Arrays and Strings(cont.)

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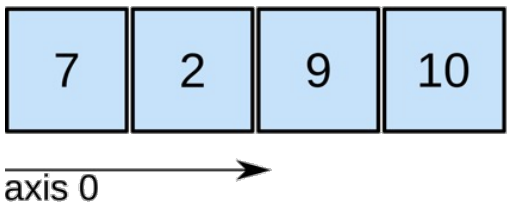
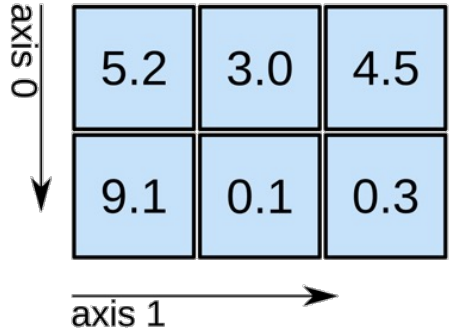
Pictorial representation

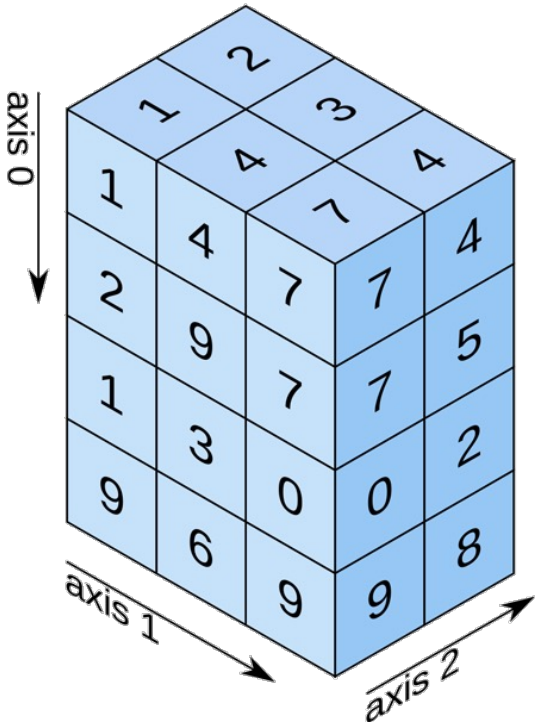
1D array



2D array



3D array



Two Dimensional Arrays

- We have seen that an array variable can store a list of values.
- Many applications require us to store a **table** of values.

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Student 1	75	82	90	65	76
Student 2	68	75	80	70	72
Student 3	88	74	85	76	80
Student 4	50	65	68	40	70

- The table contains a total of 20 values, five in each line.
  - The table can be regarded as a **matrix** consisting of four rows and five columns.
- C allows us to define such tables of items by using two-dimensional arrays.

Declaring 2-D Arrays

- In 2-dimentional array, elements are arranged in row and column format.
- Array having more than one subscript variable/index is called multidimensional array.
- Multidimensional array is also called as matrix.
- General form:

```
type array_name [row_size][column_size];
```

- Examples:

```
int marks[4][5];                  // 4 rows 5 column
float sales[12][25];              // 12 rows 25 columns
double matrix[100][100]; // 100 rows 100 column
```

Declaring 2-D Arrays

- A two-dimensional array **a**, which contains three rows and four columns can be shown as follows −
- int a[3][4];

	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]

- Thus, every element in the array **a** is identified by an element name of the form **a[i][j]**, where 'a' is the name of the array, and 'i' and 'j' are the subscripts/indices that uniquely identify each element in 'a'.

Initializing Elements of a 2-D Array

- Similar to that for 1-D array, but use two indices/subscripts.
  – First indicates row, second indicates column.
  – Both the indices should be integer constant greater than 0 or expressions which evaluate to integer values.

- Examples:

```
x[7][3] = 0;
c[i][k] = a[i][j] * b[j][k];
a = sqrt (a[j*3][k]);
```

Initialization:

```
int stud[2][4] = { 1234, 56, 1212, 33, 1434, 80, 1312, 78 } ;
```

All values are assigned sequentially and row-wise.

Initializing Elements of a 2-D Array

- Multidimensional arrays may be initialized by specifying bracketed values for each row.

```
int stud[4][2] = {
                    { 1234, 56 },
                    { 1212, 33 },
                    { 1434, 80 },
                    { 1312, 78 }
                  } ;
```

Initializing and Accessing Elements of a 2-D Array

```
#include <stdio.h>
int main() {
  int i, j;
  int a[3][2] = { 1, 4, 5, 2, 6, 5 };
/* or you can initialize as
   int a[3][2] = { { 1, 4 },
                   { 5, 2 },
                   { 6, 5 }}; */
  for (i = 0; i < 3; i++)   {
    for (j = 0; j < 2; j++)
     printf("%d ", a[i][j]);
     printf("\n");
  }
  return 0;
}
```

Output :

```
1 4
5 2
6 5
```

Note-

```
for(i=0;i<row,i++)    {
     for(j=0;j<col,j++)    {
          printf("%d",a[i][j]);
       }
     }
```

Initializing Elements of a 2-D Array

- It is important to remember that while initializing a 2-D array it is necessary to mention the second (column_size) dimension, whereas the first dimension (row_size) is optional.
- Thus,

```
int arr[2][3] = { 12, 34, 23, 45, 56, 45 } ;
int arr[ ][3] = { 12, 34, 23, 45, 56, 45 } ;
```

are perfectly acceptable,

- whereas,

```
int arr[2][ ] = { 12, 34, 23, 45, 56, 45 } ;
int arr[ ][ ] = { 12, 34, 23, 45, 56, 45 } ;
```

would never work.

Accessing Elements of a 2-D Array

- An element in a two-dimensional array is accessed by using the subscripts, i.e., row index and column index of the array.

- For example − int val = a[2][3];
- It will take the element from the 2nd row and 3rd cloumn of the array and assign its value to ‘val’ variable.

Accessing Elements of a 2-D Array

```
#include <stdio.h>
int main ()
{
  /* an array with 5 rows and 2
    columns*/
  int a[5][2] = { {0,0}, {1,2}, {2,4},
    {3,6},{4,8}};
  int i, j;
  /* output each array element's value
    */
  for ( i = 0; i < 5; i++ )    {
    for ( j = 0; j < 2; j++ )
          printf("a[%d][%d] : %d\n", i, j,
    a[i][j] );
                }
  }
  return 0;
}
```

Output:

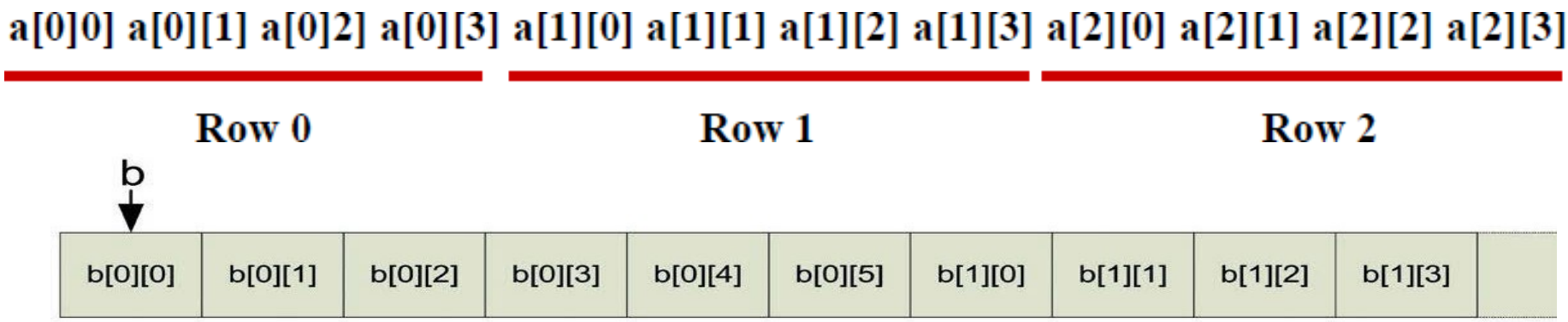
```
a[0][0]: 0
a[0][1]: 0
a[1][0]: 1
a[1][1]: 2
a[2][0]: 2
a[2][1]: 4
a[3][0]: 3
a[3][1]: 6
a[4][0]: 4
a[4][1]: 8
```

How is a 2-D array is stored in memory?

- **Starting from a given memory location, the elements are stored row-wise in consecutive memory locations.**
  - **x: starting address of the array in memory**
  - **c: number of columns**
  - **k: number of bytes allocated per array element**

a[i][j] → is allocated memory location at address

x + (i * c + j) * k



How to read the elements of a 2-D array?

- **By reading them one element at a time**

```
for (i=0; i<nrow; i++)
        for (j=0; j<ncol; j++)
                scanf (“%f”, &a[i][j]);
```

- **The ampersand (&) is necessary.**

- **The elements can be entered all in one line or in different lines.**

How to print the elements of a 2-D array?

- **By printing them one element at a time.**

```
for (i=0; i<nrow; i++)
        for (j=0; j<ncol; j++)
                printf ("\n %f", a[i][j]);
```

– **The elements are printed one per line.**

```
1
2
3
.
.
```

```
for (i=0; i<nrow; i++)
    for (j=0; j<ncol; j++)
        printf ("%f", a[i][j]);
```

– **The elements are all printed on the same line.**

```
123456789
```

```
for (i=0; i<nrow; i++)                                    {
        for (j=0; j<ncol; j++)
                printf ("%f  ", a[i][j]);
        printf ("\n");
}
```

– The elements are printed nicely in matrix form.

```
1   2   3
4   5   6
7   8   9
```

Operations on a 2D Matrix

Transpose

$$A\begin{bmatrix}1 & 2 & 3\\ 4 & 5 & 6\\ 7 & 8 & 9\end{bmatrix} \qquad A^{T}\begin{bmatrix}1 & 4 & 7\\ 2 & 5 & 8\\ 3 & 6 & 9\end{bmatrix}$$

$$A\begin{bmatrix}1 & 4 & 3\\ 8 & 2 & 6\\ 7 & 8 & 3\\ 4 & 9 & 6\\ 7 & 8 & 1\end{bmatrix} \qquad A^{T}\begin{bmatrix}1 & 8 & 7 & 4 & 7\\ 4 & 2 & 8 & 9 & 8\\ 3 & 6 & 3 & 6 & 1\end{bmatrix}$$

Example: Matrix Addition

$$\mathbf{A} = \begin{pmatrix} 2 & 1 \\ -4 & 3 \\ 2 & -2 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 & 2 \\ 1 & -3 \\ 3 & -2 \end{pmatrix}$$

$$\mathbf{A} + \mathbf{B} = \begin{pmatrix} 2+0 & 1+2 \\ -4+1 & 3+(-3) \\ 2+3 & -2+(-2) \end{pmatrix} = \begin{pmatrix} 2 & 3 \\ -3 & 0 \\ 5 & -4 \end{pmatrix}$$

Let A and B are two matrices of dimension M X N and S is the sum matrix(S = A + B).

- To add two matrices we have to add their corresponding elements. For example, S[i][j] = A[i][j] + B[i][j].
- Traverse both matrices row wise(first all elements of a row, then jump to next row) using two loops.
- For every element A[i][j], add it with corresponding element B[i][j] and store the result in Sum matrix at S[i][j].

Example: Matrix Addition

```
#include <stdio.h>
int main() {
    int rows, cols, rowCounter, colCounter;
    int firstmatrix[50][50], secondMatrix[50][50], sumMatrix[50][50];
    printf("Enter Rows and Columns of Matrix\n");
    scanf("%d %d", &rows, &cols);

    printf("Enter first Matrix of size %dX%d\n", rows, cols);
    /*  Input first matrix*/
    for(rowCounter = 0; rowCounter < rows; rowCounter++) {
        for(colCounter = 0; colCounter < cols; colCounter++)    {
            scanf("%d", &firstmatrix[rowCounter][colCounter]);
        }
    }
```

Example: Matrix Addition

```
/*  Input second matrix*/
   printf("Enter second Matrix of size %dX%d\n", rows, cols);
   for(rowCounter = 0; rowCounter < rows; rowCounter++)     {
      for(colCounter = 0; colCounter < cols; colCounter++)       {
         scanf("%d", &secondMatrix[rowCounter][colCounter]);
      }
   }

   /* adding corresponding elements of both matrices sumMatrix[i][j] =
    firstmatrix[i][j] + secondMatrix[i][j] */
```

Example: Matrix Addition

```
for(rowCounter = 0; rowCounter < rows; rowCounter++) {
      for(colCounter = 0; colCounter < cols; colCounter++)  {
       sumMatrix[rowCounter][colCounter] =   firstmatrix[rowCounter][colCounter]
         + secondMatrix[rowCounter][colCounter];
      }
   }
   printf("Sum Matrix\n");
   for(rowCounter = 0; rowCounter < rows; rowCounter++) {
      for(colCounter = 0; colCounter < cols; colCounter++) {
          printf("%d ", sumMatrix[rowCounter][colCounter]);
      }
      printf("\n");
   }
   return 0; }
```

Example: Matrix Multiplication

```
#include<stdio.h>
int main() {
    int a[50][50], b[50][50], c[50][50], i, j, k, sum = 0, m, n, o, p;
    printf("\nEnter the row and column of first matrix");
    scanf("%d%d", &m, &n);
    printf("\nEnter the row and column of second matrix");
    scanf("%d %d", &o, &p);
    if(n != 0)      {
        printf("Matrix mutiplication is not possible");
        printf("\nColumn of first matrix must be same as row of second
        matrix");
    }
```

Matrix Multiplication (Cond..)

```
else
 {
      //Read the matrix form keyboard(user)
      printf("\nEnter the First matrix->");
      for(i=0;i<m;i++)
            for(j=0;j<n;j++)
                  scanf("%d",&a[i][j]);

      printf("\nEnter the Second matrix->");
      for(i=0;i<o;i++)
            for(j=0;j<p;j++)
                  scanf("%d",&b[i][j]);
```

Matrix Multiplication (Cond..)

```
//performing the matrix Multiplication
    for(i = 0; i < m; i++)  //row of first matrix
    {
        for(j = 0;j < p; j++)   //column of second matrix
            {
                sum=0;
                for(k=0; k < n; k++)
                   sum=sum + a[i][k] * b[k][j];
                c[i][j] = sum;
            }
    }
}
```

Matrix Multiplication (Cond..)

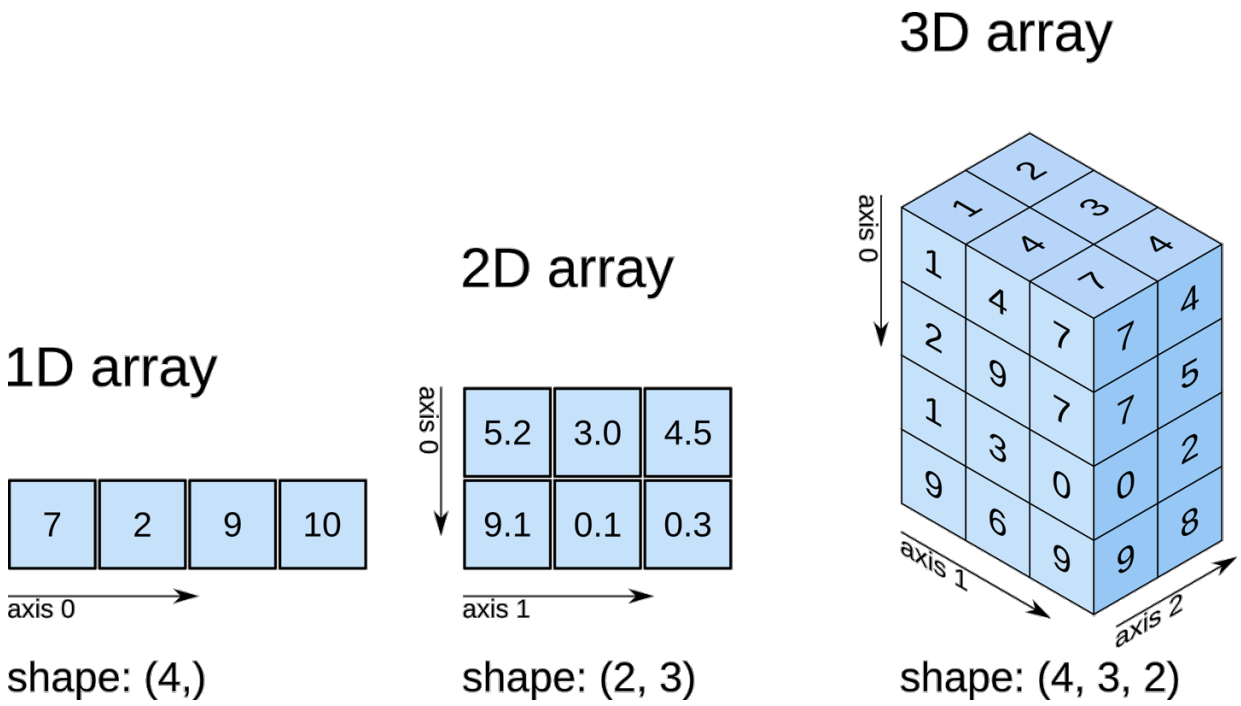
```
//Display the matrix Multiplication
printf("\nThe multiplication of two matrix is\n");
for(i = 0;i < m; i++) {
        printf("\n");
        for(j = 0; j < p; j++)    {
            printf("%d\t",c[i][j]);
        }
    }
    return 0;
}
```

Multi –dimensional Array

eg:

Last 3 months sale each of Mobiles and Laptops of 4 outlets of Croma

Sale[4][3][2]



String (Character Array)

- In C programming, the one-dimensional array of characters are called strings, which is terminated by a null character '\0.
- Last character is always '\0'
- because it is the only way the functions that work with a string can know where the string ends.
- *The ASCII value of null character('\0') is 0.*
- *A string not terminated by a '\0' is not really a string, but merely a collection of characters.*
- Note that for individual characters, C uses single quotes, whereas for strings, it uses double quotes.
- *For Example:*

  String constant : "CCourse"
  Character constant: 'C'

String Declaration in C

- Syntax:

  char string_name[SIZE_OF_STRING];

- Examples:

  char address[100];

  char welcomeMessage[200];

  char name[6];

Note- C Does not provide support for boundary checking i.e. if we store more characters than the specified size in string declaration then C compiler will not give you any error.

Remember, name of an array also specifies the base address of an array.

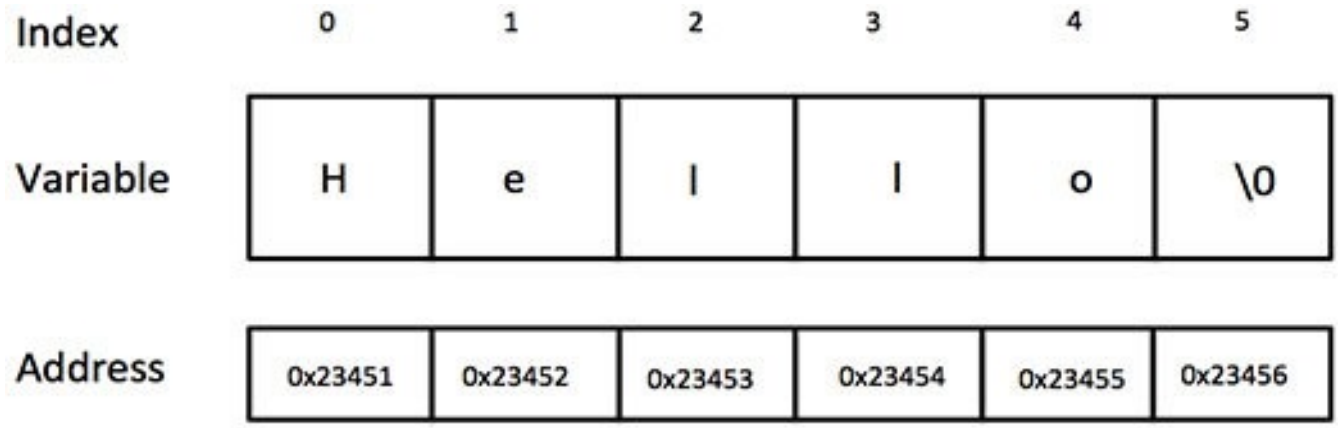
String Initialization in C

- In C programming language, a string can be initialized at the time of declarations like any other variable in C. If we don't initialize an array then by default it will contain garbage value.
- char message[6] = {‘H', ‘e', ‘l', ‘l', ‘o', '\0'};

or

- char message[] = “Hello";

Note- In this type of initialization , we don’t need to put terminating null character at the end of string constant. C compiler will automatically inserts a null character('\0'), after the last character of the string literal.



String

```
#include<stdio.h>
int main() {
    char stringArray[100];                          //  string declaration
    printf("Please write something: \n");
     scanf("%s", stringArray);
//%s is a format specifier for string
    printf("You entered the string %s \n", stringArray);
    return 0;
}
```

Note- Array name is by default **address of array**, so & not needed for scanf.

Few Points on Strings

- char str[]; // Invalid at declaration string size is must
- char str[0]; // Invalid string size must not be -ve or zero value
- char str[-1]; // Invalid
- char str[10]; // Valid

- char str[2]={'5','+','A','B'}; // Invalid can not initialized more than size of string
- char str[]={'5','+','A','B'}; // Valid In initialization of the string the size is optional

Few Points on Strings

- Each character of string is stored in consecutive memory location and occupy 1 byte of memory.
- If string contains the double quote as part of string then we can use escape character to keep double quote as a part of string.

  "Co\"ep" is an example of String

- **char string1[] = "first";**

  string1 actually has 6 elements

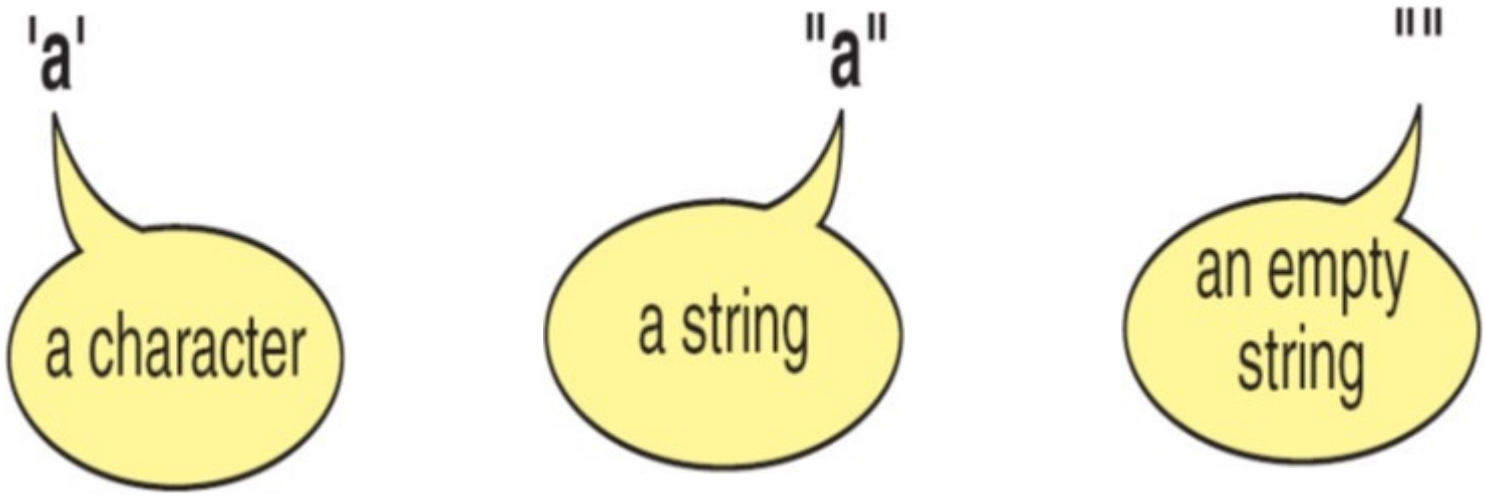
- It is equivalent to

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

- Can access individual characters

  string1[3] is character *'s'*

- If we don't specify the size of String then length is calculated automatically by the compiler. The length of the string will be one more than the number of characters in string literal/constant.


'a'
a character
"a"
a string
""
an empty string

Display a String

```
void main( ) {
    char name[ ] = “COEP" ;
    int i = 0 ;
    while ( i <= 3 ) {
        printf ( "%c", name[i] ) ;
        i++ ;
    }
}
```

Note- **printf( )** doesn’t print the ‘\0’.

Display a String

```
void main( ) {
    char name[ ] = “COEP" ;
    int i = 0 ;
    while ( name[i] != `\0’ ) {
        printf ( "%c", name[i] ) ;
        i++ ;
    }
}
```

Input strings

- Use scanf
- char string2[4];
- For reading individual characters

```
for(i=0;i<3;i++)
    scanf("%c",&string2[i])
    ;
```

```
main( ) {
    char name[10];
    int i = 0 ;
    while ( i<9 ) {
        scanf ( "%c", &name[i] ) ;
        i++ ;
    }
    name[9]='\0';
}
```

Input strings

- Use scanf
- char string2[4];

  scanf("%s", string2);
  - Array name is **address of array**, so & not needed for scanf

```
main( ) {
    char name[10];
    int i = 0 ;
    printf("Enter your name")
    scanf ( "%s", name ) ;
    printf("%s", name);

}
```

Inputting strings

- While entering the string using **scanf( ) we must be cautious about** two things:

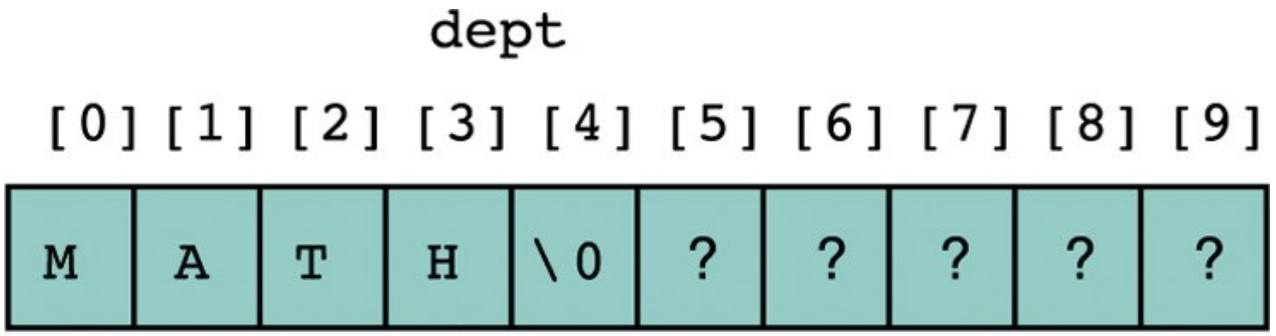
1) The length of the string should not exceed the dimension of the character array. This is because the C compiler doesn't perform bounds checking on character arrays. Hence, if you carelessly exceed the bounds there is always a danger of overwriting something important.

2) **scanf() is not capable of receiving multi-word strings.** Therefore names such as 'COEP COLLEGE' would be unacceptable. The way to get around this limitation is by using the function **gets( ).**

Execution of scanf ("%s", dept);

- Whenever encountering a white space, the scanning stops and `scanf` places the null character at the end of the string.

- e.g., if the user types "MATH 1234 TR 1800," the string "MATH" along with '\0' is stored into `dept[]`.



strings using gets() and puts()

```
void main( ) {
      char name[10];
      int i = 0 ;
      printf("Enter name")
      gets(name) ;                    //scanf("%[^\n]s", name);
                                      // printf("hello!\n%s", name);
      puts("hello!");
      puts(name);
}
```

```
Enter Name
COEP COLLEGE
hello!
COEP COLLEGE
```

strings using gets() and puts()

- puts( ) can display only one string at a time.
- Also, on displaying a string, unlike printf( ), puts( ) places the cursor on the next line.
- gets( ) can receive a multi-word string.
- gets( ) and puts( ) are available in stdio.h header file

String Handling Standard Library Function

- C supports a wide range of functions that manipulate null-terminated strings.

- The string can not be copied by the assignment operator '='.
  - e..g, `str = "Test String"` is not valid.

- C provides string manipulating functions in the "string.h" header file.

Some String Functions from string.h

Function	Purpose	Example
`strcpy()`	**strcpy(s1, s2);** Copies string s2 into string s1.	strcpy(s1, “Hi”);
`strcat()`	**strcat(s1, s2);** Appends a string s2 to the end of another string s1.	strcat(s1, “more”);
`strcmp()`	**strcmp(s1, s2);** Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2. Compares two strings character by character.	strcmp(s1, “Hi”);

Some String Functions from string.h

Function	Purpose	Example
`strlen()`	Returns the number of characters in a string.	strlen("Hi") returns 2.
`strchr()`	**strchr(s1, ch);** It searches for the first occurrence of a character ch in the string s1.	
`strstr()`	**strstr(s1, s2);** It searches for the first occurrence of a string s2 in another string s1.	

strcpy

- Function `strcpy` copies the second string (source) into the first string (destination).
  - strcpy(destination, source)
  - e.g., strcpy(dest, “test string”);
- The null character is appended at the end automatically.
- strcpy( ) goes on copying the characters in source string into the target string till it doesn't encounter the end of source string (‘\0’).
- If source string is longer than the destination string, the overflow characters may occupy the memory space used by other variables.
- to ***copy*** str2 to str1:

```
char str1[20];
char str2[]=“coep”;
strcpy(str1, str2);
str1 = str2; /* Will NOT work!! */
```

Example

```
#include<string.h>
void main( ) {
 char source[ ] = "Sayonara" ;
       char target[20] ;
 strcpy ( target, source ) ;
 printf ( "\nsource string = %s", source ) ;
 printf ( "\ntarget string = %s", target ) ;
 }
}
```

The output would be...

source string = Sayonara

target string = Sayonara

strcat

- This function concatenates the source string at the end of the target string. (without space)
  - `strcat(target,source);`

- to ***add*** (*concatenate*) str2 to the end of str1:
  - char str1[]=”coep”;
  - char str2[]=“pune”;
  - `strcat(str1, str2);`
    - returns the value of str1 with str2 added to the end
      - Make sure that str1 has room for str2

      str1 becomes “coeppune”

Example

```
#include<string.h>
void main( )          {
        char source[ ] = "Folks!" ;
       char target[30] = "Hello" ;
       strcat ( target, source ) ;
       printf ( "\nsource string = %s", source ) ;
       printf ( "\ntarget string = %s", target ) ;
}
```

The output would be...

```
        source string = Folks!
       target string = HelloFolks!
```

Finding the Length of a String

- Use **`strlen(string)`**
  - returns length of the string

- This function counts the number of characters present in a string.

- Function `strlen` is often used to check the length of a string (i.e., the number of characters before the null character).

```
char dest[6] = “Hello”;

i=strlen(dest);

i=5
```

Example

```
#include<string.h>
void  main( )
   {
       char arr[ ] = “COEP" ;
       int len1, len2 ;
       len1 = strlen ( arr ) ;
       len2 = strlen ( "Humpty Dumpty" ) ;
       printf ( "\nstring = %s length = %d", arr, len1 ) ;
       printf ( "\nstring = %s length = %d", "Humpty Dumpty", len2 ) ;
  }
```

The output would be...

string = COEP length = 4

string = Humpty Dumpty length = 13

String Comparison (1/2)

- **strcmp(string1, string2)**
- The comparison between two strings is done by comparing each corresponding character in them.
- The two strings are compared character by character until there is a mismatch or end of one of the strings is reached, whichever occurs first.
- If the two strings are identical, **strcmp( )** returns a value zero. If they're not, it returns the numeric difference between the ASCII values of the first non-matching pairs of characters.
  - "thrill" < "throw" since 'i' < 'o';
  - "joy" < joyous";

String Comparison (2/2)

Relationship	Returned Value	Example
`str1 < str2`	Negative	"Hello"< "Hi"
`str1 == str2`	0	"Hi" = "Hi"
`str1 > str2`	Positive	"Hi" > "Hello"

- e.g., we can check if two strings are the same by

  char str1[]="coep"; char str2[]="pune";

```
if(strcmp(str1, str2) != 0)
   printf("The two strings are different!");
```

Example

```
#include<string.h>
  void main( )
   {
        char string1[ ] = "Jerry" ;
        char string2[ ] = "Ferry" ;
        int i, j, k ;
        i = strcmp ( string1, "Jerry" ) ;
        j = strcmp ( string1, string2 ) ;
        k = strcmp ( string1, "Jerry boy" ) ;
        printf ( "\n%d %d %d", i, j, k ) ;
   }
```

The output would be...

0 4 -32

Example

```
#include <stdio.h>
#include <string.h>
int main ()
{
   char str1[12] = "Hello";
   char str2[12] = "World";
   char str3[12];
   int  len ;

   /* copy str1 into str3 */
   strcpy(str3, str1);
   printf("strcpy( str3, str1) :  %s\n", str3 );
```

Example

```
   /* concatenates str1 and str2 */
   strcat( str1, str2);
   printf("strcat( str1, str2):   %s\n", str1 );

   /* total lenghth of str1 after concatenation */
   len = strlen(str1);
   printf("strlen(str1) :  %d\n", len );

   return 0;
}
strcpy( str3, str1) :  Hello
strcat( str1, str2):   HelloWorld
strlen(str1) :  10
```

Review

- Character array
- Declaration of Character Array
- Input

```
for(i=0;i<4;i++)
    scanf("%c",&name[i]);
```

scanf(“%s”,name); not read space

gets(name); read the space

scanf(“%[^\n]s”, name); read the space also

- Output

printf(“%s”,name);

```
for(i=0;i<4;i++)
    print("%c",name[i]);
```

–String Library functions (strcpy, strcat, strlen, strcmp)

what is the o/p of following code?

```
void main( ) {
        char name[ ] = “College" ;
        int i = 0 ,n;
        //n=strlen(name);
        while ( name[i] != `\0’ )  {  //while(i<n)

                printf ( "%c", name[i] ) ;
                i++ ;
        }
}
```

what is the o/p of following code?

```
void main( ) {
        char name[25] ;
        printf ( "Enter your full name " ) ;
        gets ( name ) ;//scanf("%[^\n]s",name);
        printf( "Hello!" ) ;
        printf("%s",name ) ;
}
```

What does this program do

```
void main() {
   char s[20];
   int i,j,k,m;
   printf("Enter a sentence");
   gets(s);
   printf("Enter position and no of charactor");
   scanf("%d%d",&i,&j);
   for(k=0;s[k]!='\0';k++)     {
         if(k==i-1)                  {
                  for(m=k;m<i+j-1;m++)
                  printf("%c",s[m]);
         }
   }
}
```

Same program with little modification

```
void main() {
   char s[20];
   int i,j,k;
   printf("Enter a sentence");
   gets(s);
   printf("Enter position and no of charactor");
   scanf("%d%d",&i,&j);
   k=i;
   while(k<j+i)          {
         printf("%c",s[k-1]);
         k++;
   }
}
```

It made our code simpler