CSE101-Lec#22

Strings

Outline

- Introduction to string
  - Declaration
  - Initialization
- Reading and writing strings
  - functions of the standard input/output library (stdio.h)
- Processing of strings.
  - String Manipulation Functions from the String Handling Library
  - Comparing strings
  - Determining the length of string
  - All string operations without inbuilt functions
  - Other programs related to strings

Fundamentals of strings

- Strings
  - Array of characters treated as a single unit called string:
    - Can include **letters**, **digits** and **special characters** (*, /, $)
  - String literal (string constant) - written in **double** quotes
    - “Lovely Professional University."

What is a String??

- String is a collection of characters terminated by null character
- Strings are arrays of characters
  - String is a **pointer** to first character (like array)
  - Value of string is the **address** of first character
- Each element of the string is stored in a **contiguous** memory locations.
- Terminated by a **null character**('\0') which is automatically inserted by the compiler to indicate the **end of string**.

String Definition

- They are defined as

```
char array_name[size];
e.g. char carname[30];
```

- It defines an array name and reserves 30 bytes for storing characters and single character consumes 1 bytes each.
- Since the last byte is used for storing null character so total number of character specified by the user cannot exceed **29**.

String Initialization

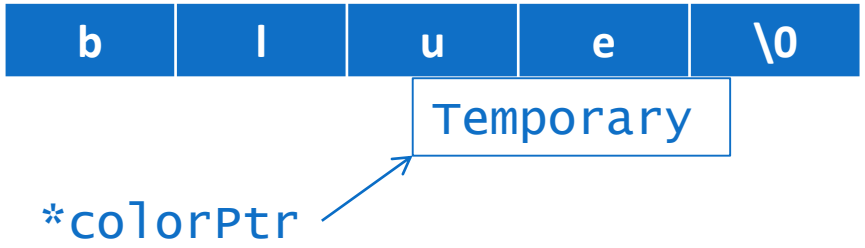
- String Initialization
  - Two ways:
  - Define as a character array or a variable of type char *

```
char color[] = "blue"; //char array
```

Or

```
char color[] = { 'b', 'l', 'u', 'e', '\0' };
char *colorPtr = "blue"; //pointer variable
```

  - Remember that strings represented as character arrays end with '\0'



String Input/Output

- Inputting strings
  - Use `scanf`.

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

    - Copies input into `word[]`
    - **Do not need & (because a string is a pointer)**
  - Remember to leave last place in the array for `'\0'`.
  - Because array knows no bounds the string written beyond char array size will **overwrite** the data in memory.
- Displaying strings
  - Use `printf`.

```
printf("%s", word);
```

Program to read and display string

```c
#include <stdio.h>
int main()
{
 char carname[20]; //string char array
 printf("Enter the name of your car: ");
 scanf("%s", carname);// to display the input
 printf("\nName of car is %s", carname);
} //end main
```

Output

```
Enter the name of your car: XUV500
Name of car is XUV500
```

How?

- The last program will print only a single word not the sentences with white spaces?
- That is if input is

  Lovely Professional University

- Output will be:

  Lovely

- So how to print:

  Lovely Professional University

use gets and puts

Standard I/O Library Functions

- List of functions in `#include<stdio.h>`
- Used for string input/output functions.

Function	Description
gets(char *s);	Inputs characters from the standard input into the array s until a **newline or end-of-file** character is encountered. A terminating null character is appended to the array.
puts(const char *s);	Prints the string s followed by a newline character.

```c
#include <stdio.h>
int main()
{
 char  name[100]; //string char array
 puts("\nEnter a string:");
 gets(name); //to input string with space
 printf("\nString is:")
 puts(name); //to output const string
}//end main
```

Program to print strings with white spaces using library functions

```
Enter a string:
Lovely Professional University
String is:
Lovely Professional University
```

Output

```c
#include <stdio.h>
int main()
{
 char  name[]={"Hello"}; //string char array
 int i=0;
 while(name[i]!='\0') //untill null character
  {
   printf("%c",name[i]);
   i++;
  }//end while
}//end main
```

Program to print strings character by character using loop.

```
Lovely Professional University
```

Output

String Handling Library

- Functions defined in `#include<string.h>`
- String handling library provides **many** useful functions:
  - Manipulate string data(copy and concatenate)
  - Comparing strings
  - Determine string length

String Manipulation Functions(or Functions in string library)

Function prototype	Function description
`char *strcpy( char *s1, const char *s2 );`	Copies the string `s2` into the character array `s1`. The value of `s1` is returned.
`char *strncpy( char *s1, const char *s2, size_t n );`	Copies at most `n` characters of the string `s2` into the character array `s1`. The value of `s1` is returned.
`char *strcat( char *s1, const char *s2 );`	Appends the string `s2` to `s1`. The first character of `s2` overwrites the terminating null character of `s1`. The value of `s1` is returned.
`char *strncat( char *s1, const char *s2, size_t n );`	Appends at most `n` characters of string `s2` to string `s1`. The first character of `s2` overwrites the terminating null character of `s1`. The value of `s1` is returned.
`int strcmp( const char *s1, const char *s2 );`	Compares the string `s1` with the string `s2`. The function returns a value of zero, less than zero or greater than zero if `s1` is equal to, less than or greater than `s2`, respectively.
`int strncmp( const char *s1, const char *s2, size_t n );`	Compares up to `n` characters of the string `s1` with the string `s2`. The function returns zero, less than zero or greater than zero if the `n`-character portion of `s1` is equal to, less than or greater than the corresponding `n`-character portion of `s2`, respectively.

More functions in string library

- strlen()-It is used to find the length of string without counting the null character
- strrev()-It is used to display the reverse of a string
- strlwr()-Converting a string from upper to lower case
- strupr()-Converting a string from lower to upper case

strcpy() and strncpy()

- **strcpy()** copies the entire **second** argument string into **first** argument.

```
strcpy( s1, s2);
```

- **strncpy()** copies the **first n** characters of **second** string argument into **first** string argument.

```
strncpy( s1, s2, 4);
```

  - A null character ('\0') is appended **explicitly** to first argument, because the call to strncpy in the program **does not** write a terminating null character.
  - The third argument is less than the string length of the second argument.

Examples

```
//strcpy() function
#include<stdio.h>
#include<string.h>
int main()
{
        //strcpy function
        char ori[20],dup[20];
        char *z;
        printf("\n Enter your name:");
        gets(ori);
        z=strcpy(dup,ori);
        printf("Original String
is:%s",ori);
        printf("\nDuplicate String
is:%s",dup);
        printf("\n Value of z is:%s",z);
        return 0;
}
```

```
//strncpy()
#include<stdio.h>
#include<string.h>
int main()
{
        char str1[15],str2[15];
        int n;
        printf("\nEnter Source String:");
        gets(str1);
        printf("\nEnter Destination String:");
        gets(str2);
        printf("Enter number of characters
to replace in destination string:");
        scanf("%d",&n);
        strncpy(str2,str1,n);
        printf("Source string is:%s",str1);
        printf("\nDestination String
is:%s",str2);
        return 0;
}
```

strcat()

- Function **strcat appends its second argument string to its first argument string.**

```
strcat( s1, s2);
```

- The array used to store the first string should be large enough to store
  - the first string
  - the second string and
  - the terminating null character copied from the second string.

strncat()

- Function `strncat` appends a specified number of characters from the second string to the first string.

```
strncat( s1, s2, 6)
```

- A terminating null character is **automatically** appended to the result.

Examples

```
//strcat
#include<stdio.h>
int main()
{
        char str1[20],str2[10];
        printf("\n Enter first string:");
        gets(str1);
        printf("\n Enter second string:");
        gets(str2);
        strcat(str1,str2);
        printf("\n String after
concatenation:%s",str1);
        return 0;
}
```

```
//strncat
#include<stdio.h>
int main()
{
        char str1[20],str2[10];
        int n;
        printf("\n Enter first string:");
        gets(str1);
        printf("\n Enter second string:");
        gets(str2);
        printf("\n Enter number of
characters you want to combine:");
        scanf("%d",&n);
        strncat(str1,str2,n);
        printf("\n String after
concatenation:%s",str1);
        return 0;
}
```

Comparison Functions of the String Handling Library

- Comparing strings
  - Computer compares numeric ASCII codes of characters in string
  - `strcmp()` Compares its first string argument with its second string argument, character by character.
  - Function `strncmp()` does not compare characters following a null character in a string.

strcmp()

```
int strcmp( const char *s1, const char *s2 );
```

- Compares string `s1` to `s2`
- Returns
  - a negative number if `s1 < s2`,
  - zero if `s1 == s2`
  - a positive number if `s1 > s2`

strncmp()

```
int strncmp( const char *s1, const char *s2, int n);
```

- Compares up to `n` characters of string `s1` to `s2`
  - a negative number if `s1 < s2`,
  - zero if `s1 == s2`
  - a positive number if `s1 > s2`

Examples

```
//strcmp
#include<stdio.h>
int main()
{
        char str1[20],str2[10];
        int x;
        printf("\n Enter first string:");
        gets(str1);
        printf("\n Enter second string:");
        gets(str2);
        x=strcmp(str1,str2);
        if(x==0)
        {
                printf("\n Strings are equal");
        }
        else if(x>0)
        {
                printf("\n First string is greater
than second string(strings are not equal)");
        }
        else
        {
                printf("\n First string is less than
second string(strings are not equal)");
        }
        return 0;
}
```

```
// strncmp
#include<stdio.h>
int main()
{
        char str1[20],str2[10];
        int x,n;
        printf("\n Enter first string:");
        gets(str1);
        printf("\n Enter second string:");
        gets(str2);
        printf("\n Enter no. of characters to compare:");
        scanf("%d",&n);
        x=strncmp(str1,str2,n);
        if(x==0)
        {
                printf("\n Strings are equal");
        }
        else if(x>0)
        {
                printf("\n First string is greater than
second string(strings are not equal)");
        }
        else
        {
                printf("\n First string is less than
second string(strings are not equal)");
        }
        return 0;
}
```

stricmp()[Ignore case], stricmp will ignore the case

```
#include<stdio.h>
int main()
{
        char str1[20],str2[10];
        int x;
        printf("\n Enter first string:");
        gets(str1);
        printf("\n Enter second string:");
        gets(str2);
        x=stricmp(str1,str2);
        if(x==0)
        {
                printf("\n Strings are equal");
        }
        else if(x>0)
        {
                printf("\n First string is greater than second string(strings are not equal)");
        }
        else
        {
                printf("\n First string is less than second string(strings are not equal)");
        }
        return 0;
}
//consider str1(HELLO) and str2(hello) and if we apply stricmp on these strings, then 0 will be returned, as strings are equal
```

Determining the length of string

strlen()

- ***Function*** `strlen` in `#include<string.h>`
- Function **strlen()** takes a **string** as an argument and returns the **number** of characters in the string
  - the terminating null character is not included in the length

Example

```
#include<stdio.h>
#include<string.h>
int main()
{
char str[]="Hello";
printf("\n Length of the given string is:%d",strlen(str));
return 0;
}
```

strrev()-Example

```
#include<stdio.h>
#include<string.h>
int main()
{
        char s[100]="Hello";
        printf("%s",strrev(s));
        return 0;
}
```

strlwr(),strupr()-Examples

```
#include<stdio.h>
#include<string.h>
int main()
{
        char s[]="hello";
        strupr(s);
        puts(s);
        strlwr(s);
        puts(s);
        return 0;
}
```

All string operations without inbuilt functions

- Copying one string to another
- Finding length of a string
- Concatenation(or Combining) of two strings
- Comparing two strings
- Displaying reverse of a number
- Checking whether a given string is palindrome or not
- Converting all characters of a given string from lowercase to uppercase
- Converting all characters of a given string from uppercase to lowercase

WAP to copy one string to another without using strcpy()/or inbuilt function

```
#include<stdio.h>
int main() {
   char s1[100], s2[100];
   int i;
   printf("\nEnter the string :");
   gets(s1);//Hello
   i = 0;
   while (s1[i] != '\0') {
      s2[i] = s1[i];
      i++;
   }
   s2[i] = '\0';
   printf("\nCopied String is %s ", s2);
   return (0);
}
```

WAP to find the length of a string without using strlen()/ or inbuilt function

```
#include<stdio.h>
int main()
{
        char x[100];
        int i=0;
        printf("\n Enter String:");
        gets(x);
        while(x[i]!='\0')
    {
                i++;
          }
        printf("\n Length of the string is:%d",i);
        return 0;
}
```

WAP to concatenate(or combine) two strings without using strcat/ or inbuilt function

```
#include<stdio.h>
int main()
{
        char str1[100],str2[100],str3[200];
        int i=0,j=0;
        printf("\n Enter the first string:");
        gets(str1);
        printf("\n Enter the second string:");
        gets(str2);
        while(str1[i]!='\0')
        {
                str3[j]=str1[i];
                i++;
                j++;
        }
        i=0;
        while(str2[i]!='\0')
        {
                str3[j]=str2[i];
                i++;
                j++;
        }
        str3[j]='\0';
        printf("\n The concatenated string is:");
        puts(str3);
        return 0;
}
```

WAP to compare two strings without using strcmp()/ or inbuilt function

```
#include <stdio.h>
#include<string.h>
int main ()
{
 // declare variables
  char str1 [30], str2 [30];
  int i = 0, flag=0 ,length1, length2, length;
 // take two string input
 printf ("Enter string1:");
 gets (str1);
 printf ("\nEnter string2:");
 gets (str2);
 //length of both string
  length1 = strlen (str1);
  length2 = strlen (str2);
  if(length1>length2)
  length=length1;
  else
  length=length2;
```

•

```
while (i<length)
   {
    if( str1 [i] == str2 [i])
     {
       i++;
       continue;
     }
 if( str1 [i] < str2 [i])
     {
       flag = -1;
       break;
     }
    if( str1 [i] > str2 [i])
     {
       flag = 1;
       break;
     }
 }
 if (flag == 0)
   printf ("\nBoth strings are equal ");
 if(flag == -1)
   printf ("\nstring1 is less than string2 ");
 if( flag == 1)
   printf ("\nstring1 is greater than string2 ");
   return 0;
}
```

Dry running

Comparing two strings

```
str1 → first string        flag = 0;
str2 → second string       i = 0
length1 = strlen(str1);
length2 = strlen(str2);
if( length1 > length2)
{
  length = length1;
}
else
{
  length = length2;
}
while( i<length )
{
  if (str1[i] == str2[i])
  {
    i++;
    continue;
  }
  if( str1[i] < str2[i] )
  {
    flag = -1;
    break;
  }
  if( str1[i] > str2[i])
  {
    flag = 1;
    break;
  }
}
if( flag == 0 )
printf(" Equal");
if( flag == -1 )
  printf("S1 is less than S2");
if( flag == 1)
  printf("\n S1 is > than S2");
```

Consider

str1 → Have
str2 → Has

length1 = 4
length2 = 3

4 > 3

length = 4.

i = 0, 0 < 4 (True)
H == H (True)
i = 1
continue (Next Iteration)
1 < 4 (True)
a == a (True)
i = 2
continue (Next Iteration)
2 < 4 (True)
v == s (False)
v < s (False)
v > s (True)
flag = 1;
break; [Loop terminates]
1 == 1 (flag == 1) True
S1 is > (greater than) S2

WAP to display the reverse of a given string without strrev()/ or inbuilt function

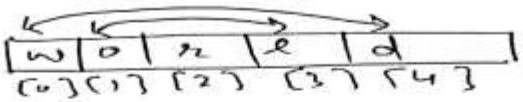
```
#include<stdio.h>
#include<string.h>
int main() {
   char str[100], temp;
   int i, j;
   printf("\nEnter the string :");
   gets(str);
   i = 0;
   j = strlen(str) - 1;
   while (i < j) {
      temp = str[i];
      str[i] = str[j];
      str[j] = temp;
      i++;
      j--;
   }
   printf("\nReverse string is :%s", str);
   return (0);
}
```

Dry running

Reverse of a given string
Without using strrev().

```
i = 0;          [ str → string ]
j = strlen(str) - 1;
while ( i < j )
{
   temp = str[i];
   str[i] = str[j];
   str[j] = temp;
   i++;
   j--;
}
printf("\n Reverse string is: %s", str);
```

str = "world"



i = 0 ;
j = 5 - 1 = 4

0 < 4 (True)

temp = w
w = d
d = w
} Swapping

i = 1
j = 3

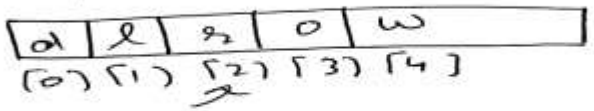
1 < 3 (True)

temp = o
o = l
l = o
} Swapping

i = 2
j = 2

2 < 2 (false)
Loop stops.

So, str:



Reverse

WAP to check whether the given string is palindrome or not(without using strrev())

```
#include<stdio.h>
#include<string.h>
int main() {
  char str[100], temp;
  char str1[100];
  int i, j;
  printf("\nEnter the string :");
  gets(str);
  i = 0;
  j = strlen(str) - 1;
  strcpy(str1,str);
  while (i < j)
  {
    temp = str[i];
    str[i] = str[j];
    str[j] = temp;
    i++;
    j--;
  }
 if(strcmp(str1,str)==0)
  {
        printf("\n Given String is Palindrome");
  }
  else
  {
        printf("\n Not a Palindrome");
  }
  return (0);
}
```

WAP to convert all characters of a given string into uppercase without using strupr()/or inbuilt function

```
#include<stdio.h>
#include<string.h>
int main()
{
char str1[10];
int i,len;
printf("Enter any string \t");
gets(str1);
len=strlen(str1);
for(i=0;i<len;i++)
            {
            if(str1[i]>='a' && str1[i]<='z')

            str1[i]=str1[i]-32;
            }
puts("string in upper is");
puts(str1);
return 0;
}
```

WAP to convert all characters of a given string into lowercase without using strlwr()/or inbuilt function

```
#include<stdio.h>
#include<string.h>
int main()
{
char str1[10];
int i,len;
printf("Enter any string \t");
gets(str1);
len=strlen(str1);
for(i=0;i<len;i++)
            {

            if(str1[i]>='A' && str1[i]<='Z')
            str1[i]=str1[i]+32;
            }
puts("string in lower is");
puts(str1);
return 0;
}
```

More programs on strings

WAP to sort the characters of a given string into ascending order

```
#include<stdio.h>
#include<string.h>
int main()
{
char s[10],t;
int n,i,j;
printf("\n Enter String:");
gets(s);
n=strlen(s);
for(i=0;i<n-1;i++)
{
for(j=0;j<n-i-1;j++)
{
if(s[j]>s[j+1])
{
   t=s[j];
   s[j]=s[j+1];
   s[j+1]=t;
}
}
}
printf("%s",s);
}
```

WAP to count vowels in a given string

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

        char x[100];
        int i=0,count=0;
        printf("\n Enter the string:");
        gets(x);
        while(x[i]!='\0')
        {
if(x[i]=='a'||x[i]=='e'||x[i]=='i'||x[i]=='o'||x[i]=='u'||x[i]=='A'||x[i]=='E'||x[i]=='I'||x[i]
=='O'||x[i]=='U')
          {
                count++;
           }
           i++;
        }
        printf("\n Number of vowels in the string are:%d",count);
        return 0;
}
```

WAP to traverse all characters of a given string using pointer to character

```
#include<stdio.h>
int main()
{
        char *g="C Programming";
        int length=0,i=0;
   while(*g!='\0')
        {
                printf("%c",*g);//Value at address
                g++;//Pointer is incremented by 1 after each iteration
                length++;//Variable for counting length
        }
        printf("\nLength of the string is:%d",length);
        return 0;
}
```

WAP to count total no. of characters and words in a given string

```
#include<stdio.h>
int main()
{
        char x[100];
        int i=0,length=0,c=0,w=1;
        printf("\n Enter String:");
        gets(x);
        while(x[i]!='\0')
    {
                if(x[i]==' ' && x[i+1]!=' ')
                 {
                    w++;
                 }
                 c++;
                 i++;
           }
        printf("\n Total number of characters are:%d, and no. of words are:%d",c,w);
        return 0;
}
```

WAP to demonstrate array of strings in C

```
#include<stdio.h>
int main()
{
        char names[5][10];
        int i,n;
        printf("\n Enter the number of students:");
        scanf("%d",&n);
        fflush(stdin);
        for(i=0;i<n;i++)
        {
                printf("\n Enter the name of student %d: ",i+1);
                gets(names[i]);
        }
        printf("\n Names of the students are:\n");
        for(i=0;i<n;i++)
        puts(names[i]);
        return 0;
}
```

WAP to traverse a string character by character

```
#include <stdio.h>
int main()
{
 char  name[]="Hello  World"; //string char array
 int i=0;
 while(name[i]!='\0') //untill null character
  {
   printf("%c\n", name[i]);
   i++;
  }//end while
}//
```

WAP to replace all spaces in a given string with '$'[Example for character replacement]

```
#include<stdio.h>
int main()
{
        char x[100];
        int i=0;
        printf("\n Enter the string:");
        gets(x);
        while(x[i]!='\0')
        {
    if(x[i]==' ')
    {
        x[i]='$';//Character replacement
    }
    i++;
   }
  printf("\n String after character replacement is:%s",x);
  return 0;
}
```

MCQ

What is the Format specifier used to print a String or Character array in C Printf or Scanf function.?

A) %c

B) %C

C) %s

D) %w

MCQ

What is the output of C Program with arrays?

```
 int main()
 {
 char str[]={"C","A","T","\0"};
printf("%s",str);
 return 0;
 }
```

A) C
B) CAT
C) CAT\0
D) Compiler error

MCQ

What is the output of C program with strings.?

```
int main()
{
 char str1[]="JOHN";
char str2[20];
 str2= str1;
 printf("%s",str2);
return 0;
}
```

A) JOHN

B) J

C) JOHN\0

D) Compiler error

What is the output of C Program with String Pointer?

```
int main()
 {
 char country[]="BRAZIL";
char *ptr; ptr=country;
while(*ptr != '\0')
 {
 printf("%c", *ptr);
 ptr++;
}
 return 0;
}
```

A) B
B) BRAZIL
C) Compiler error
D) None of the above

CSE101-Lec#23,24

- Some other functions from string handling library

Outline

- String Conversion Functions
- Character arithmetic

String Conversion Functions

- String Conversion functions
  - In <stdlib.h> (general utilities library)
- Convert strings of digits to **integer** and **floating-point values and vice versa**

Function prototype	Function description
double atof(const char *nPtr);	Converts the string nPtr to double.
int atoi(const char *nPtr);	Converts the string nPtr to int.
long atol(const char *nPtr);	Converts the string nPtr to long int.
char * itoa(int value, char *str,int base);	Converts the integer value to string

atof()

Function atof

- Function **atof converts its argument—a string that represents a floating-point** number—to a double value.
- The function returns the double value.
- If the converted value cannot be represented—for example, if the first character of the string is a letter—the behavior of function atof is undefined.

atof()-Program example

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
        double d;
        d=atof("99.23");
        printf("%.2lf",d);
        return 0;
}
```

atoi()

Function atoi

- Function **atoi converts its argument—a string of digits that represents an integer—** to an int value.
- The function returns the int value.
- If the converted value cannot be represented, the behavior of function atoi is undefined.

atoi()-Program example

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
        char x[]="99";
        int i;
        i=atoi(x);
        printf("%d",i);
        return 0;
}
```

atol()

Function atol

- Function **atol converts its argument—a string of digits representing a long integer—** to a long value.
- The function returns the long value.
- If the converted value cannot be represented, the behavior of function atol is undefined.
- If int and long are both stored in 4 bytes, function atoi and function atol work identically.

atol()-Program example

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
        long int i;
        char x[]="10000000";
        i=atol(x);
        printf("%ld",i);
        return 0;
}
```

itoa()

- itoa () function in C language converts int data type to string data type. Syntax for this function is given below.
- char * itoa (int value, char * str, int base);
- Base values could be: 2, 8, 10,16(Depending upon the number system)

itoa()-Program example

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
        int a=123;
        char str[100];
        itoa(a,str,2);
        printf("\n Binary value:%s",str);
        itoa(a,str,10);
        printf("\n Decimal value:%s",str);
        itoa(a,str,16);
        printf("\n Hexadecimal value:%s",str);
        itoa(a,str,8);
        printf("\n Octal value:%s",str);
        return 0;
}
```

Converting from float to string

- There is no inbuilt function for this type of conversion, so we need to write the explicit code for the same,
- In the following ftoa() is a user defined function which is converting floating type value to string
- Example:

```
#include<stdio.h>
#include<stdlib.h>
void ftoa(float f1,char s[])
{
sprintf(s,"%f",f1);// s is array, %f format specifier and f1 is float variable
}
int main()
{
char str[20];
float f=12.340000;
ftoa(f,str);//it means convert float value f to string and store it in str// function call//
printf("\n%s",str);
return 0;
}
```

Character arithmetic

- To perform increment , decrement, addition subtraction operations on the characters.
- These operations work on the **ASCII** value of characters.
- Starting from ASCII value of ‘a’ = 97 to the ASCII value of ‘z’ = 122

Increment

- To display next char value

```
int main()
{
char x = 'a' + 1;
printf("%c", x); // Display Result = 'b'
printf("%c", ++x); // Display Result = 'c'

}
```

Decrement

- To display previous char value

```
int main()
{
char x = 'b' - 1;
printf("%c", x); // Display Result = 'a'
}
```

Addition

- Adding two ASCII values

```
int main()
{
  char x =  'a' + 'c';
  printf("%c", x); /* Display Result = - ( addition of
   ASCII of a and c is 196) */
}
```

Subtraction

- Adding two ASCII values

```
int main()
{
  char x =  'z' - 'a';
  printf("%c",x); /* Display Result = ↓ (difference
   between ASCII of z and a ) */
}
```

MCQ

What is the ASCII value of NULL or \0.?

A) 0

B) 1

C) 10

D) 49

MCQ

C string elements are always stored in.?

A) Random memory locations

B) Alternate memory locations

C) Sequential memory locations

D) None of the above

MCQ

What is the output of C program with strings.? int main()

```
{
char str[3]="SUNDAY";
printf("%s",str);
 }
```

A) SUN
B) SUNgarbagevalues
C) compiler error
D) None of the above

MCQ

If the two strings are identical, then strcmp() function returns

A.-1

B.1

C.0

D.Yes

MCQ

What will be the output of the program ?

```
#include<stdio.h>
#include<string.h>
 int main()
{
 char str1[20] = "Hello", str2[20] = " World";
 printf("%s\n", strcpy(str2, strcat(str1, str2)));
 return 0;
 }
```

A.Hello
B.World
C.Hello World
D.WorldHello

CSE101-Lec#25

- User defined data types(Structures)

Outline

- Declaration of a structure
- Definition and initialization of structures.
- Accessing structures.

Introduction

- Structures
  - Structure is a group of data items of different data types held together in a single unit.
  - Collections of related variables under **one name**
    - Can contain variables of different data types
  - Commonly used to define records to be stored in files.

Why Use Structures?

- Quite often we deal with entities that are collection of dissimilar data types.
- For example, suppose you want to store data about a **car**. You might want to store its name (a string), its price (a float) and number of seats in it (an int).
- If data about say 3 such cars is to be stored, then we can follow two approaches:
  - Construct individual arrays, one for storing names, another for storing prices and still another for storing number of seats.
  - Use a structure variable.

Structure

- There are three aspects of working with structures:
  - Defining a structure type
  - Declaring variables and constants of newly created type
  - Using and performing operations on the objects of structure type

Structure Definition

Syntax

```
struct  sname {
        type var1;
        type var2;
        type var3;
              .
              .
        type varN;
};
```

struct is a keyword to define a structure.
sname is the name given to the structure/structure tag.
type is a built-in data type.
var1,var2,var3,…..,varN are elements of structure being defined.
; semicolon at the end.

Structure Definitions

- Example:

```
struct car{
  char *name;
  int seats;
  float price
 };
```

  - `struct` **keyword** introduces the definition for structure `car`
  - `car` is the structure name or tag and is used to declare variables of the structure type
  - `car` contains three members of type `char, float, int`
    - These members are `name, price` and `seats`.

➢ No variable has been associated with this structure

➢ No memory is set aside for this structure.

Structure Definitions

- `struct` information
  - A structure definition does not reserve space in memory .
    - Instead creates a new data type used to define structure variables
- Defining variables of structure type
  - Defined like other variables:

```
Car myCar, cars[5], *cPtr;
```

  - Can use a comma separated list along with structure definition:

```
struct car{
    char *name;
    int seats;
    float price;
} myCar, cars[5], *cPtr;
```

At this point, the memory is set aside for the structure variable myCar.

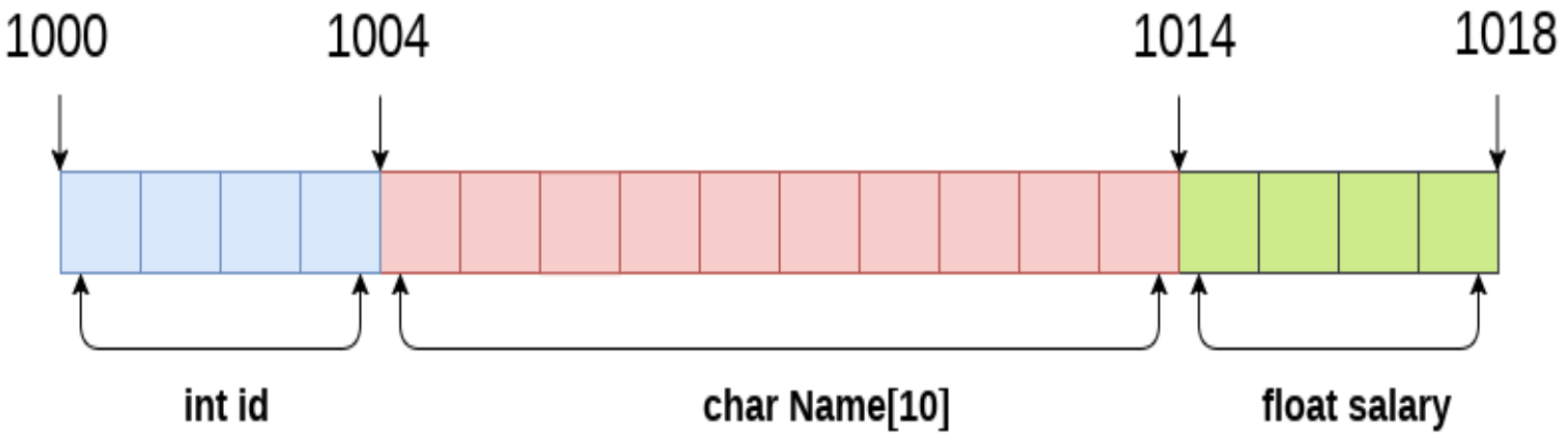
How the members are stored in memory

Consider the declarations to understand how the members of the **structure variables are stored in memory**

```
struct employee{
    int id;
    char name[20];
    float salary;
}e1;
```

Note: **all members are stored in contiguous memory location in order in which they are declared.**

Memory allocation



Structure Definitions

- Operations that can be performed on structures
  - Assigning a structure to a structure of the same type
  - Taking the address (`&`) of a structure
  - Accessing the members of a structure
  - Using the `sizeof` operator to determine the size of a structure

Initializing Structures

- Initializer list
  - To initialize a structure similarly like arrays
  - Example:

```
struct car myCar = { “Renault", 500000, 2 };
```

  - Could also define and initialize `myCar` as follows:

```
struct Car myCar;
strcpy(name,”Renault”);//if name is array of characters
myCar.price = 500000;
myCar.seats = 2;
```

Accessing Members of Structures

- Two operators are used to access members of Structures:
  - Dot operator (.) used with structure variables

```
struct car myCar;
printf("%d", myCar.seats);
```

  - Arrow operator (->) used with pointers to structure variables

```
struct car *myCarPtr = &myCar;
printf("%d", myCarPtr->seats);
```

  - `myCarPtr->name` is equivalent to

```
(*myCarPtr).seats
```

dot Operator

- Members are accessed using dot operator.
- It provides a powerful and clear way to refer to an individual element.

- **Syntax:** **sname.vname**
- **sname is structure variable name.**
- **vname is name of the element of the structure.**
- **Eg:** the members of the structure variable ***car*** can be accessed as

```
myCar.name, myCar.seats, myCar.price
```

Use of Assignment Statement for Structures

- The main advantage of structure is that it can be treated as single entity.
- The only legal operations that can be performed on structure are copying to it as a single unit using the assignment operator.
- Value of one structure variable can be assigned to another variable of the **same type** using simple assignment statement.
- If `myCar` and `newCar` are structure variable of type `car`, then

```
newCar = myCar;
```

Use of Assignment Statement for Structures

- When we assigns value of structure variable ***myCar*** to ***newCar,*** all values of members of one structure get copied into corresponding members of another structure.
- Or we can copy one member at a time:
  - `newCar.name = myCar.name;`
- ***Simple assignment cannot be used this way for arrays.***
- This is really a big advantage over arrays where in order to copy one array into another of same type, we have copied the contents element by element either using loop or individually.

```
#include <stdio.h>
struct  car{
       char name[50];
        int seats;
        float price;
};
main()
{
    struct car myCar;
    printf("Enter name of car:\n");
      gets(myCar.name);
    printf("Enter number of seats in car:\n");
      scanf("%d", &myCar.seats);
    printf("Enter price of car:\n");
      scanf("%f", &myCar.price);
    printf("\n\nParticulars of car are:\n");
    printf("Car name:%s",myCar.name);
    printf("\nNumber of seats:%d",
myCar.seats);
    printf("\nPrice:%f", myCar.price);
} //end main
```

Program to enter data into structure.

```
Enter name of car: Micra
Enter number of seats in car: 4
Enter price of car: 600000

Particulars of car are:
Car name: Micra
Number of seats: 4
Price: 600000
```

Array & Structure

Array	Structure
1. It is a collection of data items of same data type.	1. It is a collection of data items of different data types.
2. It has declaration only.	2. It has declaration & definition.
3. There is no keyword.	3. `struct` is the keyword.
4. An array name represents the address of the starting element.	4. A structure name is called tag. It is a short hand notation of the declaration.
5. An array cannot have bit fields.	5. It may contain bit fields.

MCQ

What is the size of a C structure.?

A) C structure is always 128 bytes.

B) Size of C structure is the total bytes of all elements of structure.

C) Size of C structure is the size of largest element.

D) None of the above

MCQ

What is the output of C program with structures?

```
 int main()
{
structure hotel
 {
int items;
 char name[10];
}
a; strcpy(a.name, "TAJ");
 a.items=10;
printf("%s", a.name);
return 0;
}
```

A) TAJ
B) Empty string
C) Compiler error
D) None of the above

MCQ

```
int main()
 {
 struct bus
{
 int seats;
}
F1, *F2;
 F1.seats=20;
 F2=&F1;
 F2->seats=15;
printf("%d ",F1.seats);
return 0;
 }
```

A) 15
B) 20
C) 0
D) Compiler error

MCQ

What is the output of C program?

```
 int main()
 {
struct book {
 int pages;
 char name[10];
 }
a;
 a.pages=10;
 strcpy(a.name,"Cbasics");
printf("%s=%d", a.name,a.pages);
return 0;
}
```

A) empty string=10
B) C=basics
C) Cbasics=10
D) Compiler error

CSE101-Lec#26

- Reading and displaying one record using structure
- Copying and Comparing structures
- Array of structures
- Pointer to structures

WAP to read and display information of one student[or one record] using structure

```
#include <stdio.h>
struct student
{
   char name[50];
   int roll;
   float marks;
};
int main()
{
   struct student s;
   printf("Enter information for first student:\n");
   printf("Enter name: ");
   gets(s.name);
   printf("Enter roll number: ");
   scanf("%d", &s.roll);
   printf("Enter marks: ");
   scanf("%f", &s.marks);
   printf("Displaying Information:\n");
   printf("Name: ");
   puts(s.name);
   printf("Roll number: %d\n",s.roll);
   printf("Marks: %.1f\n", s.marks);
   return 0;
}
```

Copying data from one structure variable to another

```
#include <stdio.h>
struct student
{
   char name[50];
   int roll;
   float marks;
};
int main()
{
   struct student s,s1;
   printf("Enter information:\n");
   printf("Enter name: ");
   scanf("%s", s.name);
   printf("Enter roll number: ");
   scanf("%d", &s.roll);
   printf("Enter marks: ");
   scanf("%f", &s.marks);
   s1=s;//Copying structure variable to another
   printf("Displaying Information:\n");
   printf("Name: ");
   puts(s1.name);
   printf("Roll number: %d\n",s1.roll);
   printf("Marks: %.1f\n", s1.marks);
   return 0;
}
```

Comparing two structure variables

```
#include <stdio.h>
struct student
{
   char name[50];
   int roll;
   float marks;
};
int main()
{
   struct student s,s1;
   printf("Enter information of first
student:\n");
   printf("Enter name: ");
   scanf("%s", s.name);
   printf("Enter roll number: ");
   scanf("%d", &s.roll);
;
printf("Enter marks: ");
   scanf("%f", &s.marks);
   printf("Enter information of second student:\n");
   printf("Enter name: ");
   scanf("%s", s1.name);
   printf("Enter roll number: ");
   scanf("%d", &s1.roll);
   printf("Enter marks: ");
   scanf("%f", &s1.marks);
   if(s.marks>s1.marks)
   {
      printf("\n Marks of first student are more..");
   }
   else
   {
      printf("\n Marks of second student are more..");
   }
   return 0
}
```

Array of Structures

- to store data of 100 cars we would be required to use 100 different structure variables from **car1** to **car100**, which is definitely not very convenient. A better approach would be to use an array of structures.

```
struct car mycar[100];
```

- This provides space in memory for 100 structures of the type **struct car**.

Program to print **array of structures.**

```
#include <stdio.h>
struct car{
  char name[50];
  int seats;
  float price;
};
int main()
{
 int i;
 struct car myCar[100];

for(i=0; i<100; i++){
   printf("\n\nEnter data for car[%d]:\n", i);
   scanf("%s %d %f", &myCar[i].name,
&myCar[i].seats, &myCar[i].price);
 }

 for(i=0; i<100; i++){
 printf("\nData about your car[%d] is: %s %d
%f", i, myCar[i].name, myCar[i].seats,
myCar[i].price);
 }
}
```

```
Enter data for car0: Racer 1 1200000
Data about your car0 is Racer 1 1200000

Enter data for car1: Micra 4 500000
Data about your car1 is Micra 4 500000

Enter data for car2: RacerGt 1 800000
Data about your car2 is RacerGt 1 800000
.
.
.
.
.
Enter data for car99: RacerEf 1 2000000
Data about your car99 is RacerEf 1 2000000
```

Array of structures-Example 2

WAP to read and display information of n number of books in a library

```
#include <stdio.h>
struct Bookinfo
{
    char bname[20];
    int pages;
    float price;
};
int main()
{
struct Bookinfo book[100];
int i,n;
printf("\nEnter number of records you want to
enter(less than or equal to:100)");
scanf("%d",&n);
fflush(stdin);
for(i=0;i<n;i++)
  {
  printf("\nEnter the Name of Book    : ");
  gets(book[i].bname);
  fflush(stdin);//It is used to clear the input
buffer(stdin-Input taken from keyboard)
  printf("\nEnter the Number of Pages : ");
scanf("%d",&book[i].pages);
  fflush(stdin);
  printf("\nEnter the Price of Book   : ");
  scanf("%f",&book[i].price);
  fflush(stdin);
  }
printf("\n--------- Book Details -----------
");
for(i=0;i<n;i++)
  {
  printf("\nName of Book    :
%s",book[i].bname);
  printf("\nNumber of Pages :
%d",book[i].pages);
  printf("\nPrice of Book   :
%.2f",book[i].price);
  }
return 0;
}
```

Searching in array of structures(By integer)

```
#include <stdio.h>
struct Bookinfo
{
    char bname[20];
    int id;
    float price;
};
int main()
{
struct Bookinfo book[100];
int i,n,id_to_search,loc=-1;
printf("\nEnter number of records you want to
enter(less than or equal to:100)");
scanf("%d",&n);
fflush(stdin);
for(i=0;i<n;i++)
  {
  printf("\nEnter the Name of Book    : ");
gets(book[i].bname);
  fflush(stdin);//It is used to clear the input
buffer(stdin-Input taken from keyboard)
  printf("\nEnter book id : ");
  scanf("%d",&book[i].id);
  fflush(stdin);
printf("\nEnter the Price of Book   : ");
  scanf("%f",&book[i].price);
  fflush(stdin);
  }
printf("\n Enter the id you want to search:");
scanf("%d",&id_to_search);
for(i=0;i<n;i++)
  {
   if(book[i].id==id_to_search)
   {
            loc=i;
            break;
   }
  }
  if(loc==-1)
  {
            printf("\n Entered id is not found!!!!");
  }
  else
  {
            printf("\n Id found in record
no:%d",loc+1);
            printf("\n Name of the book for the
entered id is:%s",book[loc].bname);
  }

return 0;
}
```

Searching in array of structures(By String)

```
#include <stdio.h>
#include<string.h>
struct Bookinfo
{
    char bname[20];
    int id;
    float price;
};
int main()
{
struct Bookinfo book[100];
char name[30];
int i,n,loc=-1;
printf("\nEnter number of records you want to
enter(less than or equal to:100)");
scanf("%d",&n);
fflush(stdin);
for(i=0;i<n;i++)
  {
  printf("\nEnter the Name of Book   : ");
  gets(book[i].bname);
  fflush(stdin);//It is used to clear the input
buffer(stdin-Input taken from keyboard)
  printf("\nEnter book id : ");
  scanf("%d",&book[i].id);
  fflush(stdin);
  printf("\nEnter the Price of Book   : ");
  scanf("%f",&book[i].price);
  fflush(stdin);
  }
printf("\n Enter the name you want to search:");
gets(name);
for(i=0;i<n;i++)
  {
   if(strcmp(book[i].bname,name)==0)
   {
            loc=i;
            break;
   }
  }
  if(loc==-1)
  {
            printf("\n Entered name is not
found!!!!");
  }
  else
  {
            printf("\n Name found in record
no:%d",i+1);
  }

return 0;
}
```

WAP to display the highest price in the n records of books and also display the book name using array of structures

```
#include <stdio.h>
struct Bookinfo
{
    char bname[100];
    int pages;
    float price;
};
int main()
{
struct Bookinfo book[100];
int i,n;
float max;
char maxname[100];
printf("\nEnter number of records you want to enter(less than or equal to:100)");
scanf("%d",&n);
fflush(stdin);
for(i=0;i<n;i++)
  {
  printf("\nEnter the Name of Book    : ");
  gets(book[i].bname);
  fflush(stdin);//It is used to clear the input buffer(stdin-Input taken from keyboard)
  printf("\nEnter the Number of Pages : ");
  scanf("%d",&book[i].pages);
  fflush(stdin);
  printf("\nEnter the Price of Book   : ");
  scanf("%f",&book[i].price);
  fflush(stdin);
  }
  max=book[0].price;
  strcpy(maxname,book[0].bname);
  for(i=1;i<n;i++)
  {
    if(book[i].price>max)
    {
      max=book[i].price;
      strcpy(maxname,book[i].bname);
    }
  }
  printf("\n %s is the highest priced book with amount:%f",maxname,max);
  return 0;
}
```

Pointers to Structure

```
struct  car myCar, *ptr;
```

It declares a structures variable *myCar and a* pointer variable *ptr to* structure of type *car.*

ptr can be initialized with the following assignment statement

ptr = &myCar;

HOW WE CAN ACCESS THE ELEMENTS OF STRUCTURE?

**ptr.name,*ptr.seats,*ptr.age*

*But this approach **will not work** because dot has higher priority*

Correctly way to write is:

*(*ptr).name,(*ptr).seats, (*ptr).price)*

or

ptr->name, ptr->seats, ptr->price

Accessing Members of Structures

- Arrow operator (->) used with pointers to structure variables

```
car *myCarPtr = &myCar; //intializing pointer
printf("%s", myCarPtr->name);
```

  - `myCarPtr->name` is equivalent to

```
(*myCarPtr).name
```

Program for pointer to a structure

```
#include <stdio.h>
struct car{
        char name[20];
        int seats;
        float price;
};
int main()
{
struct car myCar = {"Renault",2, 500000};
struct car *myCarPtr; //define a pointer to car
myCarPtr = &myCar;  /*assign address of myCar
to myCarPtr */

printf("%s %f %d \n%s %f %d \n%s %f %d\n",
myCar.name, myCar.price, myCar.seats,
myCarPtr->name, myCarPtr->price,
myCarPtr->seats,
(*myCarPtr).name, (*myCarPtr).price,
(*myCarPtr).seats);
} //end main
```

```
Renault 500000 2
Renault 500000 2
Renault 500000 2
```

CSE101-Lec#27

- Nested Structure
- Union

Outline

- Nested Structure
- Union

Nested Structure

- Nested structures are structures as member of another structure.
- We can also take objects of one structure as member in another structure.
- Thus, a structure within a structure can be used to create complex data application.
- Dot operator is used twice because we are accessing first structure through the object of second structure.

Nested Structure

Two ways of declaring structure within structure or Nested structure:

- Declare two separate structures
- Embedded structures

Example-1-Declare two separate structures(standalone structures)

```
struct Date
{
        int dd;
        int mm;
        int yy;
};
struct Student
{
        char name[20];
        int rollno;
        int marks;
        struct Date dob;
};
```

Here structure Student is nesting structure and structure date is nested structure

Program example-1 Nested structure-Declare two separate structures(standalone structures)

```
#include<stdio.h>
                struct Address
    {
        char Housename[25];
        char City[25];
        char Streetname[25];
    };
    struct Employee
    {
       int Id;
       char Name[25];
       float Salary;

            struct Address Add;
    };
    int main()
    {
        struct Employee E;
        printf("\n\tEnter Employee Id : ");
        scanf("%d",&E.Id);
        printf("\n\tEnter Employee Name : ");
        scanf("%s",E.Name);
        printf("\n\tEnter Employee Salary : ");
        scanf("%f",&E.Salary);
        printf("\n\tEnter Employee House Name : ");
        scanf("%s",E.Add.Housename);
        printf("\n\tEnter Employee City : ");
        scanf("%s",E.Add.City);
        printf("\n\tEnter Employee street name : ");
        scanf("%s",E.Add.Streetname);
        printf("\nDetails of Employees");
        printf("\n\tEmployee Id : %d",E.Id);
        printf("\n\tEmployee Name : %s",E.Name);
        printf("\n\tEmployee Salary : %f",E.Salary);
        printf("\n\tEmployee House No : %s",E.Add.Housename);
        printf("\n\tEmployee City : %s",E.Add.City);
        printf("\n\tEmployee street name: %s",E.Add.Streetname);

    }
```

Example-2: embedded structures(Nested structure)

```
struct Student
{
        char name[20];
        int rollno;
        struct date
        {
                int dd;
                int mm;
                int yy;
        } dob;
};
```

Program example-2 Nested structure-Embedded structure

```
#include <stdio.h>
struct Employee
{
  char ename[20];
  int ssn;
  float salary;
  struct dob
     {
     int date;
     int month;
     int year;
     }db1;
}emp = {"Aniket",1000,1000.50,{22,6,1990}};

int main()
{
printf("\nEmployee Name   : %s",emp.ename);
printf("\nEmployee SSN    : %d",emp.ssn);
printf("\nEmployee Salary : %.2f",emp.salary);
printf("\nEmployee DOB    :
%d/%d/%d",emp.db1.date,emp.db1.month,emp.db1.year);

return 0;
}
```

Unions

- union
  - Memory that contains a variety of objects over time
  - Only contains one data member at a time
  - Members of a union share space
  - Conserves storage
  - Only the last data member defined can be accessed
- union definitions
  - Same as struct

```
union Number {
  int x;
  float y;
};
union Number value;
```

Union

- Union is similar as structure. The major distinction between them is in terms of storage.
- In structure each member has its own storage location whereas all the members of union uses the same location.
- The union may contain many members of different data type but it can handle only one member at a time union can be declared using the keyword union.

Example

- A class is a very good example of structure and union in this example students are sitting in contiguous memory allocation as they are treated as a structure individually. And if we are taking the place of teacher then in a class only one teacher can teach. After leaving the first teacher then another teacher can enter.

Union Declaration

```
union item
{
 int m;
 float x;
 char c;
}code;
```

This declare a variable code of type union item

Initializing and accessing union members

```
#include <stdio.h>
#include <string.h>
union Data {
   int i;
   float f;
   char str[20];
};
int main( )
 {
   union Data data;
   data.i = 10;
   data.f = 220.5;
   strcpy( data.str, "C Programming");
   printf( "data.i : %d\n", data.i);
   printf( "data.f : %f\n", data.f);
   printf( "data.str : %s\n", data.str);
   return 0;
}
```

Program using union.

```
#include <stdio.h>
union job{
   char name[32];
   float salary;
   int worker_no;
}u;
main()
{
printf("Enter name:\n");
scanf("%s",&u.name);
printf("Enter salary: \n");
scanf("%f",&u.salary);
printf("Displaying\nName :%s\n",u.name);
printf("Salary: %.1f",u.salary);
}
```

WAP to read and display one record using union

```
#include<stdio.h>
union employee
{
        char name[30];
        int id;
        float salary;
}u;
int main()
{
        //union employee u;
        printf("\n Enter name:");
        gets(u.name);//Initialization
        printf("\n Entered name is:%s",u.name);//Accessing
        printf("\n Enter id:");
        scanf("%d",&u.id);//Initialization
        printf("\n Entered id is:%d",u.id);//Accessing
        printf("\n Enter salary:");
        scanf("%f",&u.salary);//Initialization
        printf("\n Entered salary is:%.2f",u.salary);//Accessing
        return 0;
}
```

WAP to read and display n number of records using Array of Unions

```
#include<stdio.h>
union employee
{
        char name[30];
        int id;
        float salary;
}u[100];
int main()
{
        //union employee u[100];
        int n,i;
        printf("\n Enter value of n:");
        scanf("%d",&n);
        fflush(stdin);
        for(i=0;i<n;i++)
        {
        printf("\n Enter name:");
        fflush(stdin);
        gets(u[i].name);
        printf("\n Entered name is:%s",u[i].name);
        printf("\n Enter id:");
        fflush(stdin);
        scanf("%d",&u[i].id);
        printf("\n Entered id is:%d",u[i].id);
        printf("\n Enter salary:");
        fflush(stdin);
        scanf("%f",&u[i].salary);
        printf("\n Entered salary is:%.2f",u[i].salary);
    }
        return 0;
}
```

Difference between structure and union

	STRUCTURE	UNION
Keyword	The keyword **struct** is used to define a structure	The keyword **union** is used to define a union.
Size	When a variable is associated with a structure, the compiler allocates the memory for each member. The size of structure is **greater than or equal to the sum of sizes of its members.**	when a variable is associated with a union, the compiler allocates the memory by considering the size of the largest memory. So, size of **union is equal to the size of largest member.**
Memory	Each member within a structure is assigned unique storage area of location.	Memory allocated is shared by individual members of union.
Value Altering	Altering the value of a member will not affect other members of the structure.	Altering the value of any of the member will alter other member values.
Accessing members	Individual member can be accessed at a time.	Only one member can be accessed at a time.
Initialization of Members	Several members of a structure can initialize at once.	Only the first member of a union can be initialized.

Similarities between structure and union

- Both are user-defined data types used to store data of different types as a single unit.
- Their members can be objects of any type, including other structures and unions or arrays. A member can also consist of a bit field.
- Both structures and unions support only assignment = and sizeof operators. The two structures or unions in the assignment must have the same members and member types.
- A structure or a union can be passed by value to functions and returned by value by functions. The argument must have the same type as the function parameter. A structure or union is passed by value just like a scalar variable as a corresponding parameter.
- ‘.’ operator is used for accessing members.

What will be the size of the following structure?

```
struct demo
{
 int a;
char b;
float c;
}
```

A. 12
B. 8
C. 10
D. 9

What is the output of this program?

```
#include <stdio.h>
int main()
{ struct simp
{ int i = 6;
 char city[] = "chennai";
 };
 struct simp s1;
 printf("%d",s1.city);
 printf("%d", s1.i);
 return 0;
 }
```

A. chennai 6
B. Nothing will be displayed
C. Runtime Error
D. Compilation Error