Program

```
main( )
{
/*…………printing begins………………*/

     printf("I see, I remember");

/*………………printing ends…………………*/
}
```

Fig 1.2 A program to print one line of text

Addition of Two Numbers

Program

```
/* Programm ADDITION                                      line-1  */
/* Written by EBG                                         line-2  */
main()                                                  /* line-3  */
{                                                       /* line-4  */
           int   number;                                /* line-5  */
           float amount;                                /* line-6  */
                                                        /* line-7  */
           number = 100;                                /* line-8  */
                                                        /* line-9  */
           amount = 30.75 + 75.35;                      /* line-10 */
           printf("%d\n",number);                       /* line-11 */
           printf("%5.2f",amount);                      /* line-12 */
}                                                       /* line-13 */
```

Fig.1.4 Program to add two numbers

Program

```
/*---------------------- INVESTMENT PROBLEM --------------------*/
#define PERIOD    10
#define PRINCIPAL 5000.00
/*--------------------- MAIN PROGRAM BEGINS --------------------*/
main()
{ /*-------------------- DECLARATION STATEMENTS ----------------*/
     int year;
     float amount, value, inrate;
/*------------------- ASSIGNMENT STATEMENTS -------------------*/
     amount  =  PRINCIPAL;
     inrate  =  0.11;
     year  = 0;
/*------------------ COMPUTATION STATEMENTS --------------------*/
/*--------------- COMPUTATION USING While LOOP -----------------*/
     while(year <= PERIOD)
     {     printf("%2d          %8.2f\n",year, amount);
           value =   amount + inrate * amount;
           year      =     year + 1;
           amount    =     value;
     }
/*----------------------- while LOOP ENDS ----------------------*/
}
/*------------------------ PROGRAM ENDS -----------------------*/
```

Fig. 1.5 Program for investment problem

Program

```
/*-------------------- PROGRAM USING FUNCTION ------------------*/

int mul (int a, int b);      /*------- DECLARATION ------------*/

/*-------------------- MAIN PROGRAM BEGINS ---------------------*/
     main ()
     {
           int a, b, c;

           a = 5;
           b = 10;
           c = mul (a,b);

           printf ("multiplication of %d and %d is %d",a,b,c);
     }

/* ----------------      MAIN PROGRAM ENDS
                         MUL() FUNCTION STARTS -----------------*/

     int mul (int x, int y)
     int p;

     p = x*y;
     {
           return(p);
     }
/* -------------------- MUL () FUNCTION ENDS -------------------*/
```

Fig.1.7 A Program using a user-defined function

Program

```
/*--------------- PROGRAM USING COSINE FUNCTION -------------- */
 #include <math.h>
 #define   PI      3.1416
 #define   MAX     180

 main ( )
 {

      int angle;
      float x,y;

      angle = 0;
      printf("        Angle     Cos(angle)\n\n");

      while(angle  <= MAX)
      {
           x = (PI/MAX)*angle;
           y = cos(x);
           printf("%15d %13.4f\n", angle, y);
           angle = angle + 10;
      }
 }
```

Chapter:2

Example 2.1
Representation of integer constants on a 16-bit computer.

The program in Fig.2.9 illustrates the use of integer constants on a 16-bit machine. The output in figure 2.3 shows that the integer values larger than 32767 are not properly stored on a 16-bit machine. However, when they are qualified as long integer (by appending L), the values are correctly stored.

INTEGER NUMBERS ON 16-BIT MACHINE

Program

```
     main()
     {
         printf("Integer values\n\n");
         printf("%d %d %d\n", 32767,32767+1,32767+10);
         printf("\n");
         printf("Long integer values\n\n");
         printf("%ld %ld %ld\n", 32767L,32767L+1L,32767L+10L);
      }
```

Output

```
         Integer values
```

```
        32767 -32768 -32759

        Long integer values

        32767 32768 32777
```

Fig. 2.3 Representation of integer constants

Example 2.2
Program in Figure 2.8 shows typical declarations, assignments and values stored in various types of variables.

The variables **x** and **p** have been declared as floating-point variables. Note that the way the value of 1.234567890000 that we assigned to **x** is displayed under different output formats. The value of x is displayed as 1.234567880630 under %.12lf format, while the actual value assigned is 1.234567890000. This is because the variable **x** has been declared as a **float** that can store values only upto six decimal places.

The variable **m** that has been declared as **int** is not able to store the value 54321 correctly. Instead, it contains some garbage. Since this program was run on a 16-bit machine, the maximum value that an **int** variable can store is only 32767. However, the variable **k** (declared as **unsigned**) has stored the value 54321 correctly. Similarly, the **long int** variable **n** has stored the value 1234567890 correctly.

The value 9.87654321 assigned to **y** declared as double has been stored correctly but the value is printed as 9.876543 under %lf format. Note that unless specified otherwise, the **printf** function will always display a **float** or **double** value to six decimal places. We will discuss later the output formats for displaying numbers.

EXAMPLES OF ASSIGNMENTS

Program

```
   main()
    {
    /*..........DECLARATIONS............................*/

        float      x, p ;
        double     y, q ;
        unsigned   k ;

    /*..........DECLARATIONS AND ASSIGNMENTS............*/
```

```
        int         m = 54321 ;
        long int    n = 1234567890 ;

    /*..........ASSIGNMENTS.............................*/

        x = 1.234567890000 ;
        y = 9.87654321 ;
        k = 54321 ;
        p = q = 1.0 ;

    /*..........PRINTING................................*/

        printf("m = %d\n", m) ;
        printf("n = %ld\n", n) ;
        printf("x = %.12lf\n", x) ;
        printf("x = %f\n", x) ;
        printf("y = %.12lf\n",y) ;
        printf("y = %lf\n", y) ;
        printf("k = %u  p = %f  q = %.12lf\n", k, p, q) ;
    }
```

Output

```
    m = -11215
    n = 1234567890
    x = 1.234567880630
    x = 1.234568
    y = 9.876543210000
    y = 9.876543
    k = 54321  p = 1.000000  q = 1.000000000000
```

Fig. 2.8 Examples of assignments

Example 2.3

The program in Fig.2.9 illustrates the use of **scanf** funtion.

The first executable statement in the program is a **printf,** requesting the user to enter an integer number. This is known as "prompt message" and appears on the screen like

Enter an integer number

As soon as the user types in an integer number, the computer proceeds to compare the value with 100. If the value typed in is less than 100, then a message

Your number is smaller than 100

is printed on the screen. Otherwise, the message

Your number contains more than two digits

is printed. Outputs of the program run for two different inputs are also shown in Fig.2.9.

INTERACTIVE COMPUTING USING **scanf** FUNCTION

Program

```
main()
{
     int  number;

     printf("Enter an integer number\n");
     scanf ("%d", &number);

     if ( number < 100 )
       printf("Your number is smaller than 100\n\n");
     else
       printf("Your number contains more than two digits\n");
}
```

Output

```
Enter an integer number
54
Your number is smaller than 100

Enter an integer number
108
Your number contains more than two digits
```

*Fig.2.9 Use of **scanf** function*

Example 2.4

Sample Program 3 discussed in Chapter 1 can be converted into a more flexible interactive program using **scanf** as shown in Fig.2.10.

In this case, computer requests the user to input the values of the amount to be invested, interest rate and period of investment by printing a prompt message

Input amount, interest rate, and period

and then waits for input values. As soon as we finish entering

INTERACTIVE INVESTMENT PROGRAM

Program

```
main()
{
    int    year, period ;
    float  amount, inrate, value ;

    printf("Input amount, interest rate, and period\n\n") ;
    scanf ("%f %f %d", &amount, &inrate, &period) ;
    printf("\n") ;
    year = 1 ;

    while( year <= period )
    {
          value = amount + inrate * amount ;
          printf("%2d  Rs %8.2f\n", year, value) ;
          amount = value ;
          year = year + 1 ;
    }
}
```

Output

```
Input amount, interest rate, and period

10000  0.14  5

 1  Rs 11400.00
 2  Rs 12996.00
 3  Rs 14815.44
 4  Rs 16889.60
 5  Rs 19254.15

Input amount, interest rate, and period

20000  0.12  7

 1  Rs 22400.00
 2  Rs 25088.00
 3  Rs 28098.56
 4  Rs 31470.39
 5  Rs 35246.84
 6  Rs 39476.46
 7  Rs 44213.63
```

Fig.2.10 Interactive investment program

CHAPTER 3:

Example 3.1

The program in Fig.3.1 shows the use of integer arithmetic to convert a given number of days into months and days.

PROGRAM TO CONVERT DAYS TO MONTHS AND DAYS

Program

```
main ()
{
    int   months, days ;

    printf("Enter days\n") ;
    scanf("%d", &days) ;

    months = days / 30 ;
    days   = days % 30 ;

    printf("Months = %d   Days = %d", months, days) ;
}
```

Output

```
Enter days
265
Months = 8   Days = 25

Enter days
364
Months = 12   Days = 4

Enter days
45
Months = 1   Days = 15
```

Fig. 3.1 ***Illustration of integer arithmetic***

Example 3.2

Program of Fig.3.2 prints a sequence of squares of numbers. Note the use of the shorthand operator *= .

The program attempts to print a sequence of squares of numbers starting from 2. The statement

a *= a;

which is identical to

a = a*a;

replaces the current value of **a** by its square. When the value of **a** becomes equal or greater than **N** (=100) the **while** is terminated. Note that the output contains only three values 2, 4 and 16.

USE OF SHORTHAND OPERATORS

Program

```
#define    N   100
#define    A   2

main()
{
    int  a;

    a  =  A;
    while( a < N )
    {
         printf("%d\n", a);
         a *= a;
    }
}
```

Output

```
2
4
16
```

Fig. 3.2 Use of shorthand operator *=

Example 3.3

In Fig.3.3, the program employs different kinds of operators. The results of their evaluation are also shown for comparison.

Notice the way the increment operator **++** works when used in an expression. In the statement

c = ++a - b;

new value of **a** (= 16) is used thus giving the value 6 to c. That is, a is incremented by 1 before it is used in the expression. However, in the statement

d = b++ + a;

the old value of **b** (=10) is used in the expression. Here, b is incremented by 1 after it is used in the expression.

We can print the character % by placing it immediately after another % character in the control string. This is illustrated by the statement

printf("a%%b = %d\n", a%b);

The program also illustrates that the expression

c > d ? 1 : 0

assumes the value 0 when c is less than d and 1 when c is greater than d.

ILLUSTRATION OF OPERATORS

Program

```
main()
{
    int a, b, c, d;

    a = 15;
    b = 10;
    c = ++a - b;

    printf("a = %d  b = %d  c = %d\n",a, b, c);

    d = b++ +a;
    printf("a = %d  b = %d  d = %d\n",a, b, d);

    printf("a/b = %d\n", a/b);
    printf("a%%b = %d\n", a%b);
    printf("a *= b = %d\n", a*=b);
    printf("%d\n", (c>d) ? 1 : 0);
    printf("%d\n", (c<d) ? 1 : 0);
}
```

Output

```
a = 16  b = 10  c = 6
a = 16  b = 11  d = 26
a/b = 1
a%b = 5
a *= b = 176
0
1
```

Fig. 3.3 Further illustration of arithmetic operators

Example 3.4

The program in Fig.3.4 illustrates the use of variables in expressions and their evaluation.

Output of the program also illustrates the effect of presence of parentheses in expressions. This is discussed in the next section.

EVALUATION OF EXPRESSIONS

Program

```
main()
{
    float  a, b, c, x, y, z;

    a = 9;
    b = 12;
    c = 3;

    x = a - b / 3 + c * 2 - 1;
    y = a - b / (3 + c) * (2 - 1);
    z = a -(b / (3 + c) * 2) - 1;

    printf("x = %f\n", x);
    printf("y = %f\n", y);
    printf("z = %f\n", z);
}
```

Output

```
   x = 10.000000
   y = 7.000000
   z = 4.000000
```

Fig.3.4 Illustrations of evaluation of expressions

Example 3.5

Output of the program in Fig.3.6 shows round-off errors that can occur in computation of floating point numbers.

PROGRAM SHOWING ROUND-OFF ERRORS

Program

```
/*------------------- Sum of n terms of 1/n -------------------*/
   main()
   {
       float  sum, n, term ;
       int    count = 1 ;

       sum = 0 ;
       printf("Enter value of n\n") ;
        scanf("%f", &n) ;
       term = 1.0/n ;
       while( count <= n )
       {
            sum = sum + term ;
            count++ ;
       }
       printf("Sum = %f\n", sum) ;
   }
```

Output

```
   Enter value of n
   99
   Sum = 1.000001
   Enter value of n
   143
   Sum = 0.999999
```

Fig.3.6 Round-off errors in floating point computations

We know that the sum of n terms of 1/n is 1. However, due to errors in floating point representation, the result is not always 1.

Example 3.6

Figure 3.8 shows a program using a cast to evaluate the equation

$$sum = \sum_{i=1}^{n} (1/i)$$

PROGRAM SHOWING THE USE OF A CAST

Program

```
   main()
   {
       float  sum ;
       int    n ;

       sum = 0 ;

       for( n = 1 ; n <= 10 ; ++n )
       {
          sum = sum + 1/(float)n ;
          printf("%2d  %6.4f\n", n, sum) ;
       }
   }
```

Output

```
    1  1.0000
    2  1.5000
    3  1.8333
    4  2.0833
    5  2.2833
    6  2.4500
    7  2.5929
    8  2.7179
    9  2.8290
   10  2.9290
```

Fig. 3.8 Use of a cast

CHAPTER 4:

Example 4.1

The program in Fig.4.1 shows the use of **getchar** function in an interactive environment.

The program displays a question of YES/NO type to the user and reads the user's response in a single character (Y or N). If the response is Y, it outputs the message

My name is BUSY BEE

otherwise, outputs.

You are good for nothing

Note there is one line space between the input text and output message.

READING A **CHARACTER** FROM KEYBOARD

Program

```
#include   <stdio.h>

main()
{
   char answer;

   printf("Would you like to know my name?\n");
    printf("Type Y for YES and N for NO:  ");

    answer = getchar();  /* .... Reading a character...*/

    if(answer == 'Y' || answer == 'y')
      printf("\n\nMy name is BUSY BEE\n");
    else
      printf("\n\nYou are good for nothing\n");
}
```

Output

```
Would you like to know my name?
Type Y for YES and N for NO:  Y

My name is BUSY BEE

Would you like to know my name?
Type Y for YES and N for NO:  n

You are good for nothing
```

Fig.4.1 *Use of* ***getchar*** *function*

Example 4.2

The program of Fig.4.2 requests the user to enter a character and displays a message on the screen telling the user whether the character is an alphabet or digit, or any other special character.

This program receives a character from the keyboard and tests whether it is a letter or digit and prints out a message accordingly. These tests are done with the help of the following functions:

isalpha(character)
isdigit(character)

For example, **isalpha** assumes a value non-zero (TRUE) if the argument **character** contains an alphabet; otherwise it assumes 0 (FALSE). Similar is the case with the function **isdigit**.

TESTING CHARACTER TYPE

Program:

```
#include  <stdio.h>
#include  <ctype.h>

main()
{
    char character;
    printf("Press any key\n");

    character = getchar();

    if (isalpha(character) > 0)
       printf("The character is a letter.");

    else
       if (isdigit (character) > 0)
          printf("The character is a digit.");

       else
          printf("The character is not alphanumeric.");
}
```

Output

```
Press any key
h
The character is a letter.

Press any key
5
The character is a digit.

Press any key
```

```
*
The character is not alphanumeric.
```

Fig.4.2 *Program to test the **characte**r type*

Example 4.3

A program that reads a character from keyboard and then prints it in reverse case is given in Fig.4.3. That is, if the input is upper case, the output will be lower case and vice versa.

The program uses three new functions: **islower, toupper**, and **tolower**. The function **islower** is a conditional function and takes the value TRUE if the argument is a lower case alphabet; otherwise takes the value FALSE. The function **toupper** converts the lower case argument into an upper case alphabet while the function **tolower** does the reverse.

WRITING A **CHARACTER** TO THE SCREEN

Program

```
#include <stdio.h>
#include <ctype.h>

main()
{
    char alphabet;

    printf("Enter an alphabet");
    putchar('\n');    /* move to next line */
    alphabet = getchar();

    if (islower(alphabet))
       putchar(toupper(alphabet));
    else
       putchar(tolower(alphabet));
}
```

Output

```
Enter an alphabet
a
A
Enter an alphabet
Q
q
Enter an alphabet
z
Z
```

Fig.4.3 *Reading and writing of alphabets in reverse case*

Example 4.4

Various input formatting options for reading integers are experimented in the program shown in Fig. 4.4.

The first **scanf** requests input data for three integer values **a, b,** and **c,** and accordingly three values 1, 2, and 3 are keyed in. Because of the specification %*d the value 2 has been skipped and 3 is assigned to the variable **b**. Notice that since no data is available for c, it contains garbage.

The second **scanf** specifies the format %2d and %4d for the variables **x** and **y** respectively. Whenever we specify field width for reading integer numbers, the input numbers should not contain more digits that the specified size. Otherwise, the extra digits on the right-hand side will be truncated and assigned to the next variable in the list. Thus, the second **scanf** has truncated the four digit number 6789 and assigned 67 to **x** and 89 to **y**. The value 4321 has been assigned to the first variable in the immediately following **scanf** statement.

READING **INTEGER** NUMBERS

Program:

```
 main()
{
    int a,b,c,x,y,z;
    int p,q,r;

    printf("Enter three integer numbers\n");
    scanf("%d %*d %d",&a,&b,&c);
    printf("%d %d %d \n\n",a,b,c);

    printf("Enter two 4-digit numbers\n");
    scanf("%2d %4d",&x,&y);
    printf("%d %d\n\n", x,y);

    printf("Enter two integers\n");
    scanf("%d %d", &a,&x);
    printf("%d %d \n\n",a,x);

    printf("Enter a nine digit number\n");
    scanf("%3d %4d %3d",&p,&q,&r);
    printf("%d %d %d \n\n",p,q,r);

    printf("Enter two three digit numbers\n");
    scanf("%d %d",&x,&y);
    printf("%d %d",x,y);
}
```

Output

```
Enter three integer numbers
1 2 3
1 3 -3577

Enter two 4-digit numbers
6789  4321
67 89

Enter two integers
44  66
4321 44

Enter a nine-digit number
123456789
66 1234 567

Enter two three-digit numbers
123  456
89 123
```

Fig.4.4 *Reading integers using* **scanf**

Example 4.5

Reading of real numbers (in both decimal point and exponential notation) is illustrated in Fig.4.5.

READING OF **REAL** NUMBERS

Program:

```
main()
{
    float x,y;
    double p,q;

    printf("Values of x and y:");
    scanf("%f %e", &x, &y);
    printf("\n");
    printf("x = %f\ny = %f\n\n", x, y);

    printf("Values of p and q:");
    scanf("%lf %lf", &p, &q);
    printf("\np = %lf\nq = %e",p,q);
    printf("\n\np = %.12lf\np = %.12e", p,q);
}
```

Output

```
Values of x and y:12.3456  17.5e-2

x = 12.345600
y = 0.175000

Values of p and q:4.142857142857  18.5678901234567890

p = 4.142857142857
q = 1.856789012346e+001
```

Fig.4.5 *Reading of **real** numbers*

Example 4.6

Reading of strings using **%wc** and **%ws** is illustrated in Fig.4.6.

The program in Fig.4.6 illustrates the use of various field specifications for reading strings. When we use **%wc** for reading a string, the system will wait until the *w*th character is keyed in.

Note that the specification **%s** terminates reading at the encounter of a blank space. Therefore, **name2** has read only the first part of "New York" and the second part is automatically assigned to **name3**. However, during the second run, the string "New-York" is correctly assigned to **name2**.

READING STRINGS

Program

```
main()
{
    int no;
    char name1[15], name2[15], name3[15];

    printf("Enter serial number and name one\n");
    scanf("%d %15c", &no, name1);
    printf("%d %15s\n\n", no, name1);

    printf("Enter serial number and name two\n");
    scanf("%d %s", &no, name2);
    printf("%d %15s\n\n", no, name2);

    printf("Enter serial number and name three\n");
    scanf("%d %15s", &no, name3);
    printf("%d %15s\n\n", no, name3);
}
```

Output

```
Enter serial number and name one
1 123456789012345
1 123456789012345r

Enter serial number and name two
2 New York
2             New

Enter serial number and name three
2            York

Enter serial number and name one
1 123456789012
1 123456789012   r

Enter serial number and name two
2 New-York
2 New-York
Enter serial number and name three
3 London
3 London
```

Fig. 4.6 *Reading of strings*

Example 4.7

The program in Fig. 4.7 illustrates the function of %[ ] specification.

```
ILLUSTRATION OF %[ ] SPECIFICATION
```

Program-A

```
main()
{
    char address[80];

    printf("Enter address\n");
    scanf("%[a-z’]", address);
    printf("%-80s\n\n", address);
}
```

Output

```
Enter address
new delhi 110002
new delhi
```

```
ILLUSTRATION OF %[^ ] SPECIFICATION
```

Program-B

```
main()
{
    char address[80];

    printf("Enter address\n");
    scanf("%[^\n]", address);
    printf("%-80s", address);
}
```

Output

```
Enter address
New Delhi 110 002
New Delhi 110 002
```

Fig.4.7 *Illustration of conversion specification%[] for strings*

Example 4.8

The program presented in Fig.4.8 illustrates the testing for correctness of reading of data by **scanf** function.

The function **scanf** is expected to read three items of data and therefore, when the values for all the three variables are read correctly, the program prints out their values. During the third run, the second item does not match with the type of variable and therefore the reading is terminated and the error message is printed. Same is the case with the fourth run.

In the last run, although data items do not match the variables, no error message has been printed. When we attempt to read a real number for an **int** variable, the integer part is assigned to the variable, and the truncated decimal part is assigned to the next variable.

Note that the character `2' is assigned to the character variable c.

TESTING FOR CORRECTNESS OF INPUT DATA

Program

```
main()
{
    int a;
    float b;
    char c;

    printf("Enter values of a, b and c\n");

    if (scanf("%d %f %c", &a, &b, &c) == 3)
       printf("a = %d  b = %f   c = %c\n" , a, b, c);
    else
       printf("Error in input.\n");
}
```

Output

```
Enter values of a, b and c
12  3.45  A
a = 12  b = 3.450000   c = A

Enter values of a, b and c
23  78  9
a = 23  b = 78.000000   c = 9

Enter values of a, b and c
8  A  5.25

Error in input.
Enter values of a, b and c
Y  12  67

Error in input.
Enter values of a, b and c
15.75  23  X

a = 15  b = 0.750000   c = 2
```

***Fig.4.8** Detection of errors in **scanf** input*

Example 4.9

The program in Fig.4.9 illustrates the output of integer numbers under various formats.

PRINTING OF **INTEGER** NUMBERS

Program:

```
main()
{
    int m = 12345;
    long n = 987654;

    printf("%d\n",m);
    printf("%10d\n",m);
    printf("%010d\n",m);
    printf("%-10d\n",m);
    printf("%10ld\n",n);
    printf("%10ld\n",-n);
}
```

Output

```
12345
     12345
0000012345
12345
    987654
   -987654
```

Fig.4.9 *Formatted output of integers*

Example 4.10
All the options of printing a real number are illustrated in Fig.4.10.

PRINTING OF **REAL NUMBERS**

***Program*:**

```
main()
{
    float y = 98.7654;
    printf("%7.4f\n", y);
    printf("%f\n", y);
    printf("%7.2f\n", y);
    printf("%-7.2f\n", y);
    printf("%07.2f\n", y);
```

```
        printf("%*.*f", 7, 2, y);
        printf("\n");
        printf("%10.2e\n", y);
        printf("%12.4e\n", -y);
        printf("%-10.2e\n", y);
        printf("%e\n", y);
    }
```

Output

```
98.7654
98.765404
98.77
98.77
0098.77
98.77
9.88e+001
-9.8765e+001
9.88e+001

9.876540e+001
```

Fig.4.10 *Formatted output of* ***real*** *numbers*

Example 4.11

Printing of characters and strings is illustrated in Fig.4.11.

```
                PRINTING OF CHARACTERS AND STRINGS
```

Program

```
    main()
    {
        char x = 'A';
        static char  name[20] = "ANIL KUMAR GUPTA";

        printf("OUTPUT OF CHARACTERS\n\n");
        printf("%c\n%3c\n%5c\n", x,x,x);
        printf("%3c\n%c\n", x,x);
        printf("\n");

        printf("OUTPUT OF STRINGS\n\n");
        printf("%s\n", name);
        printf("%20s\n", name);
        printf("%20.10s\n", name);
        printf("%.5s\n", name);
        printf("%-20.10s\n", name);
        printf("%5s\n", name);
    }
```

Output

```
   OUTPUT OF CHARACTERS

    A
      A
        A
      A
    A

   OUTPUT OF STRINGS

   ANIL KUMAR GUPTA
       ANIL KUMAR GUPTA
             ANIL KUMAR
   ANIL
   ANIL KUMAR
   ANIL KUMAR GUPTA
```

Fig.4.11 *Printing of characters and strings*

CHAPTER 5:

Example 5.1

The program in Fig.5.3 reads four values a, b, c, and d from the terminal and evaluates the ratio of (a+b) to (c-d) and prints the result, if c-d is not equal to zero.

The program given in Fig.5.3 has been run for two sets of data to see that the paths function properly. The result of the first run is printed as

```
      Ratio =  -3.181818
```

ILLUSTRATION OF **if** *STATEMENT*

Program

```
   main()
   {
       int a, b, c, d;
       float ratio;

       printf("Enter four integer values\n");
       scanf("%d %d %d %d", &a, &b, &c, &d);
```

```
        if (c-d  != 0)  /* Execute statement block */
        {
            ratio = (float)(a+b)/(float)(c-d);
            printf("Ratio = %f\n", ratio);
        }
    }
```

Output

```
   Enter four integer values
   12  23  34  45
   Ratio = -3.181818

   Enter four integer values
   12  23  34  34
```

Fig. 5.3 *Illustration of simple* ***if*** *statement*

Example 5.2

The program in Fig.5.4 counts the number of boys whose weight is less than 50 kgs and height is greater than 170 cm.

The program has to test two conditions, one for weight and another for height. This is done using the compound relation

```
if (weight < 50 && height > 170)
```

This would have been equivalently done using two **if** statements as follows:

```
if  (weight < 50)
   if  (height > 170)
      count = count +1;
```

If the value of **weight** is less than 50, then the following statement is executed, which in turn is another **if** statement. This **if** statement tests **height** and if the **height** is greater than 170, then the **count** is incremented by 1.

COUNTING WITH **if**

Program

```
main()
{
    int count, i;
    float weight, height;

    count = 0;
    printf("Enter weight and height for 10 boys\n");

    for (i =1; i <= 10; i++)
    {
       scanf("%f %f", &weight, &height);
       if (weight < 50 && height > 170)
          count = count + 1;
    }

    printf("Number of boys with weight < 50 kgs\n");
    printf("and height > 170 cm = %d\n", count);
}
```

Output

```
Enter weight and height for 10 boys
45  176.5

55  174.2

47  168.0

49  170.7

54  169.0

53  170.5

49  167.0

48  175.0

47  167

51  170

Number of boys with weight < 50 kgs
and height > 170 cm = 3
```

Fig. 5.4 *Use of* ***if*** *for counting*

Example 5.3

A program to evaluate the power series

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots\ldots + \frac{x^n}{n!}, \quad 0 < x < 1$$

is given in Fig. 5.6. It uses **if......else** to test the accuracy.

The power series contains the recurrence relationship of the type

$$T_n = T_{n-1} \left(\frac{x}{n}\right) \quad \text{for } n > 1$$

$$T_1 = x \qquad \text{for } n = 1$$

$$T_0 = 1$$

If T_{n-1} (usually known as *previous term*) is known, then T_n (known as *present term*) can be easily found by multiplying the previous term by x/n. Then

$$e^x = T_0 + T_1 + T_2 + \ldots\ldots + T_n = \text{sum}$$

EXPERIMENT WITH if...else STATEMENT

Program

```
#define ACCURACY 0.0001

main()
{
    int n, count;
    float x, term, sum;

    printf("Enter value of x:");
    scanf("%f", &x);

    n = term = sum = count = 1;

    while (n <= 100)
    {
       term = term * x/n;
       sum = sum + term;
       count = count + 1;
       if (term < ACCURACY)
          n = 999;
       else
          n = n + 1;
    }

    printf("Terms = %d Sum = %f\n", count, sum);

}
```

Output

```
Enter value of x:0
```

```
Terms = 2 Sum = 1.000000

Enter value of x:0.1
Terms = 5 Sum = 1.105171

Enter value of x:0.5
Terms = 7 Sum = 1.648720

Enter value of x:0.75
Terms = 8 Sum = 2.116997

Enter value of x:0.99
Terms = 9 Sum = 2.691232

Enter value of x:1
Terms = 9 Sum = 2.718279
```

Fig 5.6 *Illustration of **if...else** statement*

Example 5.4

The program in Fig. 5.8 selects and prints the largest of the three numbers using nested **if....else** statements.

SELECTING THE LARGEST OF THREE VALUES

Program

```
main()
{
    float A, B, C;

    printf("Enter three values\n");
    scanf("%f %f %f", &A, &B, &C);

    printf("\nLargest value is  ");

    if (A>B)
    {
        if (A>C)
           printf("%f\n", A);
        else
           printf("%f\n", C);
    }
    else
    {
        if (C>B)
           printf("%f\n", C);
```

```
            else
                printf("%f\n", B);
        }
    }
```

Output

```
   Enter three values
   23445  67379  88843

   Largest value is  88843.000000
```

Fig 5.8 **Selecting the largest of three numbers**

Example 5.5

An electric power distribution company charges its domestic consumers as follows:

Consumption Units	*Rate of Charge*
0 - 200	Rs. 0.50 per unit
201 - 400	Rs. 100 plus Rs.0.65 per unit excess of 200
401 - 600	Rs. 230 plus Rs.0.80 per unit excess of 400
601 and above	Rs. 390 plus Rs.1.00 per unit excess of 600

The program in Fig.5.10 reads the customer number and power consumed and prints the amount to be paid by the customer.

USE OF else if **LADDER**

Program

```
   main()
   {
       int  units, custnum;
       float charges;

       printf("Enter CUSTOMER NO. and UNITS consumed\n");
       scanf("%d %d", &custnum, &units);

       if (units <= 200)
          charges = 0.5 * units;
       else if (units <= 400)
  charges = 100 + 0.65 * (units - 200);           else if (units <= 600)
                  charges = 230 + 0.8 * (units - 400);
               else
                  charges = 390 + (units - 600);

       printf("\n\nCustomer No: %d: Charges = %.2f\n",
              custnum, charges);
    }
```

Output

```
    Enter CUSTOMER NO. and UNITS consumed 101  150
    Customer No:101 Charges = 75.00

    Enter CUSTOMER NO. and UNITS consumed 202  225
    Customer No:202 Charges = 116.25

    Enter CUSTOMER NO. and UNITS consumed 303  375
    Customer No:303 Charges = 213.75

    Enter CUSTOMER NO. and UNITS consumed 404  520
    Customer No:404 Charges = 326.00

    Enter CUSTOMER NO. and UNITS consumed 505  625
    Customer No:505 Charges = 415.00
```

Fig. 5.10 *Illustration of* ***else..if*** *ladder*

Example 5.6

An employee can apply for a loan at the beginning of every six months, but he will be sanctioned the amount according to the following company rules:

Rule 1 : An employee cannot enjoy more than two loans at any point of time.
Rule 2 : Maximum permissible total loan is limited and depends upon the category of the employee.

A program to process loan applications and to sanction loans is given in Fig. 5.12.

CONDITIONAL OPERATOR

Program

```
    #define   MAXLOAN  50000

    main()
    {
        long int loan1, loan2, loan3, sancloan, sum23;

        printf("Enter the values of previous two loans:\n");
        scanf(" %ld %ld", &loan1, &loan2);

        printf("\nEnter the value of new loan:\n");
        scanf(" %ld", &loan3);

        sum23 = loan2 + loan3;
        sancloan = (loan1>0)? 0 : ((sum23>MAXLOAN)?
                      MAXLOAN - loan2 : loan3);

         printf("\n\n");
         printf("Previous loans pending:\n%ld %ld\n",loan1,loan2);
         printf("Loan requested  = %ld\n", loan3);
         printf("Loan sanctioned = %ld\n", sancloan);

      }
```

Output

```
   Enter the values of previous two loans:
   0    20000
   Enter the value of new loan:
   45000
   Previous loans pending:
   0   20000
   Loan requested  = 45000
   Loan sanctioned = 30000
   Enter the values of previous two loans:
   1000   15000
    Enter the value of new loan:
   25000
   Previous loans pending:
   1000   15000
   Loan requested  = 25000
   Loan sanctioned = 0
```

Fig 5.12 **Illustration of the conditional operator**

Example 5.7

Program presented in Fig.5.13 illustrates the use of the **goto** statement.

The program evaluates the square root for five numbers. The variable count keeps the count of numbers read. When count is less than or equal to 5, **goto read**; directs the control to the label **read**; otherwise, the program prints a message and stops.

USE OF *goto* ***STATEMENT***

Program

```
#include  <math.h>
main()
{
     double x, y;
     int count;

     count = 1;

     printf("Enter FIVE real values in a LINE \n");
read:
     scanf("%lf", &x);
     printf("\n");
     if (x < 0)
        printf("Value - %d is negative\n",count);
     else
     {
        y = sqrt(x);
        printf("%lf\t %lf\n", x, y);
     }
     count = count + 1;

     if (count <= 5)
goto read;
     printf("\nEnd of computation");
}
```

Output

```
Enter FIVE real values in a LINE
50.70  40  -36  75  11.25
50.750000        7.123903
40.000000        6.324555
Value -3 is negative
75.000000        8.660254
11.250000        3.354102
End of computation
```

Fig.5.13 *Use of the* ***goto*** *statement*

CHAPTER 6:

Example 6.1

A program to evaluate the equation

$$y = x^n$$

when n is a non-negative integer, is given in Fig.6.2

The variable **y** is initialized to 1 and then multiplied by **x**, n times using the **while** loop. The loop control variable, **count** is initialized outside the loop and incremented inside the loop. When the value of **count** becomes greater than **n**, the control exists the loop.

EXAMPLE OF **while** STATEMENT

Program

```
main()
{
     int count, n;
     float x, y;

     printf("Enter the values of x and n : ");
     scanf("%f %d", &x, &n);
     y = 1.0;
     count = 1;                /* Initialisation */

     /* LOOP BEGINs */

     while ( count <= n)      /* Testing */
     {
          y = y*x;
          count++;            /* Incrementing */
     }
     /* END OF LOOP */
     printf("\nx = %f; n = %d; x to power n = %f\n",x,n,y);
}
```

Output

```
Enter the values of x and n : 2.5  4
x = 2.500000; n = 4; x to power n = 39.062500

Enter the values of x and n : 0.5  4
x = 0.500000; n = 4; x to power n = 0.062500
```

Fig.6.*2 Program to compute* ***x*** *to the power n using* ***while*** *loop*

Example 6.2

A program to print the multiplication table from 1 x 1 to 12 x 10 as shown below is given in Fig. 6.3.

```
1     2     3     4    ......... 10
2     4     6     8    ......... 20
3     6     9     12   ......... 30
4                      ......... 40
-                                -
-                                -
-                                -
12  .     .     .      ........ 120
```

This program contains two **do.... while** loops in nested form. The outer loop is controlled by the variable **row** and executed 12 times. The inner loop is controlled by the variable **column** and is executed 10 times, each time the outer loop is executed. That is, the inner loop is executed a total of 120 times, each time printing a value in the table.

PRINTING OF MULTIPLICATION **TABLE**

Program:

```
#define COLMAX 10
#define ROWMAX 12

main()
{
    int row,column, y;

    row = 1;
    printf("          MULTIPLICATION TABLE           \n");
    printf("-----------------------------------------\n");
    do    /*......OUTER LOOP BEGINS........*/
    {
         column = 1;

         do   /*.......INNER LOOP BEGINS.......*/
         {
              y = row * column;
              printf("%4d", y);
              column = column + 1;
         }
         while (column <= COLMAX); /*... INNER LOOP ENDS ...*/
```

```
            printf("\n");
            row = row + 1;
        }
        while (row <= ROWMAX);/*.....   OUTER LOOP ENDS   .....*/

        printf("-------------------------------------------\n");
    }
```

Output

```
                   MULTIPLICATION TABLE
   ----------------------------------------------------------
     1     2     3     4     5     6     7     8     9     10
     2     4     6     8     10    12    14    16    18    20
     3     6     9     12    15    18    21    24    27    30
     4     8     12    16    20    24    28    32    36    40
     5     10    15    20    25    30    35    40    45    50
     6     12    18    24    30    36    42    48    54    60
     7     14    21    28    35    42    49    56    63    70
     8     16    24    32    40    48    56    64    72    80
     9     18    27    36    45    54    63    72    81    90
     10    20    30    40    50    60    70    80    90    100
     11    22    33    44    55    66    77    88    99    110
     12    24    36    48    60    72    84    96    108   120
   ----------------------------------------------------------
```

Fig.6.3 *Printing of a multiplication table using* ***do...while loop***

Example 6.3

The program in Fig.6.4 uses a **for** loop to print the "Powers of 2" table for the power 0 to 20, both positive and negative.

The program evaluates the value

$$p = 2^{n}$$

successively by multiplying 2 by itself n times.

$$q = 2^{-n} = \frac{1}{p}$$

Note that we have declared **p** as a ***long int*** and **q** as a **double**.

Additional Features of for Loop

The **for** loop in C has several capabilities that are not found in other loop constructs. For example, more than one variable can be initialized at a time in the **for** statement. The statements

```
p = 1;
for (n=0; n<17; ++n)
```

can be rewritten as

```
for (p=1, n=0; n<17; ++n)
```

*USE OF **for** LOOP*

Program:

```
main()
{
    long int p;
    int      n;
    double   q;
    printf("------------------------------------------\n");
    printf(" 2 to power n       n       2 to power -n\n");
    printf("------------------------------------------\n");
    p = 1;
    for (n = 0; n < 21 ; ++n)    /* LOOP BEGINS */
    {
        if (n == 0)
           p = 1;
        else
           p = p * 2;
        q = 1.0/(double)p ;
        printf("%10ld %10d %20.12lf\n", p, n, q);
    }                            /* LOOP ENDS   */
    printf("------------------------------------------\n");
}
```

Output

```
-----------------------------------------------
     2 to power n   n       2 to power -n
-----------------------------------------------
          1          0       1.000000000000
          2          1       0.500000000000
          4          2       0.250000000000
          8          3       0.125000000000
         16          4       0.062500000000
         32          5       0.031250000000
         64          6       0.015625000000
        128          7       0.007812500000
        256          8       0.003906250000
        512          9       0.001953125000
       1024         10       0.000976562500
       2048         11       0.000488281250
       4096         12       0.000244140625
       8192         13       0.000122070313
      16384         14       0.000061035156
      32768         15       0.000030517578
      65536         16       0.000015258789
     131072         17       0.000007629395
     262144         18       0.000003814697
     524288         19       0.000001907349
    1048576         20       0.000000953674
-----------------------------------------------
```

Fig.6.4 *Program to print **'Power of 2'** table using for loop*

Example 6.4

A class of **n** students take an annual examination in **m** subjects. A program to read the marks obtained by each student in various subjects and to compute and print the total marks obtained by each of them is given in Fig.6.5.

The program uses two **for** loops, one for controlling the number of students and the other for controlling the number of subjects. Since both the number of students and the number of subjects are requested by the program, the program may be used for a class of any size and any number of subjects.

The outer loop includes three parts:

(1) reading of roll-numbers of students, one after another,

(2) inner loop, where the marks are read and totaled for each student, and

(3) printing of total marks and declaration of grades.

ILLUSTRATION OF **NESTED** LOOPS

Program

```
#define FIRST   360
#define SECOND  240
main()
{
    int n, m, i, j,
        roll_number, marks, total;
    printf("Enter number of students and subjects\n");
    scanf("%d %d", &n, &m);
    printf("\n");
    for (i = 1; i <= n ; ++i)
    {
        printf("Enter roll_number : ");
        scanf("%d", &roll_number);
        total = 0 ;
        printf("\nEnter marks of %d subjects for ROLL NO %d\n",
                 m,roll_number);
        for (j = 1; j <= m; j++)
        {
            scanf("%d", &marks);
            total = total + marks;
        }
        printf("TOTAL MARKS = %d ", total);
        if (total >= FIRST)
            printf("( First Division )\n\n");
        else if (total >= SECOND)
                printf("( Second Division )\n\n");
             else
                printf("( ***  F A I L  *** )\n\n");
    }
}
```

Output
```
Enter number of students and subjects
 3   6
Enter roll_number : 8701
Enter marks of 6 subjects for ROLL NO 8701
81  75  83  45  61  59
TOTAL MARKS = 404 ( First Division )

Enter roll_number : 8702
Enter marks of 6 subjects for ROLL NO 8702
51  49  55  47  65  41
TOTAL MARKS = 308 ( Second Division )

Enter roll_number : 8704
Enter marks of 6 subjects for ROLL NO 8704
40  19  31  47  39  25
TOTAL MARKS = 201 ( ***  F A I L  *** )
```

Fig.6.5 *Illustration of* ***nested for loops***

Example 6.5

The program in Fig.6.8 illustrates the use of the break statement in a C program.

The program reads a list of positive values and calculates their average. The **for** loop is written to read 1000 values. However, if we want the program to calculate the average of any set of values less than 1000, then we must enter a 'negative' number after the last value in the list, to mark the end of input.

USE OF **break** IN A PROGRAM

Program
```
main()
{
    int m;
    float x, sum, average;

    printf("This program computes the average of a
                 set of numbers\n");
    printf("Enter values one after another\n");
    printf("Enter a NEGATIVE number at the end.\n\n");
    sum = 0;
    for (m = 1 ; m <= 1000 ; ++m)
    {
        scanf("%f", &x);
        if (x < 0)
           break;
        sum += x ;
    }
```

```
        average = sum/(float)(m-1);
        printf("\n");
        printf("Number of values = %d\n", m-1);
        printf("Sum              = %f\n", sum);
        printf("Average          = %f\n", average);
    }
```

Output

```
This program computes the average of a set of numbers
Enter values one after another
Enter a NEGATIVE number at the end.

21  23  24  22  26  22  -1

Number of values = 6
Sum              = 138.000000
Average          = 23.000000
```

Fig.6.8 *Use of* ***break*** *in a program*

Example 6.6

A program to evaluate the series

$$\frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots + x^n$$

for -1 < x < 1 with 0.01 per cent accuracy is given in Fig.6.9. The **goto** statement is used to exit the loop on achieving the desired accuracy.

We have used the **for** statement to perform the repeated addition of each of the terms in the series. Since it is an infinite series, the evaluation of the function is terminated when the term x^n reaches the desired accuracy. The value of n that decides the number of loop operations is not known and therefore we have decided arbitrarily a value of 100, which may or may not result in the desired level of accuracy.

EXAMPLE OF **exit** WITH **goto** STATEMENT

Program

```
#define   LOOP       100
#define   ACCURACY   0.0001
main()
{
    int n;
    float x, term, sum;

    printf("Input value of x : ");
    scanf("%f", &x);
    sum = 0 ;
    for (term = 1, n = 1 ; n < = LOOP ; ++n)
    {
        sum += term ;
        if (term < = ACCURACY)
           goto output; /* EXIT FROM THE LOOP */
        term *= x ;
    }
    printf("\nFINAL VALUE OF N IS NOT SUFFICIENT\n");
    printf("TO ACHIEVE DESIRED ACCURACY\n");
    goto end;
    output:
    printf("\nEXIT FROM LOOP\n");
    printf("Sum = %f;  No.of terms = %d\n", sum, n);
    end:
    ;       /* Null Statement */
}
```

Output

```
    Input value of x : .21
    EXIT FROM LOOP
    Sum = 1.265800;  No.of terms = 7

    Input value of x : .75
    EXIT FROM LOOP
    Sum = 3.999774;  No.of terms = 34

    Input value of x : .99
    FINAL VALUE OF N IS NOT SUFFICIENT
    TO ACHIEVE DESIRED ACCURACY
```

***Fig.6.9** Use of **goto** to exit from a loop*

Example 6.7

The program in Fig.6.11 illustrates the use of **continue** statement.

The program evaluates the square root of a series of numbers and prints the results. The process stops when the number 9999 is typed in.

In case, the series contains any negative numbers, the process of evaluation of square root should be bypassed for such numbers because the square root of a negative number is not defined. The **continue** statement is used to achieve this. The program also prints a message saying that the number is negative and keeps an account of negative numbers.

The final output includes the number of positive values evaluated and the number of negative items encountered.

USE OF **continue** STATEMENT

Program:

```
#include <math.h>

main()
{
    int count, negative;
    double number, sqroot;

    printf("Enter 9999 to STOP\n");
    count = 0 ;
    negative = 0 ;

    while (count <= 100)
    {
        printf("Enter a number : ");
        scanf("%lf", &number);
        if (number == 9999)
           break;     /* EXIT FROM THE LOOP */
        if (number < 0)
        {
           printf("Number is negative\n\n");
           negative++ ;
           continue;  /* SKIP REST OF THE LOOP */
        }
        sqroot = sqrt(number);
        printf("Number      = %lf\n Square root = %lf\n\n",
                              number, sqroot);
        count++ ;
    }
    printf("Number of items done = %d\n", count);
    printf("\n\nNegative items       = %d\n", negative);
    printf("END OF DATA\n");
}
```

Output

```
Enter 9999 to STOP
Enter a number : 25.0
```

```
   Number      = 25.000000
   Square root = 5.000000

   Enter a number : 40.5
   Number      = 40.500000
   Square root = 6.363961

   Enter a number : -9
   Number is negative

   Enter a number : 16
   Number      = 16.000000
   Square root = 4.000000

   Enter a number : -14.75
   Number is negative

   Enter a number : 80
   Number      = 80.000000
   Square root = 8.944272

   Enter a number : 9999
   Number of items done = 4
   Negative items       = 2
   END OF DATA
```

Fig.6.11 *Use of* ***continue*** *statement*

CHAPTER 7:

Example 7.1

Write a program using a single-subscripted variable to evaluate the following expressions:

$$\text{Total} = \sum_{i=1}^{10} x_i^2$$

The values of x1,x2,....are read from the terminal.

Program in Fig.7.1 uses a one-dimensional array **x** to read the values and compute the sum of their squares.

PROGRAM SHOWING **ONE-DIMENSIONAL ARRAY**

Program :

```
main()
  {
       int    i ;
       float  x[10], value, total ;

 /* . . . . . .READING VALUES INTO ARRAY . . . . . . */

       printf("ENTER 10 REAL NUMBERS\n") ;

       for( i = 0 ; i < 10 ; i++ )
       {
          scanf("%f", &value) ;
          x[i] = value ;
       }
 /* . . . . . .  .COMPUTATION OF TOTAL . . . . . . .*/

       total = 0.0 ;
       for( i = 0 ; i < 10 ; i++ )
          total = total + x[i] * x[i] ;

 /*. . .  . PRINTING OF x[i] VALUES AND TOTAL . . . */

       printf("\n");
       for( i = 0 ; i < 10 ; i++ )
          printf("x[%2d] = %5.2f\n", i+1, x[i]) ;

       printf("\ntotal = %.2f\n", total) ;
  }
```

Output

```
ENTER 10 REAL NUMBERS
1.1  2.2  3.3  4.4  5.5  6.6  7.7  8.8  9.9  10.10

x[ 1] =  1.10
x[ 2] =  2.20
x[ 3] =  3.30
x[ 4] =  4.40
x[ 5] =  5.50
x[ 6] =  6.60
x[ 7] =  7.70
x[ 8] =  8.80
x[ 9] =  9.90
x[10] = 10.10

Total = 446.86
```

Fig.7.1 *Program to illustrate **one-dimensional array***

Example 7.2

Given below is the list of marks obtained by a class of 50 students in an annual examination.

```
43 65 51 27 79 11 56 61 82 09 25 36 07 49 55 63 74 81 49 37
 40 49 16 75 87 91 33  24 58 78 65 56 76 67 45 54 36 63 12 21
 73 49 51 19 39 49 68 93 85 59
```

Write a program to count the number of students belonging to each of following groups of marks: 0-9, 10-19, 20-29,.....,100.

The program coded in Fig.7.2 uses the array **group** containing 11 elements, one for each range of marks. Each element counts those values falling within the range of values it represents.

For any value, we can determine the correct group element by dividing the value by 10. For example, consider the value 59. The integer division of 59 by 10 yields 5. This is the element into which 59 is counted.

PROGRAM FOR **FREQUENCY COUNTING**

Program

```
   #define   MAXVAL    50
   #define   COUNTER   11

   main()
   {
       float        value[MAXVAL];
       int          i, low, high;
       int   group[COUNTER] = {0,0,0,0,0,0,0,0,0,0,0};

        /* . . . . . . . .READING AND COUNTING . . . .  . .*/
       for( i = 0 ; i < MAXVAL ; i++ )
       {

         /*. . . . . . . .READING OF VALUES . . . . . . . . */
           scanf("%f", &value[i]) ;

         /*. . . . . .COUNTING FREQUENCY OF GROUPS. . . . . */
           ++ group[ (int) ( value[i] + 0.5 ) / 10] ;
       }

         /* . . . .PRINTING OF FREQUENCY TABLE . . . . . . .*/
       printf("\n");
       printf(" GROUP     RANGE     FREQUENCY\n\n") ;
       for( i = 0 ; i < COUNTER ; i++ )
       {
          low  = i * 10 ;
          if(i == 10)
            high = 100 ;
          else
            high = low + 9 ;
          printf("  %2d    %3d to %3d       %d\n",
                  i+1, low, high, group[i] ) ;
       }
```

```
}
```

Output

```
43 65 51 27 79 11 56 61 82 09 25 36 07 49 55 63 74     (Input data)
81 49 37 40 49 16 75 87 91 33 24 58 78 65 56 76 67
45 54 36 63 12 21 73 49 51 19 39 49 68 93 85 59


GROUP          RANGE            FREQUENCY
  1          0   to   9            2
  2          10  to  19            4
  3          20  to  29            4
  4          30  to  39            5
  5          40  to  49            8
  6          50  to  59            8
  7          60  to  69            7
  8          70  to  79            6
  9          80  to  89            4
 10          90  to  99            2
 11          100 to 100            0
```

Fig.7.2 *Program for* ***frequency counting***

Example 7.3

Write a program using a two-dimensional array to compute and print the following information from the table of data discussed above:

(a) Total value of sales by each girl.
(b) Total value of each item sold.
(c) Grand total of sales of all items by all girls.

The program and its output are shown in Fig.7.4. The program uses the variable **value** in two-dimensions with the index i representing girls and j representing items. The following equations are used in computing the results:

(a) Total sales by m th girl (girl_total[m]) $= \sum_{j=0}^{2} \text{value [m][j]}$

(b) Total value of nth item (item_total[n]) $= \sum_{i=0}^{3} \text{value [i][n]}$

(c) Grand total $= \sum_{i=0}^{3} \sum_{j=0}^{2} \text{value[i][j]}$

3

$$= \sum_{i=0} \text{girl\_total[i]}$$

$$= \sum_{j=0}^{2} \text{item\_total[j]}$$

PROGRAM SHOWING TWO-DIMENSIONAL ARRAYS

Program:

```
   #define     MAXGIRLS     4
   #define     MAXITEMS     3

   main()
   {
       int   value[MAXGIRLS][MAXITEMS];
       int   girl_total[MAXGIRLS] , item_total[MAXITEMS];
       int   i, j, grand_total;

   /*.......READING OF VALUES AND COMPUTING girl_total ...*/

       printf("Input data\n");
       printf("Enter values, one at a time, row-wise\n\n");

       for( i = 0 ; i < MAXGIRLS ; i++ )
       {
          girl_total[i] = 0;
          for( j = 0 ; j < MAXITEMS ; j++ )
          {
             scanf("%d", &value[i][j]);
             girl_total[i] = girl_total[i] + value[i][j];
          }
       }
  /*.......COMPUTING item_total.........................*/

       for( j = 0 ; j < MAXITEMS ; j++ )
       {
          item_total[j] = 0;
          for( i =0 ; i < MAXGIRLS ; i++ )
             item_total[j] = item_total[j] + value[i][j];
       }


/*.......COMPUTING grand_total.......................*/

       grand_total = 0;
       for( i =0 ; i < MAXGIRLS ; i++ )
          grand_total = grand_total + girl_total[i];

/* .......PRINTING OF RESULTS.........................*/

       printf("\n GIRLS TOTALS\n\n");
```

```
        for( i = 0 ; i < MAXGIRLS ; i++ )
           printf("Salesgirl[%d] = %d\n", i+1, girl_total[i] );
        printf("\n ITEM  TOTALS\n\n");
        for( j = 0 ; j < MAXITEMS ; j++ )
           printf("Item[%d] = %d\n", j+1 , item_total[j] );
        printf("\nGrand Total = %d\n", grand_total);
    }
```

Output

```
Input data
Enter values, one at a time, row_wise

310  257  365
210  190  325
405  235  240
260  300  380

GIRLS TOTALS

Salesgirl[1] = 950
Salesgirl[2] = 725
Salesgirl[3] = 880
Salesgirl[4] = 940

 ITEM  TOTALS

Item[1] = 1185
Item[2] = 1000
Item[3] = 1310

Grand Total = 3495
```

Fig.7.4 *Illustration of two-dimensional arrays.*

Example 7.4

Write a program to compute and print a multiplication table for numbers 1 to 5 as shown below:

	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	.	.	.
4	4	8	.	.	.
5	5	10	.	.	25

The program shown in Fig.7.5 uses a two-dimensional array to store the table values. Each value is calculated using the control variables of the nested for loops as follows:

product(i,j) = row * column

where i denotes rows and j denotes columns of the product table. Since the indices i and j ranges from 0 to 4, we have introduced the following transformation:

row = i+1
column = j+1

PROGRAM TO PRINT MULTIPLICATION TABLE

Program:

```
#define    ROWS     5
#define    COLUMNS  5
main()
{
    int   row, column, product[ROWS][COLUMNS] ;
    int   i, j ;
    printf("   MULTIPLICATION TABLE\n\n") ;
    printf("    ") ;
    for( j = 1 ; j <= COLUMNS ; j++ )
      printf("%4d" , j ) ;
    printf("\n") ;
    printf("-------------------------\n");
    for( i = 0 ; i < ROWS ; i++ )
    {
        row = i + 1 ;
        printf("%2d |", row) ;
        for( j = 1 ; j <= COLUMNS ; j++ )
        {
           column = j ;
           product[i][j] = row * column ;
           printf("%4d", product[i][j] ) ;
        }
        printf("\n") ;
    }
}
```

Output

```
     MULTIPLICATION TABLE
        1   2   3   4   5
   ----------------------
   1 |  1   2   3   4   5
   2 |  2   4   6   8  10
   3 |  3   6   9  12  15
   4 |  4   8  12  16  20
   5 |  5  10  15  20  25
```

Fig.7.5 *Program to print multiplication table using two-dimensional array*

Example 7.5

A survey to know the popularity of four cars (Ambassador, Fiat, Dolphin and Maruti) was conducted in four cities (Bombay, Calcutta, Delhi and Madras). Each person surveyed was asked to give his city and the type of car he was using. The results, in coded form, are tabulated as follows:

M	1	C	2	B	1	D	3	M	2	B	4
C	1	D	3	M	4	B	2	D	1	C	3
D	4	D	4	M	1	M	1	B	3	B	3
C	1	C	1	C	2	M	4	M	4	C	2
D	1	C	2	B	3	M	1	B	1	C	2
D	3	M	4	C	1	D	2	M	3	B	4

Codes represent the following information:

M - Madras	1 - Ambassador
D – Delhi	2 - Fiat
C – Calcutta	3 - Dolphin
B – Bombay	4 - Maruti

Write a program to produce a table showing popularity of various cars in four cities.

A two-dimensional array **frequency** is used as an accumulator to store the number of cars used, under various categories in each city. For example, the element **frequency** [i][j] denotes the number of cars of type j used in city i. The **frequency** is declared as an array of size 5x5 and all the elements are initialized to zero.

The program shown in fig.7.6 reads the city code and the car code, one set after another, from the terminal. Tabulation ends when the letter X is read in place of a city code.

PROGRAM TO TABULATE SURVEY DATA

Program

```
main()
{
    int  i, j, car;
    int  frequency[5][5] = { {0},{0},{0},{0},{0} };
    char city;

    printf("For each person, enter the city code \n");
    printf("followed by the car code.\n");
    printf("Enter the letter X to indicate end.\n");

/*. . . . . . TABULATION BEGINS  . . . . . */

    for( i = 1 ; i < 100 ; i++ )
    {
       scanf("%c", &city );
```

```
            if( city == 'X' )
              break;
            scanf("%d", &car );

            switch(city)
            {

                  case 'B' :  frequency[1][car]++;
                              break;
                  case 'C' :  frequency[2][car]++;
                              break;
                  case 'D' :  frequency[3][car]++;
                              break;
                  case 'M' :  frequency[4][car]++;
                              break;
            }
         }
  /*. . . . .TABULATION COMPLETED AND PRINTING BEGINS. . . .*/
         printf("\n\n");
         printf("             POPULARITY  TABLE\n\n");
         printf("-------------------------------------------\n");
         printf("City     Ambassador  Fiat  Dolphin  Maruti \n");
         printf("-------------------------------------------\n");
         for( i = 1 ; i <= 4 ; i++ )
         {
```

```
         switch(i)
         {
               case 1 :  printf("Bombay    ") ;
                         break ;
               case 2 :  printf("Calcutta  ") ;
                         break ;
               case 3 :  printf("Delhi     ") ;
                         break ;
               case 4 :  printf("Madras    ") ;
                         break ;
         }
         for( j = 1 ; j <= 4 ; j++ )
            printf("%7d", frequency[i][j] ) ;
         printf("\n") ;
      }
      printf("-------------------------------------------\n");
   /*. . . . . . . . . PRINTING ENDS. . . . . . . . . . .*/
  }
```

Output

```
   For each person, enter the city code
   followed by the car code.
   Enter the letter X to indicate end.

   M 1 C 2 B 1 D 3 M 2 B 4
   C 1 D 3 M 4 B 2 D 1 C 3
   D 4 D 4 M 1 M 1 B 3 B 3
   C 1 C 1 C 2 M 4 M 4 C 2
   D 1 C 2 B 3 M 1 B 1 C 2
   D 3 M 4 C 1 D 2 M 3 B 4  X

                    POPULARITY TABLE
         -------------------------------------------
         City     Ambassador  Fiat  Dolphin  Maruti
         -------------------------------------------
         Bombay          2      1      3      2
         Calcutta        4      5      1      0
         Delhi           2      1      3      2
         Madras          4      1      1      4
         -------------------------------------------
```

Fig.7.6 Program to tabulate a survey data

CHAPTER 8:

Example 8.1

Write a program to read a series of words from a terminal using **scanf** function

The program shown in Fig.8.1 reads four words and displays them on the screen. Note that the string 'Oxford Road' is treated as *two words* while the string 'Oxford-Road' as *one word.*

READING A SERIES OF WORDS USING **scanf** FUNCTION

Program

```
main( )
{
    char word1[40], word2[40], word3[40], word4[40];

    printf("Enter text : \n");
    scanf("%s %s", word1, word2);
    scanf("%s", word3);
    scanf("%s", word4);

    printf("\n");
    printf("word1 = %s\nword2 = %s\n", word1, word2);
    printf("word3 = %s\nword4 = %s\n", word3, word4);
}
```

Output

```
Enter text :
Oxford Road, London M17ED

word1 = Oxford
word2 = Road,
word3 = London
word4 = M17ED

Enter text :
Oxford-Road, London-M17ED United Kingdom
word1 = Oxford-Road
word2 = London-M17ED
word3 = United
word4 = Kingdom
```

*Fig.8.1 Reading a series of words using **scanf***

Example 8.2

Write a program to read a line of text containing a series of words from the terminal.

The program shown in Fig.8.2 can read a line of text (upto a maximum of 80 characters) into the string **line** using **getchar** function. Every time a character is read, it is assigned to its location in the string **line** and then tested for *newline* character. When the *newline* character is read (signalling the end of line), the reading loop is terminated and the *newline* character is replaced by the null character to indicate the end of character string.

When the loop is exited, the value of the index **c** is one number higher than the last character position in the string (since it has been incremented after assigning the new character to the string). Therefore the index value **c-1** gives the position where the *null* character is to be stored.

PROGRAM TO **READ A LINE OF TEXT** FROM TERMINAL

Program

```
#include  <stdio.h>

main( )
{
    char  line[81], character;
    int   c;

    c = 0;

    printf("Enter text. Press <Return> at end\n");
    do
    {
        character = getchar();
        line[c]   = character;
        c++;
    }
    while(character != '\n');

    c = c - 1;
    line[c] = '\0';
    printf("\n%s\n", line);
}
```

Output

```
Enter text. Press <Return> at end
Programming in C is interesting.

Programming in C is interesting.

Enter text. Press <Return> at end
National Centre for Expert Systems, Hyderabad.

National Centre for Expert Systems, Hyderabad.
```

Fig.8.2 *Program to* ***read a line of text*** *from terminal*

Example 8.3

Write a program to copy one string into another and count the number of characters copied.

The program is shown in Fig.8.3. We use a **for** loop to copy the characters contained inside **string2** into the **string1**. The loop is terminated when the *null* character is reached. Note that we are again assigning a null character to the **string1.**

COPYING ONE **STRING** INTO **ANOTHER**

Program

```
main( )
{
    char  string1[80], string2[80];
    int   i;

    printf("Enter a string \n");
    printf("?");

    scanf("%s", string2);

    for( i=0 ; string2[i] != '\0'; i++)
       string1[i] = string2[i];

    string1[i] = '\0';

    printf("\n");
    printf("%s\n", string1);
    printf("Number of characters = %d\n", i );
}
```

Output

```
Enter a string
?Manchester

Manchester
Number of characters = 10

Enter a string
?Westminster

Westminster
Number of characters = 11
```

Fig.8.3 *Copying one string into another*

Example 8.4

Write a program to store the string "United Kingdom" in the array **country** and display the string under various format specifications.

The program and its output are shown in Fig.8.4. The output illustrates the following features of the **%s** specifications.

1. When the field width is less than the length of the string, the entire string is printed.
2. The integer value on the right side of the decimal point specifies the number of characters to be printed.
3. When the number of characters to be printed is specified as zero, nothing is printed.
4. The minus sign in the specification causes the string to be printed left-justified.
5. The specification % **.**ns prints the first n characters of the string

WRITING STRINGS USING **%s** FORMAT

Program

```
main()
{
    char  country[15] = "United Kingdom";

    printf("\n\n");
    printf("*123456789012345*\n");
    printf(" --------------- \n");

    printf("%15s\n", country);
    printf("%5s\n", country);
    printf("%15.6s\n", country);
    printf("%-15.6s\n", country);
    printf("%15.0s\n", country);
    printf("%.3s\n", country);
    printf("%s\n", country);
    printf("---------------- \n");
}
```

Output

```
*123456789012345*
------------------
  United Kingdom
 United Kingdom
          United
 United

 Uni
 United Kingdom
------------------
```

Fig.8.4 *Writing strings using %s format*

Example 8.5

Write a program using **for loop** to print the following output.

```
C
CP
CPr
CPro
.....
.....
CProgramming
------------
CProgramming
.....
.....
CPro
CPr
CP
C
```

The outputs of the program in Fig.8.5, for variable specifications **%12.*s, %.*s,** and **%*.1s** are shown in Fig.8.6, which further illustrates the variable field width and the precision specifications.

PRINTING **SEQUENCES OF CHARACTERS**

Program

```
main()
{
    int  c, d;
    char  string[] = "CProgramming";

    printf("\n\n");
    printf("--------------\n");
    for( c = 0 ; c <= 11 ; c++ )
    {
       d = c + 1;
       printf("|%-12.*s|\n", d, string);
    }
    printf("|------------|\n");

    for( c = 11 ; c >= 0 ; c-- )
    {
       d = c + 1;
       printf("|%-12.*s|\n", d, string);
    }
    printf("--------------\n");
}
```

Output

```
C
CP
CPr
CPro
CProg
CProgr
CProgra
CProgram
CProgramm
CProgrammi
CProgrammin
CProgramming

CProgramming
CProgrammin
CProgrammi
CProgramm
CProgram
CProgra
CProgr
CProg
CPro
CPr
CP
C
```

Fig.8.5 *Illustration of variable field specifications*

Example 8.6

Write a program which would print the alphabet set a to z and A to Z in decimal and character form.

The program is shown in Fig.8.7. In ASCII character set, the decimal numbers 65 to 90 represent uppercase alphabets and 97 to 122 represent lowercase alphabets. The values from 91 to 96 are excluded using an **if** statement in the **for** loop.

```
PRINTING ALPHABET SET IN DECIMAL AND CHARACTER FORM
```

Program

```
main()
{
    char  c;

    printf("\n\n");
    for( c = 65 ; c <= 122 ; c = c + 1 )
    {
       if( c > 90  &&  c < 97 )
         continue;
       printf("|%4d - %c ", c, c);
    }
    printf("|\n");
}
```

Output

```
|  65 - A |  66 - B |  67 - C |  68 - D |  69 - E |  70 - F
|  71 - G |  72 - H |  73 - I |  74 - J |  75 - K |  76 - L
|  77 - M |  78 - N |  79 - O |  80 - P |  81 - Q |  82 - R
|  83 - S |  84 - T |  85 - U |  86 - V |  87 - W |  88 - X
|  89 - Y |  90 - Z |  97 - a |  98 - b |  99 - c | 100 - d
| 101 - e | 102 - f | 103 - g | 104 - h | 105 - i | 106 - j
| 107 - k | 108 - l | 109 - m | 110 - n | 111 - o | 112 - p
| 113 - q | 114 - r | 115 - s | 116 - t | 117 - u | 118 - v
| 119 - w | 120 - x | 121 - y | 122 - z |
```

Fig.8.7 *Printing of the alphabet set in decimal and character form*

Example 8.7

The names of employees of an organization are stored in three arrays, namely **first_name**, **second_name,** and **last_name**. Write a program to concatenate the three parts into one string to be called **name**.

The program is given in Fig.8.8. Three **for** loops are used to copy the three strings. In the first loop, the characters contained in the **first_name** are copied into the variable **name** until the *null* character is reached. The *null* character is not copied; instead it is replaced by a *space* by the assignment statement

name[i] = ' ' ;

Similarly, the **second_name** is copied into **name**, starting from the column just after the space created by the above statement. This is achieved by the assignment statement

name[i+j+1] = second_name[j];

If **first_name** contains 4 characters, then the value of i at this point will be 4 and therefore the first character from **second_name** will be placed in the *fifth cell* of **name.** Note that we have stored a space in the *fourth cell*.

In the same way, the statement

name[i+j+k+2] = last_name[k];

is used to copy the characters from **last_name** into the proper locations of **name.**
At the end, we place a null character to terminate the concatenated string **name**. In this example, it is important to note the use of the expressions **i+j+1** and **i+j+k+2.**

CONCATENATION OF STRINGS

Program

```
main()
{
    int  i, j, k ;
    char   first_name[10] = {"VISWANATH"}  ;
    char  second_name[10] = {"PRATAP"} ;
    char    last_name[10] = {"SINGH"} ;
    char   name[30] ;

  /* Copy first_name into name */

    for( i = 0 ; first_name[i] != '\0' ; i++ )
       name[i] = first_name[i] ;

  /* End first_name with a space */

    name[i] = ' ' ;

  /* Copy second_name into name */

    for( j = 0 ; second_name[j] != '\0' ; j++ )
       name[i+j+1] = second_name[j] ;

  /* End second_name with a space */

    name[i+j+1] = ' ' ;

  /* Copy last_name into name */

    for( k = 0 ; last_name[k] != '\0'; k++ )
       name[i+j+k+2] = last_name[k] ;

  /* End name with a null character */

    name[i+j+k+2] = '\0' ;

    printf("\n\n") ;
    printf("%s\n", name) ;
}
```

Output

```
           VISWANATH PRATAP SINGH
```

Fig.8.8 Concatenation of strings

Example 8.8

s1, s2, and **s3** are three string variables. Write a program to read two string constants into **s1** and **s2** and compare whether they are equal or not. If they are not, join them together. Then copy the contents of **s1** to the variable **s3**. At the end, the program should print the contents of all the three variables and their lengths.

The program is shown in Fig.8.9. During the first run, the input strings are "New" and "York". These strings are compared by the statement

x = strcmp(s1, s2);

Since they are not equal, they are joined together and copied into **s3** using the statement

strcpy(s3, s1);

The program outputs all the three strings with their lengths.

During the second run, the two strings **s1** and **s2** are equal, and therefore, they are not joined together. In this case all the three strings contain the same string constant "London".

CHAPTER 9:

Example 9.1

Write a program with multiple functions that do not communicate any data between them.

A program with three user-defined functions is given in Fig.9.4. **main** is the calling function that calls **printline** and **value** functions. Since both the called functions contain no arguments, there are no argument declarations. The **printline** function, when encountered, prints a line with a length of 35 characters as prescribed in the function. The **value** function calculates the value of principal amount after a certain period of years and prints the results. The following equation is evaluated repeatedly:

value = principal(1+interest-rate)

FUNCTIONS WITH THE ARGUMENTS, NO RETURN VALUES

Program

```
/* Function declaration */
void printline (void);
void value (void);
main()
{
    printline();
    value();
    printline();
}
/*       Function1: printline( )       */

void printline(void)   /* contains no arguments */
{
    int i ;

    for(i=1; i <= 35; i++)
       printf("%c",'-');
    printf("\n");
}
/*       Function2: value( )           */
void value(void)       /* contains no arguments */
{
    int    year, period;
    float  inrate, sum, principal;

    printf("Principal amount?");
    scanf("%f", &principal);
    printf("Interest rate?   ");
    scanf("%f", &inrate);
    printf("Period?          ");
    scanf("%d", &period);

    sum = principal;
    year = 1;
    while(year <= period)
    {
        sum = sum *(1+inrate);
        year = year +1;
    }
    printf("\n%8.2f %5.2f %5d %12.2f\n",
            principal,inrate,period,sum);
}
```

Output

```
     -----------------------------------
        Principal amount?  5000
        Interest rate?     0.12
        Period?            5

        5000.00  0.12      5      8811.71
     ------------------------------------
```

Fig.9.4 *Functions with no arguments and no return values*

Example 9.2

Modify the program of Example 9.1 to include the arguments in the function calls.

The modified program with function arguments is presented in Fig.9.7. Most of the program is identical to the program in Fig.9.4. The input prompt and **scanf** assignment statement have been moved from **value** function to **main.** The variables **principal, inrate,** and **period** are declared in **main** because they are used in main to receive data. The function call

value(principal, inrate, period);

passes information it contains to the function **value.**

The function header of **value** has three formal arguments **p,r,** and **n** which correspond to the actual arguments in the function call, namely, **principal, inrate,** and **period.** On execution of the function call, the values of the actual arguments are assigned to the corresponding formal arguments. In fact, the following assignments are accomplished across the function boundaries:

p = principal;
r = inrate;
n = period;

FUNCTIONS WITH ARGUMENTS BUT NO RETURN VALUES

Program

```
   /* prototypes */
   void printline (char c);
   void value (float, float, int);

   main( )
   {
        float principal, inrate;
        int period;

        printf("Enter principal amount, interest");
        printf(" rate, and period \n");
        scanf("%f %f %d",&principal, &inrate, &period);
        printline('Z');
        value(principal,inrate,period);
        printline('C');
```

```
}



void printline(char ch)
{
     int i ;
     for(i=1; i <= 52; i++)
          printf("%c",ch);
     printf("\n");
}

void value(float p, float r, int n)
{
     int year ;
     float sum ;
     sum = p ;
     year = 1;
     while(year <= n)
     {
         sum = sum * (1+r);
         year = year +1;
     }
     printf("%f\t%f\t%d\t%f\n",p,r,n,sum);
}
```

Output

```
Enter principal amount, interest rate, and period
5000 0.12  5
ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ
5000.000000     0.120000        5       8811.708984
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

Fig.9.7 *Functions with arguments but no return values*

Example 9.3

In the program presented in Fig. 9.7 modify the function **value,** to return the final amount calculated to the **main**, which will display the required output at the terminal. Also extend the versatility of the function **printline** by having it to take the length of the line as an argument.

The modified program with the proposed changes is presented in Fig. 9.9. One major change is the movement of the **printf** statement from **value** to **main.**

FUNCTIONS WITH ARGUMENTS AND RETURN VALUES

Program

```
void printline (char ch, int len);
value (float, float, int);

main( )
{
      float principal, inrate, amount;
      int period;
      printf(“Enter principal amount, interest”);
      printf(“rate, and period\n”);
      scanf(%f %f %d”, &principal, &inrate, &period);
      printline (‘*’ , 52);
      amount = value (principal, inrate, period);
      printf(“\n%f\t%f\t%d\t%f\n\n”,principal,
            inrate,period,amount);
      printline(‘=’,52);
}
void printline(char ch, int len)
{
      int i;
      for (i=1;i<=len;i++) printf(“%c”,ch);
      printf(“\n”);
}
value(float p, float r, int n) /* default return type */
{
      int year;
      float sum;
      sum = p; year = 1;
      while(year <=n)
      {
            sum = sum * (l+r);
            year = year +1;
      }
      return(sum);        /* returns int part of sum */
}
```

Output

```
Enter principal amount, interest rate, and period
5000  0.12    5
***************************************************
5000.000000          0.1200000  5    8811.000000
= = = = = = = = = = = = = = = = = = = = = = = = = =
```

Fig.9.9 *Functions with arguments and return values*

Example 9.4

Write a function **power** that computes x raised to the power y for integers x and y and returns double-type value.

Fig 9.10 shows a **power** function that returns a **double.** The prototype declaration

double power(int, int);

appears in **main**, before **power** is called.

```
                              POWER FUNCTIONS
Program

     main( )
     {    int x,y;                      /*input data */

          double power(int, int);       /* prototype declaration*/

          printf("Enter x,y:");

          scanf("%d %d" , &x,&y);
          printf("%d to power %d is %f\n", x,y,power (x,y));
     }

     double power (int x, int y);

     {
          double p;
          p = 1.0 ;           /* x to power zero */

          if(y >=o)
               while(y--)     /* computes positive powers */
                p *= x;
          else
               while (y++)    /* computes negative powers */
                p /= x;
          return(p);

     }
```

Output

```
     Enter x,y:16 2
     16 to power 2 is 256.000000

     Enter x,y:16 -2
     16 to power -2 is 0.003906
```

***Fig 9.10** Illustration of return of float values*

Example 9.5

Write a program to calculate the standard deviation of an array of values. The array elements are read from the terminal. Use functions to calculate standard deviation and mean.

Standard deviation of a set of n values is given by

$$S.D = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\overline{x}-x_i)^2}$$

Where $\overline{x}$ is the mean of the values.

Program

```
#include     <math.h>
#define SIZE    5
float std_dev(float a[], int n);
float mean (float a[], int n);
main( )
{
     float value[SIZE];
     int i;

     printf("Enter %d float values\n", SIZE);
     for (i=0 ;i < SIZE ; i++)
         scanf("%f", &value[i]);
     printf("Std.deviation is %f\n", std_dev(value,SIZE));
}
float std_dev(float a[], int n)
{    int i;
     float x, sum = 0.0;
     x = mean (a,n);
     for(i=0; i < n; i++)
        sum += (x-a[i])*(x-a[i]);
     return(sqrt(sum/(float)n));
}
float mean(float a[],int n)
{
     int i ;
     float sum = 0.0;
     for(i=0 ; i < n ; i++)
        sum = sum + a[i];
     return(sum/(float)n);
}
```

Output

```
           Enter 5 float values

           35.0 67.0 79.5 14.20 55.75


           Std.deviation is 23.231582
```

Fig.9.11 *Passing of arrays to a function*

Example 9.6

Write a program that uses a function to sort an array of integers.

A program to sort an array of integers using the function **sort()** is given in Fig.9.12. Its output clearly shows that a function can change the values in an array passed as an argument.

```
                    SORTING OF ARRAY ELEMENTS
```

Program

```
   void sort(int m, int x[ ]);
   main()
   {
       int i;
       int marks[5] = {40, 90, 73, 81, 35};

       printf("Marks before sorting\n");
       for(i = 0; i < 5; i++)
          printf("%d ", marks[i]);
       printf("\n\n");

       sort (5, marks);

       printf("Marks after sorting\n");
       for(i = 0; i < 5; i++)
```

```
        printf("%4d", marks[i]);
     printf("\n");
}
void sort(int m, int x[ ])
{
     int i, j, t;

     for(i = 1; i <= m-1; i++)
        for(j = 1; j <= m-i; j++)
           if(x[j-1] >= x[j])
           {
              t = x[j-1];
              x[j-1] = x[j];
              x[j] = t;
           }
}
```

Output

```
              Marks before sorting
              40 90 73 81 35

              Marks after sorting
              35  40  73  81  90
```

Fig.9.12 Sorting of array elements using a function

Example 9.7

Write a multifunction to illustrate how automatic variables work.

A program with two subprograms **function1** and **function2** is shown in Fig.9.13. **m** is an automatic variable and it is declared at the beginning of each function. **m** is initialized to 10, 100, and 1000 in function1, function2, and **main** respectively.

When executed, **main** calls **function2** which in turn calls **function1**. When **main** is active, m = 1000; but when **function2** is called, the **main**'s **m** is temporarily put on the shelf and the new local **m** = 100 becomes active. Similarly, when **function1** is called, both the previous values of **m** are put on the shelf and the latest value of **m** (=10) becomes active. As soon as **function1** (m=10) is finished, **function2** (m=100) takes over again. As soon it is done, **main** (m=1000) takes over. The output clearly shows that the value assigned to **m** in one function does not affect its value in the other functions; and the local value of **m** is destroyed when it leaves a function.

ILLUSTRATION OF WORKING OF **auto** VARIABLES

Program

```
void function1(void);
void function2(void);
main( )
{
     int m = 1000;
     function2();

     printf("%d\n",m);   /* Third output */
}
void function1(void)
{
     int m = 10;

     printf("%d\n",m);   /* First output */
}


void function2(void)
{
     int m = 100;
     function1();
     printf("%d\n",m);   /* Second output */
}
```

Output

```
        10
        100
        1000
```

Fig.9.13 *Working of automatic variables*

Example 9.8

Write a multifunction program to illustrate the properties of global variables.

A program to illustrate the properties of global variables is presented in Fig.9.14. Note that variable **x** is used in all functions but none except **fun2,** has a definition for **x.** Because **x** has been declared 'above' all the functions, it is available to each function without having to pass x as a function argument. Further, since the value of **x** is directly available, we need not use **return(x)** statements in **fun1** and **fun3.** However, since **fun2** has a definition of **x,** it returns its local value of **x** and therefore uses a **return** statement. In **fun2**, the global **x** is not visible. The local **x** hides its visibility here.

ILLUSTRATION OF PROPERTIES OF GLOBAL VARIABLES

Program

```
int fun1(void);
int fun2(void);
int fun3(void);
int x ;             /* global */
main( )
{
     x = 10 ;       /* global x */
     printf("x = %d\n", x);
     printf("x = %d\n", fun1());
     printf("x = %d\n", fun2());
     printf("x = %d\n", fun3());
}
fun1(void)
{
     x = x + 10 ;
}
int fun2(void)
{
     int x ;        /* local */
     x = 1 ;
     return (x);
}
fun3(void)
{
     x = x + 10 ;  /* global x */
}
```

Output

```
x = 10
x = 20
x = 1
x = 30
```

Fig.9.14 *Illustration of global variables*

Example 9.9

Write a program to illustrate the properties of a static variable.

The program in Fig.9.15 explains the behaviour of a static variable.

ILLUSTRATION OF STATIC VARIABLE

Program

```
void stat(void);
main ( )
```

```
{
   int i;
   for(i=1; i<=3; i++)
    stat( );
 }
void stat(void)
{
  static int x = 0;

  x = x+1;
  printf("x = %d\n", x);
}
```

Output

```
x = 1
x = 2
x = 3
```

Fig.9.15 *Illustration of static variable*

CHAPTER 10:

Example 10.1

Define a structure type, **struct personal** that would contain person name, date of joining and salary. Using this structure, write a program to read this information for one person from the keyboard and print the same on the screen.

Structure definition along with the program is shown in Fig.10.1. The **scanf** and **printf** functions illustrate how the member operator `.' is used to link the structure members to the structure variables. The variable name with a period and the member name is used like an ordinary variable.

DEFINING AND ASSIGNING VALUES TO STRUCTURE MEMBERS

Program

```
struct  personal
{
    char  name[20];
    int   day;
    char  month[10];
    int   year;
    float salary;
};
main()
{
    struct personal person;
    printf("Input Values\n");
    scanf("%s %d %s %d %f",
              person.name,
             &person.day,
              person.month,
             &person.year,
             &person.salary);
    printf("%s %d %s %d %f\n",
              person.name,
              person.day,
              person.month,
              person.year,
              person.salary);
}
```

Output

```
Input Values
M.L.Goel 10 January 1945 4500
M.L.Goel 10 January 1945 4500.00
```

Fig.10.1 ***Defining and accessing structure members***

Example 10.2

Write a program to illustrate the comparison of structure variables.

The program shown in Fig.10.2 illustrates how a structure variable can be copied into another of the same type. It also performs member-wise comparison to decide whether two structure variables are identical.

COMPARISON OF STRUCTURE VARIABLES

Program

```
struct class
{
    int  number;
    char name[20];
    float marks;
};

main()
{
    int  x;
    struct class student1 = {111,"Rao",72.50};
    struct class student2 = {222,"Reddy", 67.00};
    struct class student3;

    student3 = student2;

    x = ((student3.number ==  student2.number) &&
         (student3.marks  ==  student2.marks)) ? 1 : 0;

    if(x == 1)
   {
        printf("\nstudent2 and student3 are same\n\n");
        printf("%d %s %f\n", student3.number,
                             student3.name,
                             student3.marks);
    }
    else
        printf("\nstudent2 and student3 are different\n\n");

}
```

Output

```
student2 and student3 are same

222 Reddy 67.000000
```

Fig.10.2 *Comparing and copying structure variables*

Example 10.3

For the **student** array discussed above, write a program to calculate the subject-wise and student-wise totals and store them as a part of the structure.

The program is shown in Fig.10.4. We have declared a four-member structure, the fourth one for keeping the student-totals. We have also declared an **array** total to keep the subject-totals and the grand-total. The grand-total is given by **total.total.** Note that a member name can be any valid C name and can be the same as an existing structure variable name. The linked name **total.total** represents the **total** member of the structure variable total.

ARRAYS OF STRUCTURES

Program

```
struct marks
{
    int  sub1;
    int  sub2;
    int  sub3;
    int  total;
};
main()
{
    int  i;
    struct marks student[3] =  {{45,67,81,0},
                                {75,53,69,0},
                                {57,36,71,0}};
    struct marks total;

    for(i = 0; i <= 2; i++)
    {
        student[i].total = student[i].sub1 +
                           student[i].sub2 +
                           student[i].sub3;
        total.sub1 = total.sub1 + student[i].sub1;
        total.sub2 = total.sub2 + student[i].sub2;
        total.sub3 = total.sub3 + student[i].sub3;
        total.total = total.total + student[i].total;
    }
    printf(" STUDENT          TOTAL\n\n");
    for(i = 0; i <= 2; i++)
       printf("Student[%d]      %d\n", i+1,student[i].total);

    printf("\n SUBJECT          TOTAL\n\n");

    printf("%s       %d\n%s       %d\n%s       %d\n",
           "Subject 1   ", total.sub1,
           "Subject 2   ", total.sub2,
           "Subject 3   ", total.sub3);

    printf("\nGrand Total = %d\n", total.total);
}
```

Output

```
STUDENT           TOTAL
Student[1]         193
Student[2]         197
Student[3]         164

SUBJECT           TOTAL
Subject 1          177
Subject 2          156
Subject 3          221
```

```
        Grand Total  = 554
```

Fig.10.4 *Illustration of subscripted structure variables*

Example 10.4

Rewrite the program of Example 10.3 using an array member to represent the three subjects.

The modified program is shown in Fig.10.5. You may notice that the use of array name for subjects has simplified in code.

ARRAYS WITHIN A STRUCTURE

Program

```
   main()
   {
       struct  marks
       {
           int  sub[3];
           int  total;
       };
       struct marks student[3] =
       {45,67,81,0,75,53,69,0,57,36,71,0};
       struct marks total;
       int  i,j;

       for(i = 0; i <= 2; i++)
       {
          for(j = 0; j <= 2; j++)
          {
             student[i].total += student[i].sub[j];
             total.sub[j] += student[i].sub[j];
          }
          total.total += student[i].total;
       }
       printf("STUDENT         TOTAL\n\n");
       for(i = 0; i <= 2; i++)
          printf("Student[%d]      %d\n", i+1, student[i].total);

       printf("\nSUBJECT         TOTAL\n\n");
       for(j = 0; j <= 2; j++)
          printf("Subject-%d        %d\n", j+1, total.sub[j]);

       printf("\nGrand Total  =   %d\n", total.total);
```

```
    }
```

Output

```
   STUDENT         TOTAL
   Student[1]       193
   Student[2]       197
   Student[3]       164

   SUBJECT         TOTAL
   Subject-1        177
   Subject-2        156
   Subject-3        221

   Grand Total  =   554
```

Fig.10.5 *Use of subscripted members in structures*

Example 10.5

Write a simple program to illustrate the method of sending an entire structure as a parameter to a function.

A program to update an item is shown in Fig.10.6. The function **update** receives a copy of the structure variable **item** as one of its parameters. Note that both the function **update** and the formal parameter **product** are declared as type **struct stores.** It is done so because the function uses the parameter **product** to receive the structure variable **item** and also to return the updated values of **item**.

The function **mul** is of type **float** because it returns the product of **price** and **quantity.** However, the parameter **stock,** which receives the structure variable **item** is declared as type **struct stores.**

The entire structure returned by **update** can be copied into a structure of identical type. The statement

item = update(item,p_increment,q_increment);

replaces the old values of **item** by the new ones.

STRUCTURES AS FUNCTION PARAMETERS

Program

```
 /*        Passing a copy of the entire structure        */

   struct stores
   {
       char  name[20];
       float price;
       int   quantity;
```

```
};
struct stores update (struct stores product, float p, int q);
float mul (struct stores stock);

main()
{
    float    p_increment, value;
    int      q_increment;

    struct stores item = {"XYZ", 25.75, 12};

    printf("\nInput increment values:");
    printf("   price increment and quantity increment\n");
    scanf("%f %d", &p_increment, &q_increment);

/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
    item  = update(item, p_increment, q_increment);
/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
    printf("Updated values of item\n\n");
    printf("Name      : %s\n",item.name);
    printf("Price     : %f\n",item.price);
    printf("Quantity  : %d\n",item.quantity);

/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
    value  = mul(item);
/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
    printf("\nValue of the item  =  %f\n", value);
}

struct stores update(struct stores product, float p, int q)
{
    product.price += p;
    product.quantity += q;
    return(product);
}
float mul(struct stores stock)
{
    return(stock.price * stock.quantity);
}
```

Output

```
Input increment values:   price increment and quantity increment
10 12
Updated values of item

Name      : XYZ
Price     : 35.750000
Quantity  : 24
```

```
Value of the item  =  858.000000
```

Fig.10.6 *Using structure as a function parameter*

CHAPTER 11:

Example 11.1

Write a program to print the address of a variable along with its value.

The program shown in Fig.11.4, declares and initializes four variables and then prints out these values with their respective storage locations. Notice that we have used %u format for printing address values. Memory addresses are unsigned integers.

```
                  ACCESSING ADDRESSES OF VARIABLES
Program

   main()
   {
       char   a;
       int    x;
       float  p, q;

       a  = 'A';
       x  = 125;
       p  = 10.25, q = 18.76;

       printf("%c is stored at addr %u.\n", a, &a);
       printf("%d is stored at addr %u.\n", x, &x);
       printf("%f is stored at addr %u.\n", p, &p);
       printf("%f is stored at addr %u.\n", q, &q);

   }
```

Output

```
   A is stored at addr 4436.
   125 is stored at addr 4434.
   10.250000 is stored at addr 4442.
   18.760000 is stored at addr 4438.
```

Fig.11.4 *Accessing the address of a variable*

Example 11.2

Write a program to illustrate the use of indirection operator '*' to access the value pointed to by a printer.

The program and output are shown in Fig.11.5. The program clearly shows how we can access the value of a variable using a pointer. You may notice that the value of the pointer **ptr** is 4104 and the value it points to is 10. Further, you may also note the following equivalences:

```
x = *(&x) = *ptr = y
&x = &*ptr
```

ACCESSING VARIABLES USING POINTERS

Program

```
main()
{
    int   x, y;
    int   *ptr;
    x = 10;
    ptr = &x;
    y = *ptr;
    printf("Value of x is %d\n\n",x);
    printf("%d is stored at addr %u\n", x, &x);
    printf("%d is stored at addr %u\n", *&x, &x);
    printf("%d is stored at addr %u\n", *ptr, ptr);
    printf("%d is stored at addr %u\n", y, &*ptr);
    printf("%d is stored at addr %u\n", ptr, &ptr);
    printf("%d is stored at addr %u\n", y, &y);
    *ptr = 25;
    printf("\nNow x = %d\n",x);

}
```

Output

```
Value of x is 10

10   is stored at addr 4104
10   is stored at addr 4104
10   is stored at addr 4104
10   is stored at addr 4104
4104 is stored at addr 4106
10   is stored at addr 4108

Now x = 25
```

Fig.11.5 *Accessing a variable through its pointer*

Example 11.3

Write a program to illustrate the use of pointers in arithmetic operations.

The program in Fig.11.7 shows how the pointer variables can be directly used in expressions. It also illustrates the order of evaluation of expressions. For example, the expression

4* - *p2 / *p1 + 10

is evaluated as follows:

((4 * (-(*p2))) / (*p1)) + 10

When *p1 = 12 and *p2 = 4, this expression evaluates to 9. Remember, since all the variables are of type int, the entire evaluation is carried out using the integer arithmetic.

ILLUSTRATION OF POINTER EXPRESSIONS

Program

```
   main()
   {
       int  a, b, *p1, *p2, x, y, z;

       a  = 12;
       b  =  4;
       p1 = &a;
       p2 = &b;

       x  =  *p1 * *p2 - 6;
       y  =  4*  - *p2 / *p1 + 10;

       printf("Address of a = %u\n", p1);
       printf("Address of b = %u\n", p2);
       printf("\n");
       printf("a = %d, b = %d\n", a, b);
       printf("x = %d, y = %d\n", x, y);

       *p2  = *p2 + 3;
       *p1  = *p2 - 5;
       z    = *p1 * *p2 - 6;

       printf("\na = %d, b = %d,", a, b);
       printf(" z = %d\n", z);
   }
```

Output

```
   Address of a = 4020
   Address of b = 4016

   a = 12, b = 4
   x = 42, y = 9
   a = 2, b = 7, z = 8
```

Fig.11.7 *Evaluation of pointer expressions*

Example 11.4

Write a program using pointers to compute the sum of all elements stored in an array.

The program shown in Fig.11.8 illustrates how a pointer can be used to traverse an array element. Since incrementing an array pointer causes it to point to the next element, we need only to add one to **p** each time we go through the loop.

POINTERS IN ONE-DIMENSIONAL ARRAY

Program

```
main()
{
    int *p, sum, i;
    int x[5] = {5,9,6,3,7};
    i  = 0;
    p  = x;          /* initializing with base address of x */
    printf("Element   Value   Address\n\n");
    while(i < 5)
    {
       printf(" x[%d] %d %u\n", i, *p, p);
       sum = sum + *p;   /* accessing array element  */
       i++, p++;        /* incrementing pointer     */
    }
    printf("\n  Sum    =  %d\n", sum);
    printf("\n  &x[0]  =  %u\n", &x[0]);
    printf("\n  p      =  %u\n", p);
}
```

Output

```
Element    Value     Address
 x[0]       5          166
 x[1]       9          168
 x[2]       6          170
 x[3]       3          172
 x[4]       7          174
Sum    =  55
&x[0]  =  166
p      =  176
```

Fig.11.8 *Accessing array elements using the pointer*

Example 11.5

Write a program using pointers to determine the length of a character string.

A program to count the length of a string is shown in Fig.11.10. The statement

char *cptr = name;

declares **cptr** as a pointer to a character and assigns the address of the first character of **name** as the initial value. Since a string is always terminated by the null character, the statement

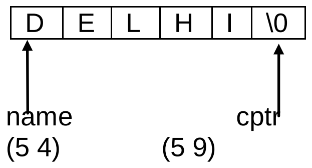
while(*cptr != '\0')

is true until the end of the string is reached.

When the **while** loop is terminated, the pointer **cptr** holds the address of the null character. Therefore, the statement

length = cptr - name;

gives the length of the string **name.**



The output also shows the address location of each character. Note that each character occupies one memory cell (byte).

POINTERS AND CHARACTER STRINGS

Program

```
main()
{
    char  *name;
    int   length;
    char  *cptr = name;
    name  = "DELHI";
    printf ("%s\n", name);

    while(*cptr != '\0')
    {
        printf("%c is stored at address %u\n", *cptr, cptr);
        cptr++;
    }
    length = cptr - name;
    printf("\nLength of the string = %d\n", length);
}
```

Output

```
DELHI
D is stored at address 54
E is stored at address 55
L is stored at address 56
H is stored at address 57
I is stored at address 58

Length of the string = 5
```

Fig.11.10 **String handling by pointers**

Example 11.6

Write a function using pointers to exchange the values stored in two locations in the memory.

The program in Fig.11.11 shows how the contents of two locations can be exchanged using their address locations. The function **exchange()** receives the addresses of the variables **x** and **y** and exchanges their contents.

Program

```
void exchange (int *, int *);     /* prototype */
main()
{
    int  x, y;
    x = 100;
    y = 200;
    printf("Before exchange  : x = %d   y = %d\n\n", x, y);
    exchange(&x,&y);          /* call */
    printf("After exchange   : x = %d   y = %d\n\n", x, y);
}
exchange (int *a, int *b)
{
    int t;

    t = *a;    /* Assign the value at address a to t */
    *a = *b;   /* put b into a */
    *b = t;    /* put t into b */
}
```

Output

```
Before exchange  : x = 100   y = 200

After exchange   : x = 200   y = 100
```

Fig.11.11 *Passing of pointers as function parameters*

Example 11.7

Write a program that uses a function pointer as a function argument.

A program to print the function values over a given range of values is shown in Fig.11.12. The printing is done by the function **table** by evaluating the function passed to it by the **main.**

With **table,** we declare the parameter **f** as a pointer to a function as follows:

double (*f)();

The value returned by the function is of type **double.** When **table** is called in the statement

table (y, 0.0, 2, 0.5);

we pass a pointer to the function **y** as the first parameter of **table**. Note that **y** is not followed by a parameter list.

During the execution of **table,** the statement

value = (*f)(a);

calls the function **y** which is pointed to by **f,** passing it the parameter **a.** Thus the function **y** is evaluated over the range 0.0 to 2.0 at the intervals of 0.5.

Similarly, the call

table (cos, 0.0, PI, 0.5);

passes a pointer to **cos** as its first parameter and therefore, the function **table** evaluates the value of **cos** over the range 0.0 to PI at the intervals of 0.5.

ILLUSTRATION OF POINTERS TO FUNCTIONS

Program

```
#include  <math.h>
#define  PI  3.1415926
double y(double);
double cos(double);
double table (double(*f)(), double, double, double);

main()
{   printf("Table of y(x) = 2*x*x-x+1\n\n");
    table(y, 0.0, 2.0, 0.5);

    printf("\nTable of cos(x)\n\n");
    table(cos, 0.0, PI, 0.5);
}
double table(double(*f)(),double min, double max, double step)
{   double a, value;
    for(a = min; a <= max; a += step)
    {
       value = (*f)(a);
       printf("%5.2f  %10.4f\n", a, value);
    }
}
double y(double x)
{  return(2*x*x-x+1);
}
```

Output

```
Table of y(x) = 2*x*x-x+1
     0.00      1.0000
     0.50      1.0000
     1.00      2.0000
     1.50      4.0000
     2.00      7.0000

Table of cos(x)
     0.00      1.0000
     0.50      0.8776
     1.00      0.5403
```

```
          1.50      0.0707
          2.00     -0.4161
          2.50     -0.8011
          3.00     -0.9900
```

Fig.11.12 *Use of pointers to functions*

Example 11.8

Write a program to illustrate the use of structure pointers.

A program to illustrate the use of a structure pointer to manipulate the elements of an array of structures is shown in Fig.11.13. The program highlights all the features discussed above. Note that the pointer **ptr** (of type **struct invent)** is also used as the loop control index in **for** loops.

POINTERS TO STRUCTURE VARIABLES

Program

```
struct invent
{
    char  *name[20];
    int   number;
    float price;
};
main()
{
   struct invent product[3], *ptr;
   printf("INPUT\n\n");
   for(ptr = product; ptr < product+3; ptr++)
     scanf("%s %d %f", ptr->name, &ptr->number, &ptr->price);

   printf("\nOUTPUT\n\n");

    ptr = product;
    while(ptr < product + 3)
    {
        printf("%-20s %5d %10.2f\n",
                 ptr->name,
                 ptr->number,
                 ptr->price);
        ptr++;
    }
}
```

Output

```
INPUT

Washing_machine   5    7500
Electric_iron    12     350
Two_in_one        7    1250
```

```
OUTPUT

Washing machine    5   7500.00
Electric_iron      12   350.00
Two_in_one         7   1250.00
```

Fig.11.13 *Pointer to structure variables*

ILLUSTRATIONS OF STRING-HANDLING FUNCTIONS

Program

```
#include    <string.h>
main()
{   char  s1[20], s2[20], s3[20];
    int   x, l1, l2, l3;
    printf("\n\nEnter two string constants \n");
    printf("?");
    scanf("%s %s", s1, s2);
 /* comparing s1 and s2 */
    x = strcmp(s1, s2);
    if(x != 0)
    {   printf("\n\nStrings are not equal \n");
        strcat(s1, s2);   /* joining s1 and s2 */
    }
    else
        printf("\n\nStrings are equal \n");
/* copying s1 to s3
    strcpy(s3, s1);
 /* Finding length of strings */
    l1 = strlen(s1);
    l2 = strlen(s2);
    l3 = strlen(s3);
 /* output */
    printf("\ns1 = %s\t length = %d characters\n", s1, l1);
    printf("s2 = %s\t length = %d characters\n", s2, l2);
    printf("s3 = %s\t length = %d characters\n", s3, l3);

}
```

Output

```
Enter two string constants
? New York

Strings are not equal

s1 = NewYork     length = 7 characters
s2 = York        length = 4 characters
s3 = NewYork     length = 7 characters

Enter two string constants
? London   London

Strings are equal

s1 = London      length = 6 characters
s2 = London      length = 6 characters
s3 = London      length = 6 characters
```

Fig.7.9 *Illustration of string handling functions*

Example 8.9

Write a program that would sort a list of names in alphabetical order.

A program to sort the list of strings in alphabetical order is given in Fig.8.10. It employs the method of bubble sorting described in Case Study 1 in the previous chapter.

SORTING OF STRINGS IN ALPHABETICAL ORDER

Program

```
#define ITEMS   5
#define MAXCHAR 20

main( )
{
    char string[ITEMS][MAXCHAR], dummy[MAXCHAR];
     int  i = 0, j = 0;

    /* Reading the list */

    printf ("Enter names of %d items \n ",ITEMS);
    while (i < ITEMS)
         scanf ("%s", string[i++]);

    /* Sorting begins */

    for (i=1; i < ITEMS; i++) /* Outer loop begins */
    {
         for (j=1; j <= ITEMS-i ; j++) /*Inner loop begins*/
```

```
            {
                 if (strcmp (string[j-1], string[j]) > 0)
                 {   /* Exchange of contents */
                     strcpy (dummy, string[j-1]);
                     strcpy (string[j-1], string[j]);
                     strcpy (string[j], dummy );
                 }

            } /* Inner loop ends */

       } /* Outer loop ends */

       /* Sorting completed */

       printf ("\nAlphabetical list \n\n");
       for (i=0; i < ITEMS ; i++)
           printf ("%s", string[i]);
   }
```

Output

Enter names of 5 items

```
London Manchester Delhi Paris Moscow
Alphabetical list

Delhi
London
Manchester
Moscow
Paris
```

Fig.8.10 *Sorting of strings.*

CHAPTER 12:

Example 12.1

Write a program to read data from the keyboard, write it to a file called **INPUT,** again read the same data from the **INPUT** file, and display it on the screen.

A program and the related input and output data are shown in Fig.12.1. We enter the input data via the keyboard and the program writes it, character by character, to the file **INPUT**. The end of the data is indicated by entering an **EOF** character, which is *control-Z* in the reference system. (This may be control-D in other systems). The file INPUT is closed at this signal.

WRITING TO AND READING FROM A FILE

Program

```
   #include  <stdio.h>

   main()
   {
       FILE *f1;
       char c;
       printf("Data Input\n\n");
      /* Open the file INPUT */
       f1 = fopen("INPUT", "w");

      /* Get a character from keyboard   */
       while((c=getchar()) != EOF)

          /* Write a character to INPUT  */
           putc(c,f1);
       /* Close the file INPUT   */
       fclose(f1);
       printf("\nData Output\n\n");
       /* Reopen the file INPUT    */
       f1 = fopen("INPUT","r");

      /* Read a character from INPUT*/
       while((c=getc(f1)) != EOF)

          /* Display a character on screen */
           printf("%c",c);

       /* Close the file INPUT       */
       fclose(f1);
   }
```

Output

```
   Data Input
   This is a program to test the file handling
   features on this system^Z

   Data Output
   This is a program to test the file handling
   features on this system
```

Fig.12.1 *Character oriented read/write operations on a file*

Example 12.2

A file named **DATA** contains a series of integer numbers. Code a program to read these numbers and then write all 'odd' numbers to a file to be called **ODD** and all `even' numbers to a file to be called **EVEN.**

The program is shown in Fig.12.2. It uses three files simultaneously and therefore we need to define three-file pointers **f1, f2** and **f3.**

First, the file DATA containing integer values is created. The integer values are read from the terminal and are written to the file **DATA** with the help of the statement

putw(number, f1);

Notice that when we type -1, the reading is terminated and the file is closed. The next step is to open all the three files, **DATA** for reading, **ODD** and **EVEN** for writing. The contents of **DATA** file are read, integer by integer, by the function **getw(f1)** and written to **ODD** or **EVEN** file after an appropriate test. Note that the statement

(number = getw(f1)) != EOF

reads a value, assigns the same to **number**, and then tests for the end-of-file mark.

Finally, the program displays the contents of ODD and EVEN files. It is important to note that the files **ODD** and **EVEN** opened for writing are closed before they are reopened for reading.

HANDLING OF INTEGER DATA FILES

Program

```
   #include  <stdio.h>
   main()
   {
       FILE  *f1, *f2, *f3;
       int   number, i;

       printf("Contents of DATA file\n\n");
       f1 = fopen("DATA", "w");      /* Create DATA file    */
       for(i = 1; i <= 30; i++)
       {
          scanf("%d", &number);
          if(number == -1) break;
          putw(number,f1);
       }
       fclose(f1);

       f1 = fopen("DATA", "r");
       f2 = fopen("ODD", "w");
       f3 = fopen("EVEN", "w");

       /* Read from DATA file */
       while((number = getw(f1)) != EOF)
       {
           if(number %2 == 0)
```

```
            putw(number, f3);   /*  Write to EVEN file  */
          else
            putw(number, f2);   /*  Write to ODD file   */
      }
      fclose(f1);
      fclose(f2);
      fclose(f3);

      f2 = fopen("ODD","r");
      f3 = fopen("EVEN", "r");
      printf("\n\nContents of ODD file\n\n");

      while((number = getw(f2)) != EOF)
         printf("%4d", number);
      printf("\n\nContents of EVEN file\n\n");

      while((number = getw(f3)) != EOF)
         printf("%4d", number);

      fclose(f2);
      fclose(f3);

  }
```

Output

```
Contents of DATA file
111 222 333 444 555 666 777 888 999 000 121 232 343 454 565 -1

Contents of ODD file
111 333 555 777 999 121 343 565

Contents of EVEN file
222 444 666 888   0 232 454
```

Fig.12.2 Operations on integer data

Example 12.3

Write a program to open a file named INVENTORY and store in it the following data:

Item name	Number	Price	Quantity
AAA-1	111	17.50	115
BBB-2	125	36.00	75
C-3	247	31.75	104

Extend the program to read this data from the file INVENTORY and display the inventory table with the value of each item.

The program is given in Fig.12.3. The filename INVENTORY is supplied through the keyboard. Data is read using the function **fscanf** from the file **stdin,** which refers to the terminal and it is then written to the file that is being pointed to by the file pointer **fp.** Remember that the file pointer **fp** points to the file INVENTORY.

After closing the file INVENTORY, it is again reopened for reading. The data from the file, along with the item values are written to the file **stdout,** which refers to the screen. While reading from a file, care should be taken to use the same format specifications with which the contents have been written to the file.…é

HANDLING OF FILES WITH MIXED DATA TYPES
(fscanf and fprinf)

Program

```
#include  <stdio.h>

main()
{
    FILE  *fp;
    int    number, quantity, i;
    float  price, value;
    char   item[10], filename[10];

    printf("Input file name\n");
    scanf("%s", filename);

    fp = fopen(filename, "w");

    printf("Input inventory data\n\n");
    printf("Item name  Number   Price   Quantity\n");
    for(i = 1; i <= 3; i++)
    {
       fscanf(stdin, "%s %d %f %d",
                     item, &number, &price, &quantity);
       fprintf(fp, "%s %d %.2f %d",
                     item, number, price, quantity);
    }
    fclose(fp);
    fprintf(stdout, "\n\n");

    fp = fopen(filename, "r");

    printf("Item name  Number   Price   Quantity    Value\n");
    for(i = 1; i <= 3; i++)
    {
       fscanf(fp, "%s %d %f d",item,&number,&price,&quantity);
       value = price * quantity;
       fprintf(stdout, "%-8s %7d %8.2f %8d %11.2f\n",
                      item, number, price, quantity, value);
    }
    fclose(fp);
}
```

Output

```
Input file name
INVENTORY
Input inventory data

Item name  Number   Price   Quantity
AAA-1  111  17.50  115
BBB-2  125  36.00  75
C-3    247  31.75  104

Item name  Number   Price   Quantity    Value
AAA-1        111    17.50      115     2012.50
BBB-2        125    36.00       75     2700.00
C-3          247    31.75      104     3302.00
```

Fig.12.3 ***Operations on mixed data types***

Example 12.4

Write a program to illustrate error handling in file operations.

The program shown in Fig.12.4 illustrates the use of the **NULL** pointer test and **feof** function. When we input filename as TETS, the function call

fopen("TETS", "r");

returns a **NULL** pointer because the file TETS does not exist and therefore the message "Cannot open the file" is printed out.

Similarly, the call **feof(fp2)** returns a non-zero integer when the entire data has been read, and hence the program prints the message "Ran out of data" and terminates further reading.

ERROR HANDLING IN FILE OPERATIONS

Program

```
#include  <stdio.h>

main()
{
   char  *filename;
    FILE  *fp1, *fp2;
    int   i, number;
```

```
     fp1 = fopen("TEST", "w");
     for(i = 10; i <= 100; i += 10)
        putw(i, fp1);

     fclose(fp1);

     printf("\nInput filename\n");

 open_file:
     scanf("%s", filename);

     if((fp2 = fopen(filename,"r")) == NULL)
     {
        printf("Cannot open the file.\n");
        printf("Type filename again.\n\n");
        goto open_file;
     }

     else

     for(i = 1; i <= 20; i++)
     {  number = getw(fp2);
        if(feof(fp2))
        {
           printf("\nRan out of data.\n");
           break;
        }
        else
           printf("%d\n", number);
     }

     fclose(fp2);
 }
```

Output

```
Input filename
TETS
Cannot open the file.
Type filename again.

TEST
10
20
30
```

```
40
50
60
70
80
90
100

Ran out of data.
```

Fig.12.4 *Illustration of error handling*

Example 12.5

Write a program that uses the functions **ftell** and **fseek.**

A program employing **ftell** and **fseek** functions is shown in Fig.12.5. We have created a file **RANDOM** with the following contents:

Position ----> 0 1 2 25

Character
stored ----> A B C . . . . .Z

We are reading the file twice. First, we are reading the content of every fifth position and printing its value along with its position on the screen. The second time, we are reading the contents of the file from the end and printing the same on the screen.

During the first reading, the file pointer crosses the end-of-file mark when the parameter **n** of **fsee(fp,n,0)** becomes 30. Therefore, after printing the content of position 30, the loop is terminated.

For reading the file from the end, we use the statement

fseek(fp,-1L,2);

to position the file pointer to the last character. Since every read causes the position to move forward by one position, we have to move it back by two positions to read the next character. This is achieved by the function

fseek(fp, -2L, 1);

in the while statement. This statement also tests whether the file pointer has crossed the file boundary or not. The loop is terminated as soon as it crosses it.

ILLUSTRATION OF fseek & ftell FUNCTIONS

Program

```
#include <stdio.h>
main()
{
    FILE  *fp;
    long  n;
```

```
        char c;

        fp = fopen("RANDOM", "w");

        while((c = getchar()) != EOF)
            putc(c,fp);

        printf("No. of characters entered = %ld\n", ftell(fp));
        fclose(fp);
        fp = fopen("RANDOM","r");
        n = 0L;

        while(feof(fp) == 0)
        {
            fseek(fp, n, 0);  /*  Position to (n+1)th character */
            printf("Position of %c is %ld\n", getc(fp),ftell(fp));
            n = n+5L;
        }
        putchar('\n');

        fseek(fp,-1L,2);     /*  Position to the last character */
          do
          {
              putchar(getc(fp));
          }
          while(!fseek(fp,-2L,1));
          fclose(fp);
    }
```

Output

```
   ABCDEFGHIJKLMNOPQRSTUVWXYZ^Z
   No. of characters entered = 26
   Position of A is 0
   Position of F is 5
   Position of K is 10
   Position of P is 15
   Position of U is 20
   Position of Z is 25
   Position of   is 30

   ZYXWVUTSRQPONMLKJIHGFEDCBA
```

Fig.12.5 *Illustration of* ***fseek*** *and* ***ftell*** *functions*

Example 12.6

Write a program to append additional items to the file INVENTORY and print the total contents of the file.

The program is shown in Fig.12.6. It uses a structure definition to describe each item and a function **append()** to add an item to the file.

On execution, the program requests for the filename to which data is to be appended. After appending the items, the position of the last character in the file is assigned to **n** and then the file is closed.

The file is reopened for reading and its contents are displayed. Note that reading and displaying are done under the control of a **while** loop. The loop tests the current file position against n and is terminated when they become equal.

APPENDING ITEMS TO AN EXISTING FILE

Program

```
#include  <stdio.h>

struct invent_record
{
    char   name[10];
    int    number;
    float  price;
    int    quantity;
};

main()
{
    struct invent_record item;
    char  filename[10];
    int   response;
    FILE  *fp;
    long  n;

    void append (struct invent_record 8x, file *y);

    printf("Type filename:");
    scanf("%s", filename);

    fp = fopen(filename, "a+");
    do
    {
       append(&item, fp);
       printf("\nItem %s appended.\n",item.name);
       printf("\nDo you want to add another item\
        (1 for YES /0 for NO)?");
       scanf("%d", &response);
    }  while (response == 1);

    n = ftell(fp);      /* Position of last character  */
    fclose(fp);

    fp = fopen(filename, "r");
```

```
     while(ftell(fp) < n)
     {
        fscanf(fp,"%s %d %f %d",
        item.name, &item.number, &item.price, &item.quantity);
        fprintf(stdout,"%-8s %7d %8.2f %8d\n",
        item.name, item.number, item.price, item.quantity);
     }
     fclose(fp);
}
void append(struct invent_record *product, File *ptr)
{
     printf("Item name:");
     scanf("%s", product->name);

     printf("Item number:");
     scanf("%d", &product->number);

     printf("Item price:");
     scanf("%f", &product->price);

     printf("Quantity:");
     scanf("%d", &product->quantity);

     fprintf(ptr, "%s %d %.2f %d",
                  product->name,
                  product->number,
                  product->price,
                  product->quantity);
}
```

Output

```
Type filename:INVENTORY
Item name:XXX
Item number:444
Item price:40.50
Quantity:34

Item XXX appended.
Do you want to add another item(1 for YES /0 for NO)?1
Item name:YYY
Item number:555
Item price:50.50
Quantity:45

Item YYY appended.
Do you want to add another item(1 for YES /0 for NO)?0
AAA-1         111    17.50      115
BBB-2         125    36.00       75
C-3           247    31.75      104
XXX           444    40.50       34
```

```
   YYY           555    50.50        45
```

Fig.12.6 *Adding items to an existing file*

Example 12.7

Write a program that will receive a filename and a line of text as command line arguments and write the text to the file.

Figure 12.7 shows the use of command line arguments. The command line is

```
F12_7 TEXT AAAAAA BBBBBB CCCCCC DDDDDD EEEEEE FFFFFF GGGGGG
```

Each word in the command line is an argument to the **main** and therefore the total number of arguments is 9.

The argument vector **argv[1]** points to the string TEXT and therefore the statement

fp = fopen(argv[1], "w");

opens a file with the name TEXT. The **for** loop that follows immediately writes the remaining 7 arguments to the file TEXT.

COMMAND LINE ARGUMENTS

Program

```
   #include  <stdio.h>

   main(argc, argv)
   int  argc;                    /*   argument count           */
   char *argv[];                 /*   list of arguments        */
   {
       FILE   *fp;
       int  i;
       char word[15];

       fp = fopen(argv[1], "w"); /* open file with name argv[1] */
   printf("\nNo. of arguments in Command line = %d\n\n",argc);


       for(i = 2; i < argc; i++)
          fprintf(fp,"%s ", argv[i]); /* write to file argv[1]  */
       fclose(fp);

   /*  Writing content of the file to screen                    */

       printf("Contents of %s file\n\n", argv[1]);
       fp = fopen(argv[1], "r");
       for(i = 2; i < argc; i++)
       {
          fscanf(fp,"%s", word);
          printf("%s ", word);
       }

       fclose(fp);
       printf("\n\n");

   /*  Writing the arguments from memory */

       for(i = 0; i < argc; i++)
          printf("%*s \n", i*5,argv[i]);
   }
```

Output

```
C>F12_7 TEXT AAAAAA BBBBBB CCCCCC DDDDDD EEEEEE FFFFFF GGGGG

No. of arguments in Command line = 9

Contents of TEXT file

AAAAAA BBBBBB CCCCCC DDDDDD EEEEEE FFFFFF GGGGGG

C:\C\F12_7.EXE
 TEXT
    AAAAAA
         BBBBBB
              CCCCCC
                   DDDDDD
                        EEEEEE
                             FFFFFF
                                  GGGGGG
```

Fig.12.7 *Use of command line arguments*

CHAPTER 13:

Example 13.1

Write a program that uses a table of integers whose size will be specified interactively at run time.

The program is given in Fig.13.2. It tests for availability of memory space of required size. If it is available, then the required space is allocated and the address of the first byte of the space allocated is displayed. The program also illustrates the use of pointer variable for storing and accessing the table values.

USE OF **malloc** FUNCTION

Program

```
#include <stdio.h>
#include <stdlib.h>
#define NULL 0

main()
{
   int *p, *table;
   int size;
   printf("\nWhat is the size of table?");
   scanf("%d",size);
   printf("\n")
      /*------------Memory allocation --------------*/
   if((table = (int*)malloc(size *sizeof(int))) == NULL)
    {
      printf("No space available \n");
      exit(1);
    }
   printf("\n Address of the first byte is  %u\n", table);
   /* Reading table values*/
   printf("\nInput table values\n");

   for (p=table; p<table + size; p++)
        scanf("%d",p);
   /* Printing table values in reverse order*/
   for (p = table + size -1; p >= table; p --)
      printf("%d is stored at address %u \n",*p,p);

}
```

Output

```
What is the size of the table? 5
Address of the first byte is 2262
Input table values
11 12 13 14 15
15 is stored at address 2270
14 is stored at address 2268
13 is stored at address 2266
12 is stored at address 2264
11 is stored at address 2262
```

Fig.13.2 *Memory allocation with* ***malloc***

Example 13.2

Write a program to store a character string in a block of memory space created by **malloc** and then modify the same to store a larger string.

The program is shown in Fig. 13.3. The output illustrates that the original buffer size obtained is modified to contain a larger string. Note that the original contents of the buffer remains same even after modification of the original size.

```
                    USE OF realloc AND free FUNCTIONS
```

Program

```
#include <stdio.h>
#include<stdlib.h>
#define NULL 0

main()
{
 char *buffer;

 /* Allocating memory */

 if((buffer = (char *)malloc(10)) == NULL)
 {
   printf(“malloc failed.\n”);
   exit(1);
 }

 printf(“Buffer of size %d created \n”,_msize(buffer));
 strcpy(buffer, “HYDERABAD”);
 printf(“\nBuffer contains: %s \n “, buffer);

 /* Realloction */

 if((buffer = (char *)realloc(buffer, 15)) == NULL)
 {
   printf(“Reallocation failed. \n”);
   exit(1);
 }
 printf(“\nBuffer size modified. \n”);
 printf(“\nBuffer still contains: %s \n”,buffer);

 strcpy(buffer, “SECUNDERBAD”);
 printf(“\nBuffer now contains: %s \n”,buffer);

/* Freeing memory */

free(buffer);
}
```

Output

```
 Buffer of size 10 created
 Buffer contains: HYDERABAD
 Buffer size modified
 Buffer still contains: HYDERABAD
 Buffer now contains: SECUNDERABAD
```

Fig . 13.3 *Reallocation and release of memory space*

Example 13.3

Write a program to create a linear linked list interactively and print out the list and the total number of items in the list.

The program shown in Fig.13.7 first allocates a block of memory dynamically for the first node using the statement

head = (node *)malloc(sizeof(node));

which returns a pointer to a structure of type **node** that has been type defined earlier. The linked list is then created by the function **create**. The function requests for the number to be placed in the current node that has been created. If the value assigned to the current node is –999, then null is assigned to the pointer variable **next** and the list ends. Otherwise, memory space is allocated to the next node using again the **malloc** function and the next value is placed into it. Not that the function **create** calls itself recursively and the process will continue until we enter the number –999.

The items stored in the linked list are printed using the function **print** which accept a pointer to the current node as an argument. It is a recursive function and stops when it receives a NULL pointer. Printing algorithm is as follows;

1. Start with the first node.
2. While there are valid nodes left to print

   a) print the current item and
   b) advance to next node

Similarly, the function **count** counts the number of items in the list recursively and return the total number of items to the **main** function. Note that the counting does not include the item –999 (contained in the dummy node).

CREATING A LINEAR LINKED LIST

Program

```
#include<stdio.h>
#include<stdlib.h>
#define NULL 0

struct linked_list
{
   int number;
   struct linked_list *next;
};
typedef struct linked_list node;  /* node type defined */

main()
{
   node *head;
   void create(node *p);
   int count(node *p);
   void print(node *p);
   head = (node *)malloc(sizeof(node));
   create(head);
   printf("\n");
   printf(head);
   printf("\n");
   printf("\nNumber of items = %d \n", count(head));
}
void create(node *list)
{
   printf("Input a number\n");
   printf("(type -999 at end): ");
   scanf("%d", &list -> number); /* create current node */

   if(list->number == -999)
   {
      list->next = NULL;
   }
   else    /*create next node */
   {
      list->next = (node *)malloc(sizeof(node));
      create(list->next);
   }
   return;
}

void print(node *list)
{
      if(list->next != NULL)
      {
        printf("%d-->",list ->number);  /* print current item */

         if(list->next->next == NULL)
            printf("%d", list->next->number);

        printf(list->next);       /* move to next item */
      }
      return;
   }

   int count(node *list)
   {
      if(list->next == NULL)
              return (0);
      else
              return(1+ count(list->next));
   }
```

Output

```
Input a number
(type -999 to end); 60
Input a number
(type -999 to end); 20
Input a number
(type -999 to end); 10
Input a number
(type -999 to end); 40
Input a number
(type -999 to end); 30
Input a number
(type -999 to end); 50
Input a number
(type -999 to end); -999

60 -->20 -->10 -->40 -->30 -->50 --> -999

Number of items = 6
```

Fig. 13.7 *Creating a linear linked list*

Example 13.4

Write a function to insert a given item *before* a specified node known as key node.

The function **insert** shown in Fig.13.8 requests for the item to be inserted as well as the 'key node". If the insertion happens to be at the beginning, then memory space is created for the new node, the value of new item is assigned to it and the pointer **head** is assigned to the next member. The pointer **new** which indicates the beginning of the new node is assigned to **head.** Note the following statements:

```
new->number = x;
new->next = head;
head = new;
```

FUNCTION INSERT

```
node *insert(node *head)
{
   node *find(node *p, int a);
   node *new;          /* pointer to new node */
   node *n1;           /* pointer to node preceding key node */
   int key;
   int x;              /* new item (number) to be inserted */

   printf("Value of new item?");
   scanf("%d", &x);
   printf("Value of key item ? (type -999 if last) ");
   scanf("%d", &key);

   if(head->number == key)       /* new node is first */
   {
        new = (node *)malloc(size of(node));
        new ->number = x;
        new->next = head;
        head = new;
   }
   else          /* find key node and insert new node */
   {             /* before the key node */
     n1 = find(head, key);    /* find key node */

     if(n1 == NULL)
        printf("\n key is not found \n");
     else       /* insert new node */
     {
        new = (node *)malloc(sizeof(node));
        new->number = x;
        new->next = n1->next;
        n1->next = new;
     }
   }
return(head);
}
node *find(node *lists, int key)
{
     if(list->next->number == key)    /* key found */
          return(list);
   else

     if(list->next->next == NULL)     /* end */
          return(NULL);
   else
     find(list->next, key);
}
```

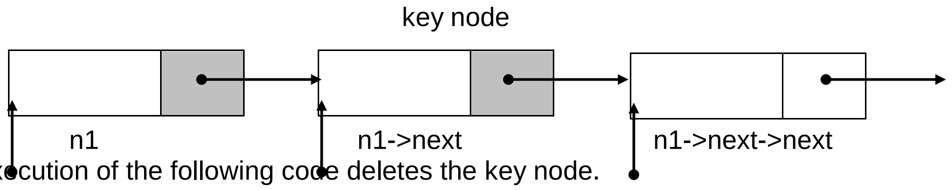
Fig. 13.8 *A function for inserting an item into a linked list*

Example 13.5

Write a function to delete a specified node.

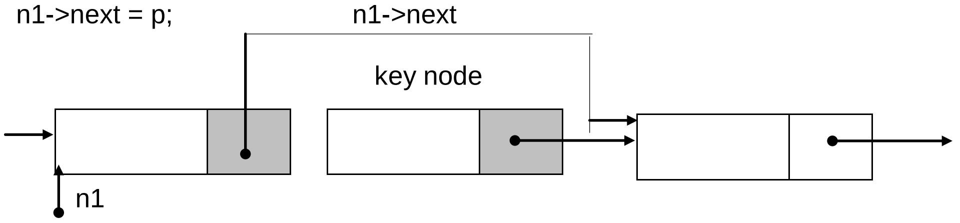
A function to delete a specified node is given in Fig.13.9. The function first checks whether the specified item belongs to the first node. If yes, then the pointer to the second node is temporarily assigned the pointer variable **p**, the memory space occupied by the first node is freed and the location of the second node is assigned to **head**. Thus, the previous second node becomes the first node of the new list.

If the item to be deleted is not the first one, then we use the **find** function to locate the position of ‘key node’ containing the item to be deleted. The pointers are interchanged with the help of a temporary pointer variable making the pointer in the preceding node to point to the node following the key node. The memory space of key node that has been deleted if freed. The figure below shows the relative position of the key node.



The execution of the following code deletes the key node.

p = n1->next->next;
free (n1->next);
n1->next = p;



FUNCTION DELETE

```
node *delete(node *head)
{
   node *find(node *p, int a);
   int  key;     /* item to be deleted */
   node *n1;     /* pointer to node preceding key node */
   node *p;      /* temporary pointer */

   printf(“\n What is the item (number) to be deleted?”);
   scanf(“%d”, &key);

   if(head->number == key)  /* first node to be deleted) */
   {
      p = head->next;        /* pointer to 2nd node  in list */
      free(head);            /* release space of key node */
      head = p;              /* make head to point to 1st node */
   }
   else
   {
      n1 = find(head, key);

      if(n1 == NULL)
         printf(“\n key not found \n”);
      else                              /* delete key node */
      {
            p = n1->next->next;         /*  pointer to the node
                                       following the keynode */
            free(n1->next);             /* free key node */
            n1->next = p;               /* establish link */
      }
   }
return(head);
}
                   /* USE FUNCTION find() HERE */
```

Fig.13.9 *A function for deleting an item from linked list*