Programming Fundamentals for Engineers - 0702113

6. Arrays

YACOUB SABATIN
MUNTASER ABULAFI
OMAR QARAEEN

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One-Dimensional Arrays

- There are times when we need to store a complete list of numbers or other data items!
- We could do that by:
  - Creating as many *individual variables* as would be needed for the job, **BUT** this is a hard and tedious process.
  - Suppose we want to **read in five numbers** and **print them out in reverse order:**

```
int a1,a2,a3,a4,a5;
scanf("%d %d %d %d %d",&a1,&a2,&a3,&a4,&a5);
printf("%d %d %d %d %d",a5,a4,a3,a2,a1);
```

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- *Comments:*
  - *Doesn't look very pretty*, and
  - What if the problem was to read in 100 or more values and print them in reverse order?
- What we would really like to do is to use a name like **a[i]** where **i** is a **variable** representing an **index** which specifies which particular value we are working with;
- This is the basic idea of an **array**.

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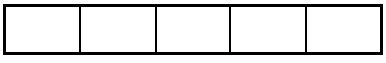
- An **array** is a data structure containing a number of data values, all of which have the **same type**.
- As usual, in **C,** we have to declare an array before using it. ➔ Similar to any variable declaration;
  int a[5]; ➔ Declares an array called ***a*** with ***five*** elements, **a[0] to a[4]**
- **a**



a[0] a[1] a[2] a[3] a[4]

- This is called array ***subscripting*** or ***indexing***.

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- Defining Arrays:

  datatype arrayName[size];
- Since array lengths ***may*** need to be adjusted when program changes, it is a good idea to use **MACRO** to define length of array:

  #define ARRAY_LENGTH 10
  int a[ARRAY_LENGTH]

  ➔ Declares array of 10 elements;
- All the elements of an array must be the **same data type (float, char, int)**

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Examples:

int ID[30]; // Stores ID numbers of students

float temperatures[31]; // Store daily temperatures

char name[20]; //Stores a *character string*, character Strings in C are terminated by the null character **'\0'** in the last element.

unsigned short int a[52]; //Holds 52 unsigned short integer values;

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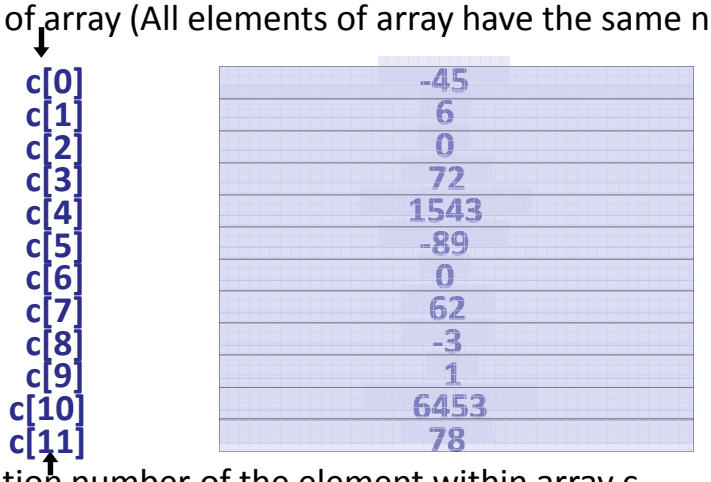
C: Name of array (All elements of array have the same name)



Position number of the element within array c

Note: i = 0;

```
While (i < N)
    a[i++] = 0;// a[i] will be initialized with 0,
    a[++i] = 0;// ⊗: 0 would be assigned to a[1]!
```


Array Initialization

- Arrays can be initialized when declared:

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

- If **initializer** shorter than array, remaining elements are given value 0:

  int a[5] = {1,2,3}; */* initial value {1,2,3,0,0} */*

- Length of array may be omitted, if **initializer** is present:

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

  Int a[6] = {0}; // Initial value of a is: {0, 0, 0, 0, 0, 0}

- To find out the **size** of an array in **Bytes**, we can use the ***sizeof operator:***
  - ***For an array of 10 integers, sizeof(a) = 20 OR 40!***
  - ***Why???***

```
/* Reverses a series of N numbers */
#define N 10  // Defines length of array to be 10

int a[N], i;  // Declares an array a of N length
                 of type integer
printf("Enter %d numbers: ", N);

for (i = 0 ; i < N ; i++)
  scanf("%d", &a[i]);       // Reads data into array a

printf("In reverse order:");

for (i = N-1 ; i >= 0 ; i--) // Array is indexed 0 to N-1
    printf(" %d\n", a[i]);
```

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Examples:

```
for (i = 0; i < N; i++)
      a[i] = 0; // Clears array a;
for (i = 0; i < N; i++)
       scanf("%d", &a[i]); // Reads data into array a;
for (i = 0; i < N; i++)
      Sum+= a[i]; // Sums the elements of array a;
for (i = 0; i < N; i++)
      a[i] = i+1;  // Sets the array elements of a
                      certain value (i+1);
for (i = 0; i <N; i++)
   printf(" %d\n", a[i]); // Prints out all elements
                             of array a;
```

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The index can be an expression

- An array subscript may be any integer expression:
  Ex: **a[i+j*10] = 0**;
- The expression can even have side effects:

```
i = 0;
While (i < N)
    a[i++] = 0;
```

- Here the **a[i]** will be initialized with 0, then **i** will be incremented, and so on.
- While **a[++i]** would not be right, because **0** would be assigned to **a[1]** in the first loop and not to **a[0]**.

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- We can use ***sizeof*** to :
  Measure the number of elements in an array :

  Length of the array = array size / Element Size
  = sizeof(a) / sizeof(a[0])

```
for (i = 0 ; i <sizeof(a) / sizeof(a[0]) ; i++)
{  a[i]=0;  }
```

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```
char arrayChar[] = {'A','r','r','a','y','\0'};
int arrayInt[5] = {1,2,4,8,16};
float arrayFloat[3] = { 1.24 , 2 , 4.68756 };
double arrayDouble[2];
int arrayInt2D[ ][4] = {1,6,3,7,   0,3,8,9,   2,5,2,3};
arrayDouble[0] = 23.23456532;
arrayDouble[1] = 2.3422267;
printf("The size of arrayChar is
        %d\n", sizeof(arrayChar));
printf("The size of arrayInt is
        %d\n", sizeof(arrayInt));
printf("The size of arrayFloat is
        %d\n", sizeof(arrayFloat));
```

Output:

```
The size of arrayChar is 6
The size of arrayInt is 20
The size of arrayFloat is 12
The size of arrayDouble is 16
The size of arrayInt2D is 48
The size of arrayInt2D[0] is 16
```

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Example:

```
/* Checks numbers
for repeated digits */
#include <stdio.h>

int main()
{
  //all false
  bool digit_seen[10] = {0};
  //holds he digit and the index
  int digit;
  long int n; //here is the number
  printf("Enter a number: ");
  scanf("%ld", &n);

  while (n > 0)
  {
    digit = n % 10; //extract the last digit
    if (digit_seen[digit])
      break;
    digit_seen[digit] = true;
    n /= 10; /*move to the next digit by
              getting rid of the last digit
              from the right */
  }

  if (n > 0) //means the digit was seen
    printf("Repeated digit\n\n");
  else
    printf("No repeated digit\n\n");

  return 0;
}
```

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Operators						Associativity	Type
[]	()					left to right	highest
++	--	!	(*type*)			right to left	unary
*	/	%				left to right	multiplicative
+	-					left to right	additive
<	<=	>	>=			left to right	relational
==	!=					left to right	equality
&&						left to right	logical and
||						left to right	logical or
?:						right to left	conditional
=	+=	-=	*=	/=	%=	right to left	assignment
,						left to right	comma

Operator precedence.

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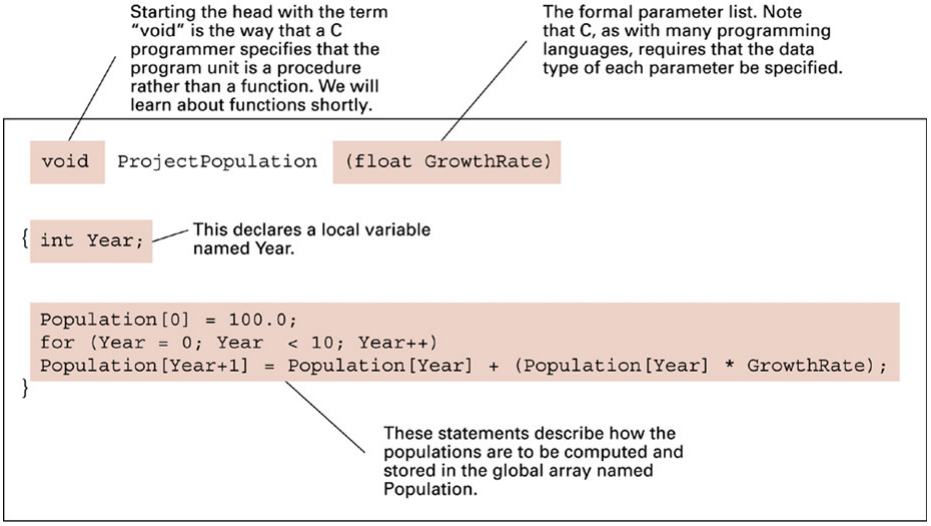
- Example: Write a concise C function to project the population in 10 years, assuming a base population



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Multidimensional Arrays

- An array can have 2 or more dimensions

Example:

double x[8][3]; */* 8 Rows, 3 Columns */*

➔This declares an 8 x 3 array, or an array of 24 elements

- A multidimensional array can be initialized

```
int x[3][3] = { {1, 4, 3}, {4, 8, 2}, {7, 9, 11} };
```

OR

```
int x[3][3] = {1, 4, 3,
               4, 8, 2,
               7, 9, 11} ;
```

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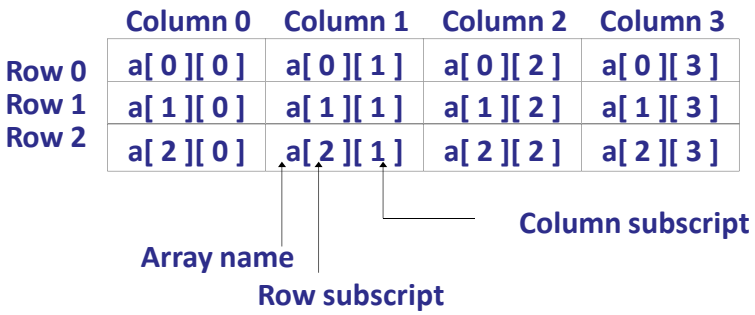
- Defining multiple arrays of same type:
  - Example: `int b[ 100 ], x[ 27 ];`
- **Tables** (**Matrices**) with rows and columns (**m** by **n** array):



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- **Example:**

double x[8][3]; //Declares a **8 x 3** array: ***8 Rows, 3 Columns***

- A multidimensional array can be initialized:

```
int x[3][3] = { {1, 4, 3}, {4, 8, 2}, {7, 9, 11} };
int x[3][3] = {1, 4, 3,
               4, 8, 2,
               7, 9, 11} ;
int b[ 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 b[ 2 ][ 2 ] = { { 1 }, { 3, 4 } };
```

1	0
3	4

- Referencing elements: Specify row, then column as

```
printf( "%d", b[ 0 ][ 1 ] );
```

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sizeof() again

- Find out the maximum of "**rows**" there are in a **2D array:**
  How many **rows** are there in **arrayInt2D[][4]** mentioned before?
  int arrayInt2D[ ][4] = {1,6,3,7, 0,3,8,9, 2,5,2,3};
  12 elements here.
  sizeof(arrayInt2D) / sizeof(arrayInt2D[0])
  ➔48/16 = 3
  Think of this calculation as:
  "size of entire array / size of a column"
- So, there are 3 **rows** & 4 **columns** in the 2D array.

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- In C, a **string** is simply an array of type **char**
- *Declaring a string:*
  char str_var[20]; /* Creates a variable that can hold a string from 0 to 19 characters long */
- ***Initializing a string***
  char str_var[20] = "Text goes here"; /* Creates the following in memory:
  T e x t g o e s h e r e \0 ? ? ? ? ? **(20 characters)**

➔ *'\0' is a null character, indicates the end of a string*

➔ *The content following the null character is* ***ignored*** *by the* ***string functions*** *in C*

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- Array of strings….

```
char names[7][6]  =  { "Ryan",
                       "Tom",
                       "Chad",
                       "Jackie",
                       "Tara",
                       "Lori",
                       "Kelly" };
```

How many strings

Amount of characters any string may have. If this number is left out, compiler will use longest name length as maximum length

```
printf("%s", names[0]);      /* print Rayan */
printf("%s", names[3]);      /* print ????? */
```

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Constant Arrays

- Arrays can be defined as constants using the keyword ***const***
- Used if array is not supposed to be modified by program

```
const int age [ ] = {20,30,40,50};
```

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Examples

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```
// Try this code that initializes an array with an initializing list
#include <stdio.h>
int main()
{
  int n[ 10 ] = { 32, 27, 64, 18, 95, 14, 90, 70, 60, 37 };
  int i; /* counter */
  printf( "%s%13s\n", "Element", "Value" );
/* output contents of array in tabular format */
    for ( i = 0; i < 10; i++ ) {
      printf( "%7d%13d\n", i, n[ i ] );
    }
    return 0;
}
```

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Element	Value
0	32
1	27
2	64
3	18
4	95
5	14
6	90
7	70
8	60
9	37

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```
// Try this code that Initializes elements of array s to even integers from 2 – 20
#include <stdio.h>
#define SIZE 10
int main()
{
  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 ;
  }
  printf( "%s%13s\n", "Element", "Value" );
  for ( j = 0; j < SIZE; j++ ) {
    printf( "%7d%13d\n", j, s[ j ] ); }
  return 0; }
```

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

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```
// Try the code that Computes the sum of the elements of the array
   #include <stdio.h>
   #define SIZE 12
   int main()
   {
    int a[ SIZE ] = { 1, 3, 5, 4, 7, 2, 99, 16, 45, 67, 89, 45 };
    int i;           /* counter */
    int total = 0; /* sum of array */
    for ( i = 0; i < SIZE; i++ )
        total += a[ i ];
   printf( "Total of array element values is %d\n", total );
   return 0;
   }
```

Total of array element values is 383

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```
// Try the code that demonstrates Student Poll
   #include <stdio.h>
   #define RESPONSE_SIZE 40 /* define array sizes */
   #define FREQUENCY_SIZE 11 /* to save expected
                                answers (0-10) */
   /* function main begins program execution */
   int main()
   {
    int answer;  /* counter */
    int rating;    /* counter */
    int frequency[ FREQUENCY_SIZE ] = { 0 }; //Reset the
                                              11 elements
    int responses[ RESPONSE_SIZE ] = { 1, 2, 6, 4, 8, 5, 9,
    7, 8, 10, 1, 6, 3, 8, 6, 10, 0, 8, 2, 7, 6, 5, 7, 6, 8, 6, 7, 5, 6,
    6, 5, 6, 7, 5, 6, 4, 8, 6, 8, 10 };
                                                        >>>
```

```
/* for each answer, select value of an element of array
responses and use that value as subscript in array
frequency to claculate the frequency of each answer. */
for ( answer = 0; answer < RESPONSE_SIZE; answer++ )
{
  ++frequency[ responses [ answer ] ]; //add this response
}  /* end for */
printf( "%s%17s\n", "Rating", "Frequency" );
for ( rating = 0; rating < FREQUENCY_SIZE; rating++ )
{  printf( "%6d%17d\n", rating, frequency[ rating ] );  }

return 0;
}
```

Rating	Frequency
0	1
1	2
2	2
3	1
4	2
5	5
6	11
7	5
8	7
9	1
10	3

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```
// Try the code that prints a Histogram
  #include <stdio.h>
  #define SIZE 10
  int main()
  {
    int n[ SIZE ] = { 19, 3, 15, 7, 11, 9, 13, 5, 17, 1 };
    int i; /* outer counter */
    int j; /* inner counter */
    printf( "%s%13s%17s\n", "Element", "Value",
    "Histogram" );
    for ( i = 0; i < SIZE; i++ )
    {
        printf( "%7d%13d        ", i, n[ i ]) ;
        for ( j = 1; j <= n[ i ]; j++ )
        { /* print one bar */
            printf( "%c", '*' ) ;
        } // end of the inner for loop
```

```
      printf( "\n" ); /* start next line of output */
   } /* end outer for */
   return 0;
}
```

Element	Value	Histogram
0	19	**********
1	3	***
2	15	**********
3	7	*******
4	11	**********
5	9	*********
6	13	**********
7	5	*****
8	17	**********
9	1	*

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```
// Try the code that deals with strings
#include <stdio.h>
int main()
{
 char string1[ 20 ];  /* reserves 20 characters */
 char string2[] = "string literal"; //reserves 15 characters
 int i;  /* counter */
 printf("Enter a string: ");
 scanf( "%s", string1 );  /* no need for & sign when we deal with
                             strings */
 printf("string1 is: %s\nstring2 is: %s\n“ , string1, string2 );
 printf("string1 with spaces between characters is:\n");
 for ( i = 0; string1[ i ] != '\0'; i++ )   //Loop until a null character
 {   printf( "%c  ", string1[ i ] );    }  //notice the “  “
```

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```
    printf( "\n" );
    return 0;
}
```

```
Enter a string: Hello there
string1 is: Hello
string2 is: string literal
string1 with spaces between characters is:
H e l l o
```

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Notes about previous example 1/2

- No need for & sign when we deal with strings in scanf: scanf("%s", string1);
- since string1 is an array name, it's treated as a pointer automatically (more about pointers later).
- A string read using scanf will never contain white spaces.
- Instead we can use gets(string1); from string.h header file.

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Notes about previous example 2/2

- gets doesn't skip white spaces.
- gets reads until it finds a *new-line character*, gets discards the new-line character and the *null character* takes the place of it.
- Another function in string.h header file is puts which can be used to print stings.
- puts prints the string contents and then writes an additional new-line character after it.

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Example:

```
#include <stdio.h>
#include <string.h>
int main()
{
    char FullName[ 20 ];
    printf("Please enter your full name   ");
    gets(FullName); /* Will read the user input until the user
                       presses enter, and
                       then store it in FullName. */
    printf("Welcome   ");
    puts(FullName); /* Will print a new-line automatically
                       AFTER the FullName. */
    return 0;
}
```

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- **Problem:** Create 3 arrays, Read data into the first two, Subtract each element in the first array from the corresponding element in the second array. Store the differences in the third array. Print all the 3 arrays. The relationships between the arrays are as bellow:
  ArrayC[i] = ArrayB[i] – ArrayA[i]

ArrayA	10	21	13	17	19
ArrayB	19	44	72	3	0
ArrayC	9	23	59	-14	-19

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Solution:

1. LOOP all array elements
   1. INPUT ArrayA[i];
2. LOOP all array elements
   1. INPUT ArrayB[i];
3. LOOP all array elements
   1. ArrayC[i] = ArrayB[i] – ArrayA[i];
4. LOOP all array elements
   1. Output ArrayA[i], ArrayB[i], ArrayC[i]
5. STOP

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Make your programs efficient, interactive, and concise as possible

Q1) Develop a C program for the previous problem.

Q2) Develop a C program to output the odd elements of a read 10-element array?

Q3) Develop a C program that inputs a list of numbers, letting the user decide how many. Output the list backwards, but only output numbers greater than 20?

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Q4) Develop the a C program for a luxury-car dealer who wants to keep a monthly log of the number of sales made for each of six different luxury cars. The dealer wants a printout at the end of the year showing the total number of sales of each car and the best sales month for the year: a) for each car, and b) for the total sales of all cars in each month?

Submission Date: _____
Documentation is very important
Include screen shots of the output!
Submit softcopy + hardcopy

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