2 4 7 ⑧ ⑨ (6<6) ×
                  Inner Loop
```

Iteration 3 : i=2 (Pass 3) 2<7

```
1 3 5 2 4 7 ⑧ ⑨ (No Swap)
1 3 5 2 4 7 ⑧ ⑨ (No Swap)
1 3 5 2 4 7 ⑧ ⑨
1 3 2 5 4 7 ⑧ ⑨
1 3 2 4 5 7 ⑧ ⑨ (No Swap)
1 3 2 4 5 ⑦ ⑧ ⑨
```

Iteration 4 : i=3 (Pass 4) 3<7

```
1 3 2 4 5 ⑦ ⑧ ⑨ (No Swap)
1 3 2 4 5 ⑦ ⑧ ⑨
1 2 3 4 5 ⑦ ⑧ ⑨ (No Swap)
1 2 3 4 5 ⑦ ⑧ ⑨ (No Swap)
1 2 3 4 ⑤ ⑦ ⑧ ⑨
```

Iteration 5 : i=4 (Pass 5) 4<7

```
1 2 3 4 ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 3 4 ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 3 4 ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 3 ④ ⑤ ⑦ ⑧ ⑨
```

Iteration 6 : i= 5 (Pass 6) 5<7

```
1 2 3 ④ ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 3 ④ ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 ③ ④ ⑤ ⑦ ⑧ ⑨
```

Iteration 7 : i=6 (Pass 7) 6<7

```
1 2 ③ ④ ⑤ ⑦ ⑧ ⑨ (No Swap)
1 2 3 4 5 7 8 9 - SORTED
```

Operations on arrays

- Insertion of element into an array
- Deletion of element from an array

Write a program to insert an element at a given position in 1D array

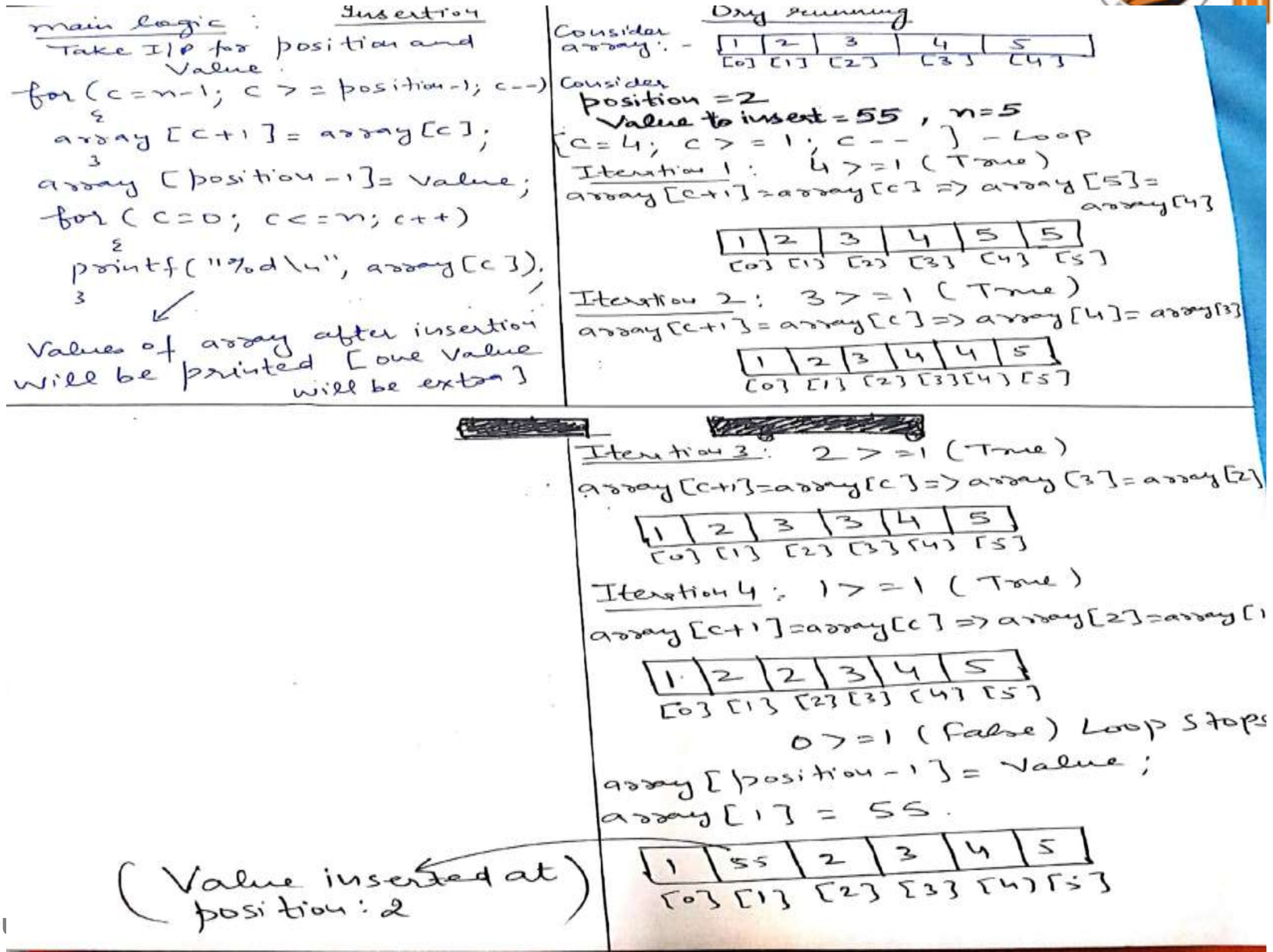
```
#include <stdio.h>
int main()
{
  int array[100], position, c, n, value;
  printf("Enter number of elements in array:\n");
  scanf("%d", &n);
  printf("Enter %d elements:\n", n);
  for (c = 0; c < n; c++)
   {
                scanf("%d", &array[c]);
                }
  printf("Enter the location where you wish to insert 
an element:\n");
  scanf("%d", &position);
  printf("Enter the value to insert:\n");
  scanf("%d", &value);

  for (c = n - 1; c >= position - 1; c--)
  {
  array[c+1] = array[c];
  }
  array[position-1] = value;
```

```
printf("Resultant array is:\n");
  for (c = 0; c <= n; c++)
  {
  printf("%d\n", array[c]);
  }
  return 0;
}
```

.

Dry running



Insertion

main logic :

Take I/P for position and Value.

```
for (c=n-1; c >= position-1; c--)
{
  array [c+1] = array [c];
}
array [position-1]= Value;
for ( c=0; c<=n; c++)
{
  printf("%d\n", array[c]);
}
```

Values of array after insertion will be printed [one value will be extra]

(Value inserted at position : 2)

Dry running

Consider array : -

1	2	3	4	5
[0]	[1]	[2]	[3]	[4]

Consider position = 2

Value to insert = 55 , n=5

[c=4; c >= 1; c--] - Loop

Iteration 1 : 4 >=1 (True)

array [c+1] = array [c] => array [5]= array [4]

1	2	3	4	5	5
[0]	[1]	[2]	[3]	[4]	[5]

Iteration 2 : 3 >=1 (True)

array [c+1] = array [c] => array [4]= array [3]

1	2	3	4	4	5
[0]	[1]	[2]	[3]	[4]	[5]

[redacted] [redacted]

Iteration 3 : 2 >=1 (True)

array [c+1]=array [c] => array [3]= array [2]

1	2	3	3	4	5
[0]	[1]	[2]	[3]	[4]	[5]

Iteration 4 : 1 >=1 (True)

array [c+1]=array [c] => array [2]=array [1

1	2	2	3	4	5
[0]	[1]	[2]	[3]	[4]	[5]

0 >=1 (false) Loop Stops

array [position - 1] = Value ;

array [1] = 55 .

1	55	2	3	4	5
[0]	[1]	[2]	[3]	[4]	[5]

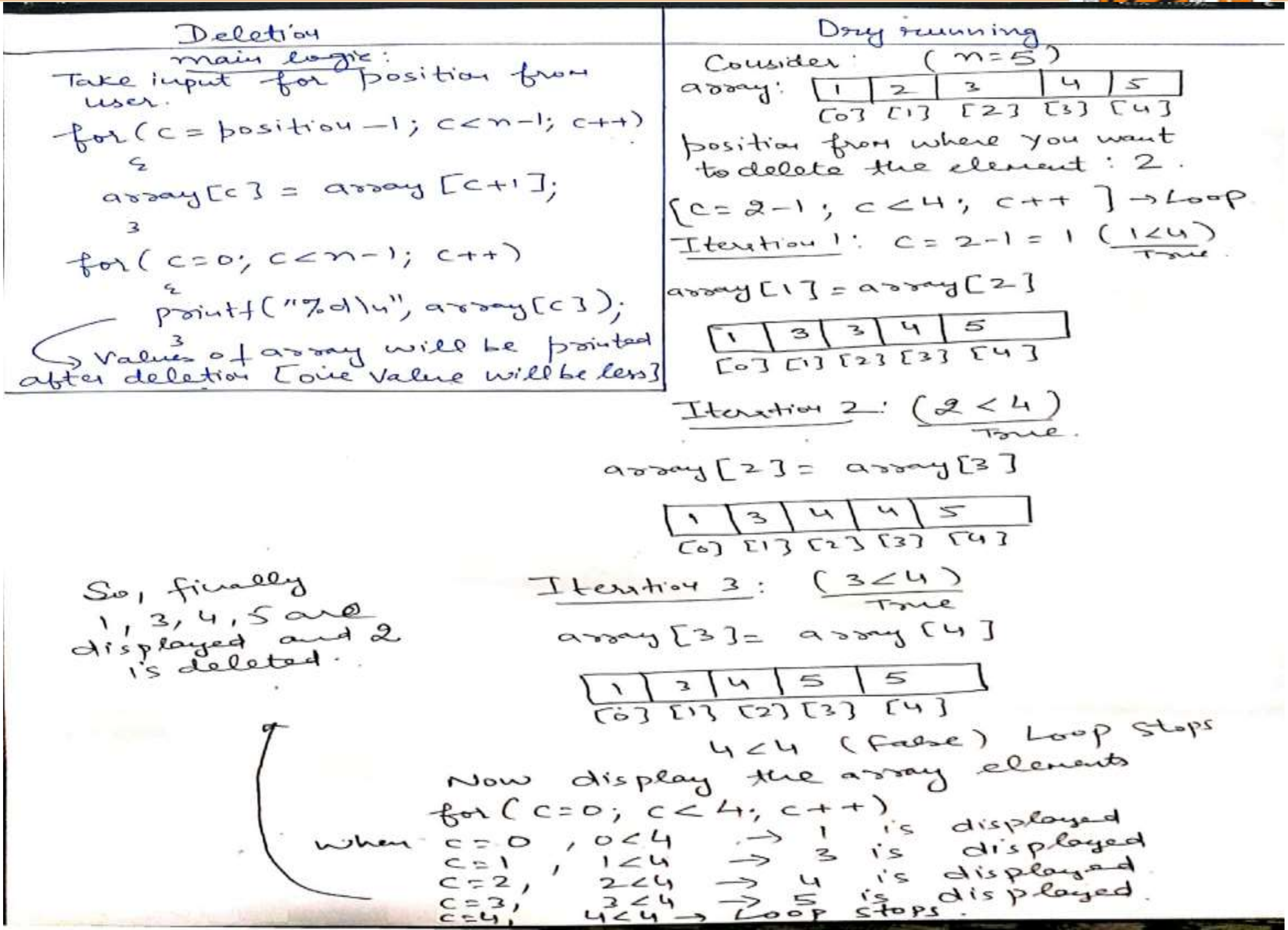
Write a program delete an element from a given position in 1D array

```
#include <stdio.h>
int main()
{
  int array[100], position, c, n;
  printf("Enter number of elements in array\n");
  scanf("%d", &n);
  printf("Enter %d elements\n", n);
  for (c = 0; c < n; c++)
   {
              scanf("%d", &array[c]);
              }
  printf("Enter the location where you wish to delete
from an array\n");

  scanf("%d", &position);
  for (c = position-1; c < n-1; c++)
    {
               array[c] = array[c+1];
    }
```

```
 printf("Resultant array is\n");
  for (c = 0; c < n-1; c++)
   {
              printf("%d\n", array[c]);
              }
}
```

Dry running



Deletion

main logic:

Take input for position from user.

```
for(c = position-1; c<n-1; c++)
{
  array[c] = array[c+1];
}
for( c=0; c<n-1; c++)
{
  printf("%d\n", array[c]);
}
```

→ Values of array will be printed after deletion [one value will be less]

Dry running

Consider: (n=5)

array:

1	2	3	4	5
[0]	[1]	[2]	[3]	[4]

position from where you want to delete the element : 2.

{c=2-1; c<4; c++ } → Loop

Iteration 1: c=2-1=1 (1<4 True).

array[1] = array[2]

1	3	3	4	5
[0]	[1]	[2]	[3]	[4]

Iteration 2: (2<4 True).

array[2]= array[3]

1	3	4	4	5
[0]	[1]	[2]	[3]	[4]

Iteration 3: (3<4 True)

array[3]= array[4]

1	3	4	5	5
[0]	[1]	[2]	[3]	[4]

4<4 (False) Loop Stops

Now display the array elements

```
for(c=0; c<4; c++)
when c=0 , 0<4 → 1 is displayed
     c=1 , 1<4 → 3 is displayed
     c=2,  2<4 → 4 is displayed
     c=3,  3<4 → 5 is displayed.
     c=4,  4<4 → Loop stops.
```

So, finally 1, 3, 4, 5 are displayed and 2 is deleted.

CSE101-Lec#17

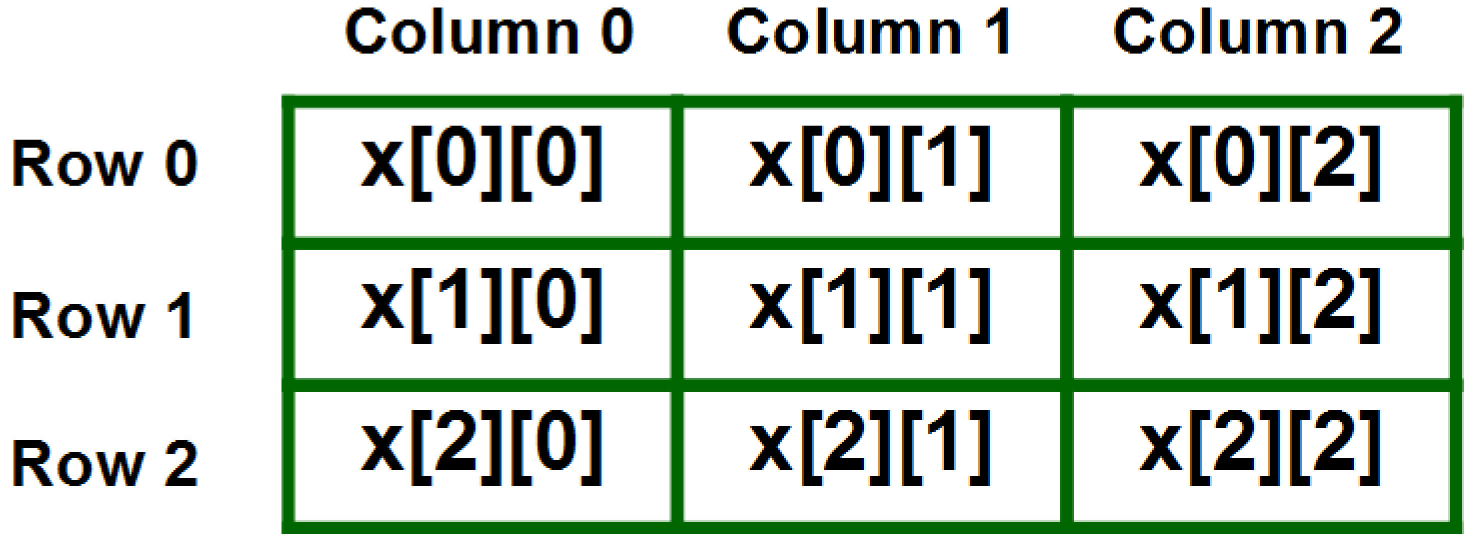
- Multidimensional Arrays(2D Array)

2D-Array

- The basic form of declaring a two-dimensional array of size x, y:
- Syntax:
- data_type array_name[x][y];
- data_type: Type of data to be stored. Valid C/C++ data type.
- We can declare a two dimensional integer array say ‘x’ of size 10,20 as:
- int x[10][20];
- Elements in two-dimensional arrays are commonly referred by x[i][j] where i is the row number and ‘j’ is the column number

2D-Array

- A two – dimensional array can be seen as a table with ‘x’ rows and ‘y’ columns where the row number ranges from 0 to (x-1) and column number ranges from 0 to (y-1). A two – dimensional array ‘x’ with 3 rows and 3 columns is shown below:

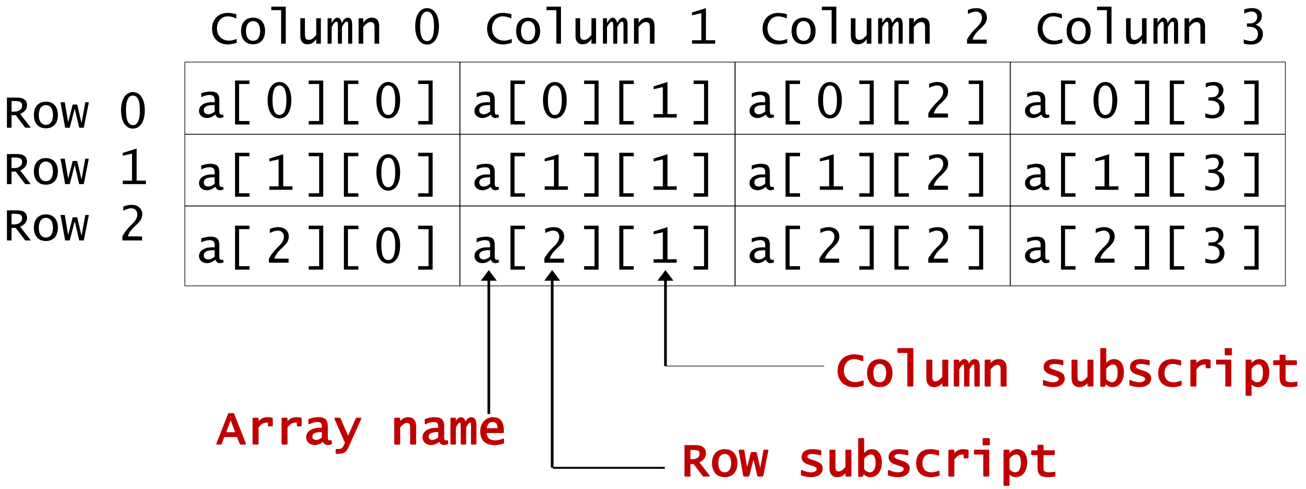


	Column 0	Column 1	Column 2
Row 0	x[0][0]	x[0][1]	x[0][2]
Row 1	x[1][0]	x[1][1]	x[1][2]
Row 2	x[2][0]	x[2][1]	x[2][2]

Also known as Multiple-Subscripted Arrays

- Multiple subscripted arrays
  - Tables with rows and columns (`m` by `n` array)
  - Like matrices: specify row, then column

```
int a[rows][column];
```



	Column 0	Column 1	Column 2	Column 3
Row 0	a[0][0]	a[0][1]	a[0][2]	a[0][3]
Row 1	a[1][0]	a[1][1]	a[1][2]	a[1][3]
Row 2	a[2][0]	a[2][1]	a[2][2]	a[2][3]

Column subscript

Array name

Row subscript

Memory representation of 2D-Array

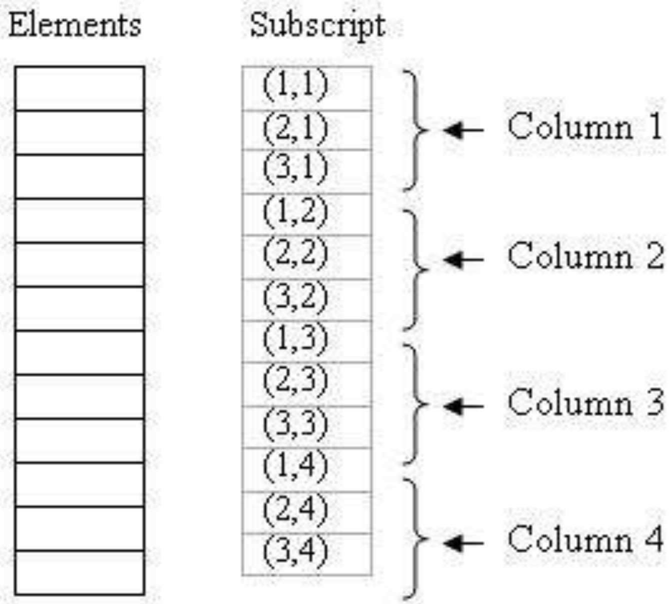
- A 2D array’s elements are stored in continuous memory locations. It can be represented in memory using any of the following two ways:

  1. Column-Major Order
  2. Row-Major Order

  1. Column-Major Order:

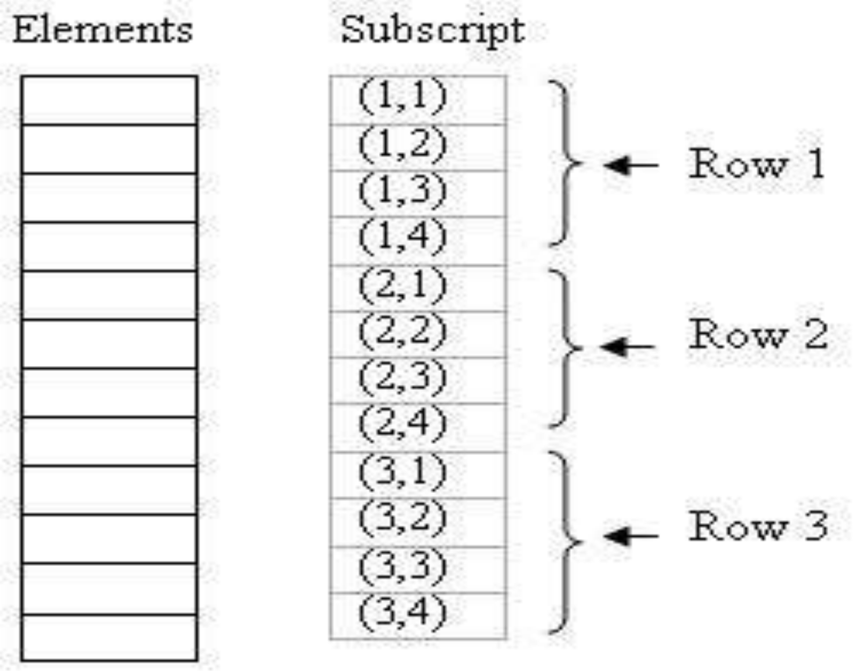
  In this method the elements are stored column wise, i.e. m elements of first column are stored in first m locations, m elements of second column are stored in next m locations and so on. E.g.

  A 3 x 4 array will stored as below:



Memory representation of 2D-Array

- 2. Row-Major Order:
  In this method the elements are stored row wise, i.e. n elements of first row are stored in first n locations, n elements of second row are stored in next n locations and so on. E.g.
  A 3 x 4 array will stored as below:



Initialization

1) Initializing at the point of declaration:

- int a[2][2]={{1,2},{3,4}};

1	2
3	4

Initializers grouped by row in braces

- If not enough, unspecified elements set to zero
  - Int a[2][2]={{1},{3,4}};

1	0
3	4

- int a3[2][2]={1,2};//Remaining elements are zero
- int a4[2][2]={0};//All elements are zero

Initialization

- int a5[][2]={1,2,3};//It is possible to skip row size, if elements are initialized at the point of declaration
- *int a[2][]={1,2,3};//Not possible to skip column size[Error will come]*
- *int a[][]={1,2,3};//Not possible to skip both row and column size[Error will come]*

Initialization

2) Taking input from user

```
int a[3][3], i, j;
for(i=0; i<3; i++)
{ // for loop for rows
 for(j=0; j<3;j++)
  { // for loop for columns
  printf(“enter the value ofa[%d][%d]: ”, i, j);
  scanf(“%d”, &a[i][j]);
  } //end for columns
} //end for rows
```

Program to display 2D array

```
#include<stdio.h>
void main()
{
int a[3][3], i, j;
for(i=0; i<3; i++)
{ // for loop for rows
 for(j=0; j<3;j++)
   { // for loop for columns
  printf(“enter the value of a[%d][%d]: ”, i, j);
  scanf(“%d”, &a[i][j]);
   } //end for columns
} //end for rows
printf(“elements of 2D matrix are”);
for(i=0; i<3; i++)
{
 for(j=0;j<3;j++)
   {
   print(“%d\t”, a[i][j]);
   }     //end for
 printf(“\n”);
} //end for
} //end main
```

```
enter the value of a[0][1] :1
enter the value of a[0][1] :2
enter the value of a[0][1] :3
enter the value of a[0][1] :4
enter the value of a[0][1] :5
enter the value of a[0][1] :6
enter the value of a[0][1] :7
enter the value of a[0][1] :8
enter the value of a[0][1] :9
Element of 2D matrix are:
1   2   3
4   5   6
7   8   9
```

Matrix operations using 2D arrays

- WAP to find the sum of two matrices
- WAP to display the transpose of a matrix
- WAP to find the sum of diagonal elements of a matrix
- WAP to perform multiplication of 2 matrices and display the result

WAP to find the sum of two matrices

```
#include <stdio.h>
int main()
{
   float a[3][3], b[3][3], c[3][3];
   int i, j;
   printf("Enter elements of 1st matrix\n");
   for(i=0; i<3; i++)
   {
   for(j=0; j<3 ;j++)
    {
       printf("Enter a%d%d: ", i, j);
       scanf("%f", &a[i][j]);
    }
   }
  // Taking input using nested for loop
   printf("Enter elements of 2nd matrix\n");
   for(i=0; i<3; i++)
   {
    for(j=0; j<3; j++)
    {
       printf("Enter b%d%d: ", i, j);
       scanf("%f", &b[i][j]);
    }
   }
   // adding corresponding elements of two arrays
 for(i=0; i<3; i++)
   {
    for(j=0; j<3; j++)
    {
       c[i][j] = a[i][j] + b[i][j];
    }
   }
   // Displaying the sum
   printf("\nSum Of Matrix:\n");

   for(i=0; i<3; i++)
   {
    for(j=0; j<3; j++)
    {
       printf("%.1f\t", c[i][j]);
    }
          printf("\n");
    }
return 0;
}
```

WAP to display the transpose of a matrix

```
#include <stdio.h>
int main()
{
    int a[10][10], transpose[10][10], r, c, i, j;
    printf("Enter rows and columns of matrix: ");
    scanf("%d %d", &r, &c);

    // Storing elements of the matrix
    printf("\nEnter elements of matrix:\n");
    for(i=0; i<r; i++)
    {
        for(j=0; j<c; j++)
        {
            printf("Enter element a%d%d: ",i, j);
            scanf("%d", &a[i][j]);
        }
    }
    // Displaying the matrix a[][] */
    printf("\nEntered Matrix: \n");
    for(i=0; i<r; i++)
    {
        for(j=0; j<c; j++)
        {
            printf("%d  ", a[i][j]);
        }
                printf("\n\n");
    }
 // Finding the transpose of matrix a
    for(i=0; i<r; i++)
    {
        for(j=0; j<c; j++)
        {
            transpose[i][j] = a[j][i];
        }
    }

    // Displaying the transpose of matrix a
    printf("\nTranspose of Matrix:\n");
    for(i=0; i<r; i++)
    {
        for(j=0; j<c; j++)
        {
            printf("%d  ",transpose[i][j]);
        }

                printf("\n\n");
    }

    return 0;
}
```

WAP to find the sum of diagonal elements of a matrix

```
#include<stdio.h>
 int main()
 {
  int a[10][10],sum=0;
  int i,j,m,n;
  printf("Enter number of rows and
column:");
  scanf("%d%d",&m,&n);
        printf("Enter Elements : ");
        for(i=0;i<m;i++)
           {
               for(j=0;j<n;j++)
                  {
                     scanf("%d",&a[i][j]);
                  }
           }
for(i=0;i<m;i++)
          {
              for(j=0;j<n;j++)
                 {
                     if(i==j)
                      {

sum=sum+a[i][j];
                      }
                 }
          }
                printf("Sum of Diagonal
Elements = %d ",sum);


  }
```

WAP to perform multiplication of 2 matrices and display the result

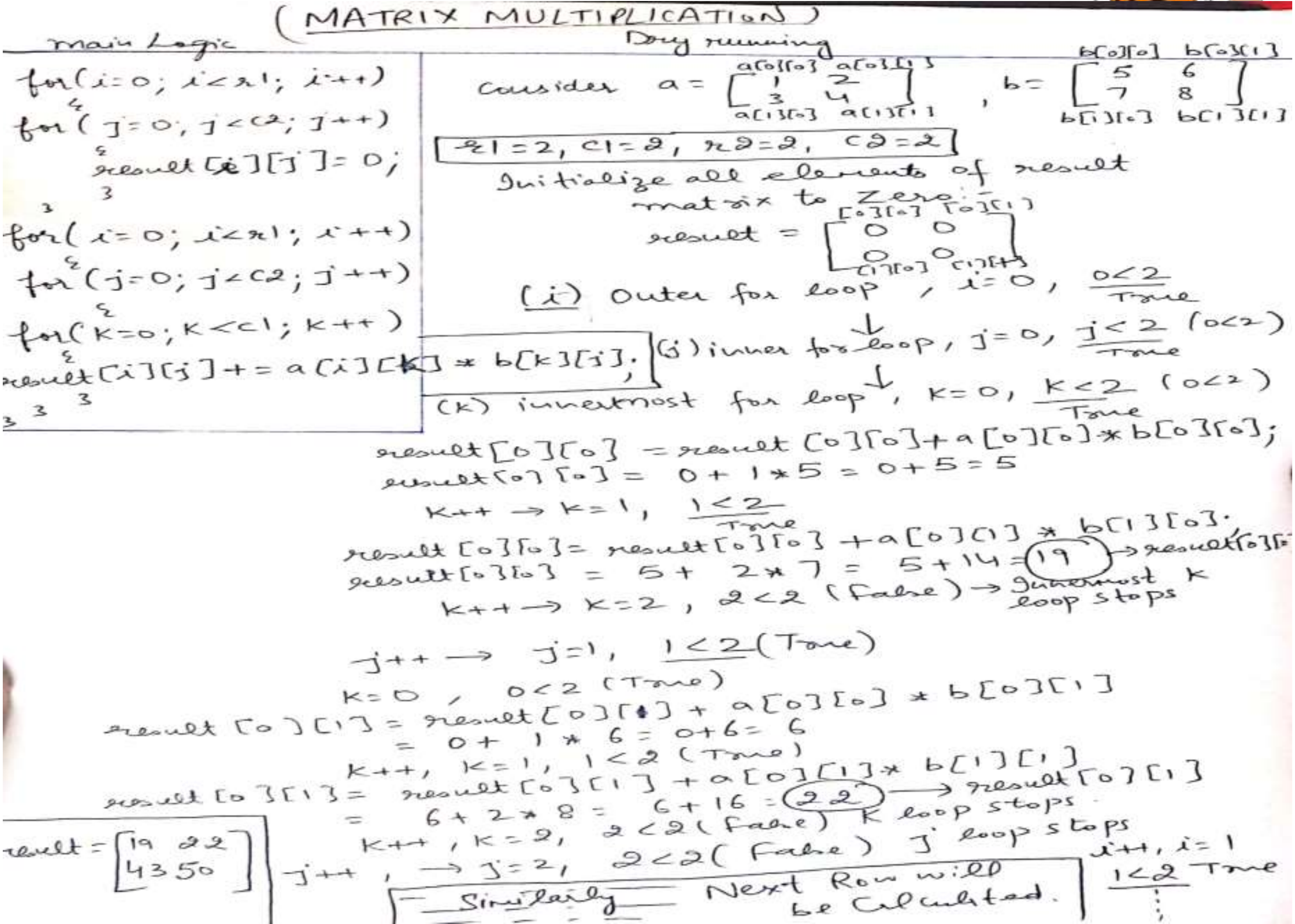
```
#include <stdio.h>
int main()
{
int a[10][10], b[10][10], result[10][10], r1, c1, r2, c2, i, j, k;
   printf("Enter rows and column for first matrix: ");
   scanf("%d %d", &r1, &c1);

   printf("Enter rows and column for second matrix: ");
   scanf("%d %d",&r2, &c2);
   // Column of first matrix should be equal to column of second
matrix and
   while (c1 != r2)
   {
      printf("Error! No. of columns of first matrix not equal to no.of
row of second.\n\n");
      printf("Enter rows and column for first matrix: ");
      scanf("%d %d", &r1, &c1);
      printf("Enter rows and column for second matrix: ");
      scanf("%d %d",&r2, &c2);
   }
   // Storing elements of first matrix.
   printf("\nEnter elements of matrix 1:\n");
   for(i=0; i<r1; i++)
   {
      for(j=0; j<c1; j++)
      {
         printf("Enter elements a%d%d: ",i,j);
         scanf("%d", &a[i][j]);
      }
   }
 // Storing elements of second matrix.
   printf("\nEnter elements of matrix 2:\n");
   for(i=0; i<r2; i++)
   {
      for(j=0; j<c2; j++)
      {
         printf("Enter elements b%d%d: ",i, j);
         scanf("%d",&b[i][j]);
      }
   }
```

```
// Initializing all elements of result matrix to 0
for(i=0; i<r1; i++)
{
   for(j=0; j<c2; j++)
   {
      result[i][j] = 0;
   }
}
// Multiplying matrices a and b and
// storing result in result matrix


                  for(i=0; i<r1; i++)
{
   for(j=0; j<c2; j++)
   {
      for(k=0; k<c1; k++)
      {
         result[i][j]+=a[i][k]*b[k][j];
      }
   }
}
// Displaying the result
printf("\nOutput Matrix:\n");
for(i=0; i<r1; i++)
{
   for(j=0; j<c2; j++)
   {
      printf("%d  ", result[i][j]);
   }
         printf("\n\n");
}
return 0;
     }
```

Dry running



(MATRIX MULTIPLICATION)

main Logic

```
for(i=0; i<r1; i++)
{
for( j=0; j<c2; j++)
{
    result[i][j]= 0;
    }
}
for( i=0; i<r1; i++)
{
for(j=0; j<c2; j++)
{
for(k=0; k<c1; k++)
{
result[i][j]+= a[i][k] * b[k][j];
}
}
}
```

Dry running

Consider

a[0][0] a[0][1]

$a = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$, $b = \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$

a[1][0] a[1][1]

b[0][0] b[0][1]

b[1][0] b[1][1]

$\boxed{r1=2,\ c1=2,\ r2=2,\ c2=2}$

Initialize all elements of result matrix to Zero:-

[0][0] [0][1]

result = $\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$

[1][0] [1][1]

(i) Outer for loop , i=0, $\underline{0<2}$ True

↓

(j) inner for loop, j=0, $\underline{j<2}$ (0<2) True

↓

(k) innermost for loop, k=0, $\underline{k<2}$ (0<2) True

result[0][0] = result[0][0]+a[0][0]*b[0][0];

result[0][0] = 0+ 1*5 = 0+5=5

k++ → k=1, $\underline{1<2}$ True

result[0][0]= result[0][0] +a[0][1] * b[1][0];

result[0][0] = 5+ 2*7 = 5+14=19 → result[0][0]

k++ → k=2 , 2<2 (False) → Innermost k loop stops

j++ → j=1, $\underline{1<2}$(True)

k=0 , 0<2 (True)

result[0][1] = result[0][1] + a[0][0] * b[0][1]

= 0+ 1*6 = 0+6= 6

k++, k=1, 1<2 (True)

result[0][1]= result[0][1] + a[0][1]* b[1][1] → result[0][1]

= 6+ 2*8 = 6+16 =22 k loop stops

k++ , k=2, 2<2(False) j loop stops

j++ , → j=2, 2<2(False)

i++, i=1

$\underline{1<2}$ True

⋮

result = $\begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix}$

Similarly Next Row will be Calculated.