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Computational Technique Lab

1. ERRORS CALCULATION

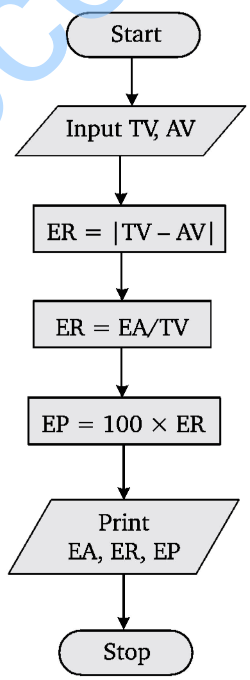
Symbols Used

TV = True Value
AV = Approximate Value
EA = Absolute Error
ER = Relative Error
EP = Percentage Error

Algorithm : Calculation of Errors

Step 1. START
Step 2. Input TV, AV
Step 3. EA = |TV – AV|
Step 4. ER = EA/TA
Step 5. EP = ER * 100
Step 6. Print EA, ER, EP
Step 7. STOP

Flow Chart : Errors Calculation



PROGRAM : *Write a program to calculate the errors.*

//error calculation

```
#include<stdio.h>
#include<conio.h>
#include<math.h>
void main()
{
   float tv,av,er,ep,ea;
   clrscr();
   printf("\n enter true value \n");
   scanf( "%f",&tv);
   printf("\n enter approximate value\n");
   scanf( "%f",&av);
   ea=fabs(tv-av);
   er=ea/tv;
   ep=100*er;
   printf("\n\n absolute error= %e ",ea);
   printf("\n\n relative error= %e ",er);
   printf("\n\n percentage error= %e ",ep);
   getch();
   }
```

Output: ERROR CALCULATION

```
enter true value
37.46235
enter approximate value
37.46
absolute error= 2.349854e-03
relative error= 6.272574e-05
percentage error= 6.272574e-03
```

2. CONVERSION OF DECIMAL TO BINARY NUMBER

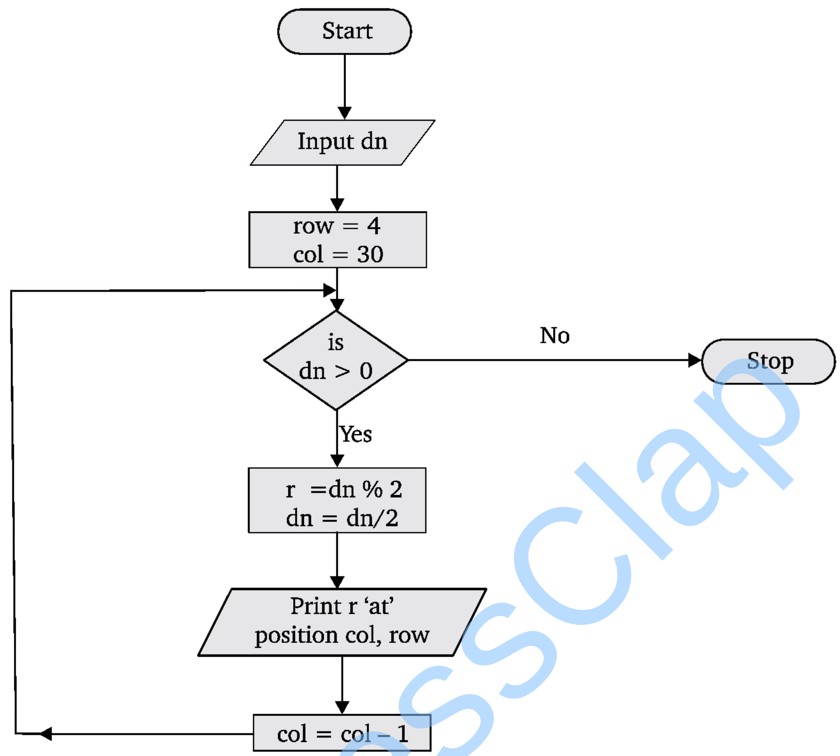
SYMBOLS USED

bn = binary number
dn = decimal number
r = remainder

ALGORITHM : DECIMAL TO BINARY CONVERSION

Step 1. START
Step 2. Input dn
Step 3. row = 4, col = 30
Step 4. Perform steps 5 to 8 while (dn > 0)
Step 5. r = dn%2
Step 6. dn = dn/2
Step 7. Print r 'at' col, row
Step 8. col = col – 1
Step 9. STOP

FLOW CHART : DECIMAL TO BINARY CONVERSION



PROGRAM. *Write a C program to convert a given decimal number into binary number.*

```
// Decimal to binary conversion
#include<stdio.h>
#include<conio.h>
void main()
 {
   int dn,r,row=4,col=30;
   clrscr();
  printf("\n enter  decimal number   ");
  scanf("%d",&dn);
  printf("\n binary no. is = ");
  while(dn>0)
      {
       r=dn%2;
       dn=dn/2;
       gotoxy(col,row);
       printf("%d",r);
       col- -;
       }
       getch();
  }
```

Output: DECIMAL TO BINARY CONVERSION

enter decimal number 99
binary no. is = 1100011

3. CONVERSION OF BINARY TO DECIMAL NUMBER

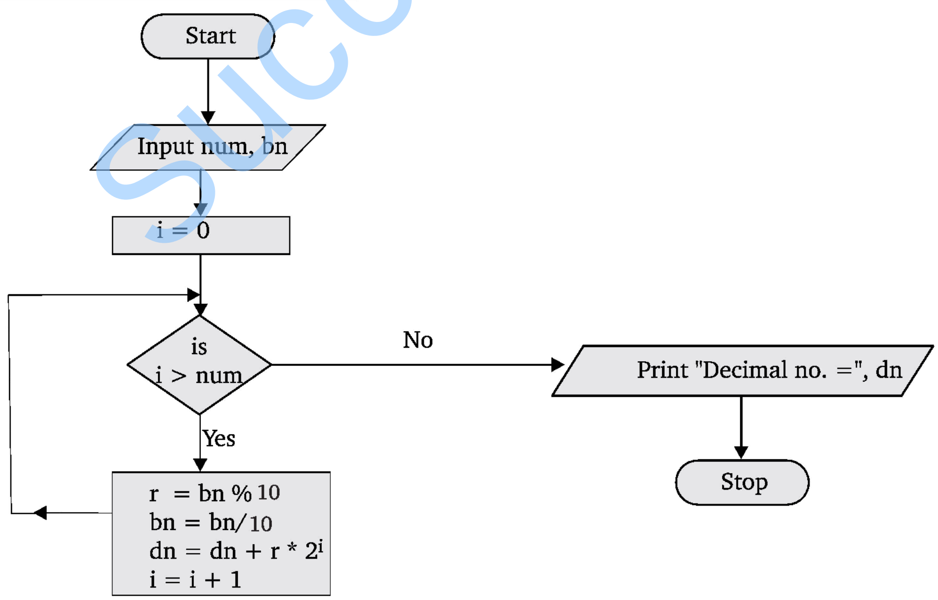
SYMBOLS USED

bn = binary number
dn = decimal number
num = number of digits in a binary number
r = remainder

ALGORITHM : BINARY TO DECIMAL CONVERSION

Step 1. Start
Step 2. Input num, bn
Step 3. i = 0
Step 4. Perform step 5 to 8 while (i < num)
Step 5. r = bn % 10
Step 6. bn = bn/10
Step 7. dn = dn + r * (2^i)
Step 8. i = i + 1
Step 9. Print "decimal no = ", dn
Step 10. Stop

FLOW CHART : BINARY TO DECIMAL NUMBER



PROGRAM. *Write a C-program to convert a given binary number to decimal number.*

```
// Binary to decimal conversion
#include<stdio.h>
#include<conio.h>
#include<math.h>
void main()
 {
   int r,i,num;
   long int bn,dn=0;
   clrscr();
  printf("\n enter  number of digits\n ");
  scanf("%d",&num);
  printf("\n enter binary number   ");
  scanf("%ld",&bn);
  printf("\n decimal no. is = ");
  for(i=0;i<num;i++)
    {
       r=bn%10;
       bn=bn/10;
       dn=dn +r*pow(2,i);
     }
printf("%ld",dn);
getch();
}
```

Output : BINARY TO DECIMAL CONVERSION
enter number of digits
7
enter binary number 1100011
decimal no. is = 99

3. CONVERSION OF DECIMAL NUMBER TO OCTAL NUMBER

SYMBOLS USED

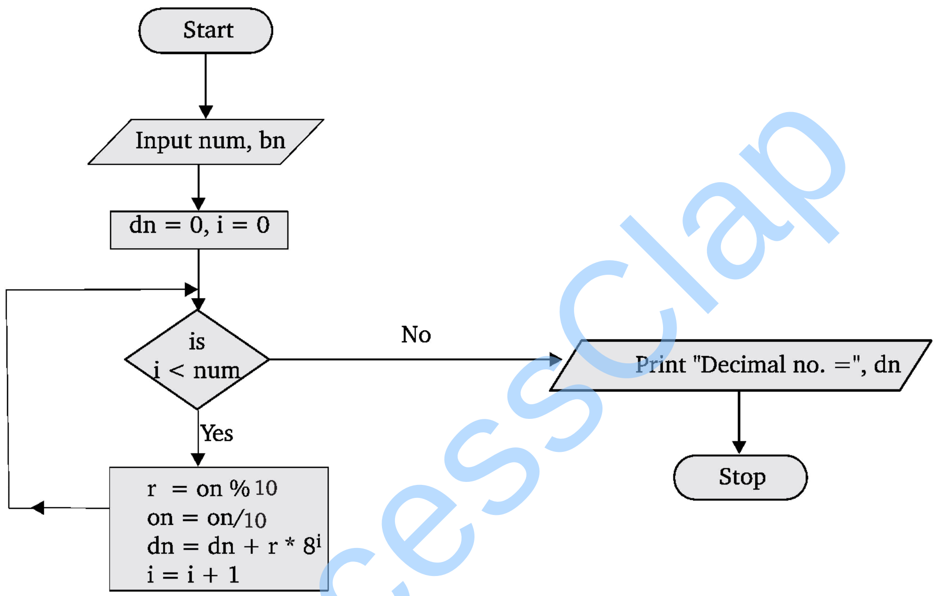
dn = decimal number
on = octal number

ALGORITHM : CONVERT DECIMAL NUMBER INTO EQUIVALENT OCTAL NUMBER

Step 1. Start
Step 2. Input dn
Step 3. on = 0, i = 1

Step 4. Perform steps 5 to 8 while (dn > 0)
Step 5. r = dn % 8
Step 6. dn = dn/8
Step 7. on = on + r* i
Step 8. i = i* 10
Step 9. Print "Equivalent octal number" on,
Step 10. Stop

FLOW CHART : CONVERSION OF DECIMAL NUMBER TO OCTAL NUMBER



PROGRAM : *Write a C program to convert a decimal number into octal number.*

// Decimal to octal conversion

```
#include<stdio.h>
#include<conio.h>
void main()
{
int dn,r,on=0,i=1;
clrscr();
printf("\n enter decimal number   ");
scanf("%d",&dn);
printf("\n octal no. is = ");
while(dn>0)
{
         r=dn%8;
         dn=dn/8;
         on=on+r*i;
         i=i*10;
}
printf("%d",on);
```

```
getch();
}
```

Output : DECIMAL TO OCTAL CONVERSION

enter decimal number 9876
Octal no. is = 23072

4. CONVERSION OF GIVEN OCTAL NUMBER INTO AN EQUIVALENT DECIMAL NUMBER

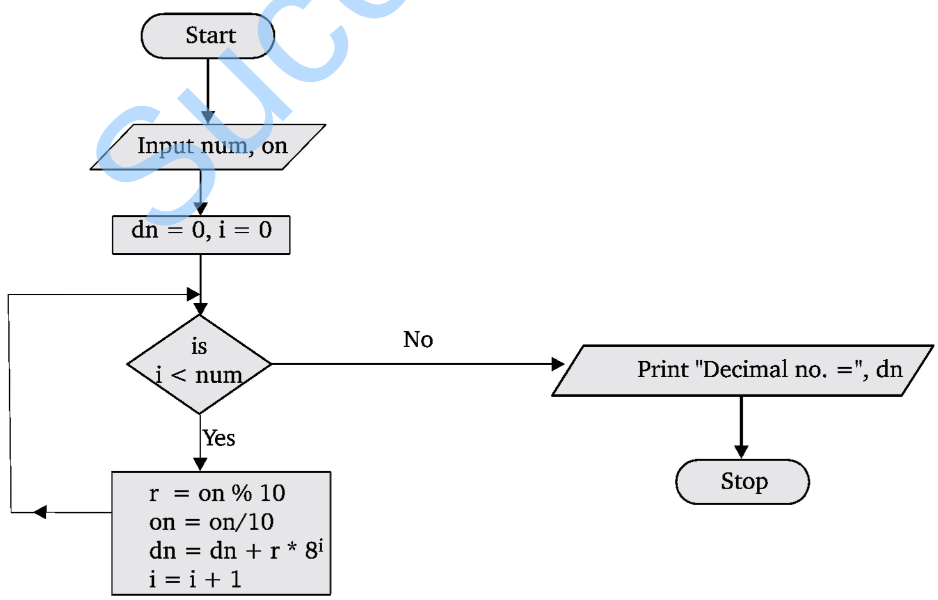
SYMBOLS USED

dn = decimal number
on = octal number
num = number of digits in Octal number

ALGORITHM : CONVERT OCTAL NUMBER INTO DECIMAL NUMBER

Step 1. START
Step 2. Input "Enter number of digits", num
Step 3. Input "Enter Octal number", on
Step 4. i = 0; dn = 0
Step 5. Perform steps 6 to 8 while (i < num)
Step 6. r = on % 10
Step 7. on = on/10
Step 8. dn = dn + r * 8^i
Step 9. Print "decimal number = ", dn
Step 10. STOP

FLOW CHART : CONVERSION OF OCTAL NUMBER INTO DECIMAL NUMBER



PROGRAM : *Write a C program to convert a given octal number into a decimal number.*

// Octal to decimal conversion

```
#include<stdio.h>
#include<conio.h>
#include<math.h>
void main()
 {
int r,i,num;
int on,dn=0;
clrscr();
printf("\n enter  number of digits\n ");
scanf("%d",&num);
printf("\n enter octal number   ");
scanf("%d",&on);
printf("\n decimal no. is = ");
for(i=0;i<num;i++)
{
       r=on%10;
       on=on/10;
       dn=dn+r*pow(8,i);
}
printf("%d",dn);
getch();
}
```

Output : OCTAL TO DECIMAL CONVERSION

enter number of digits 4
enter octal number 1727
decimal no. is = 983

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COMPUTATIONAL TECHNIQUE LAB

1. BISECTION METHOD

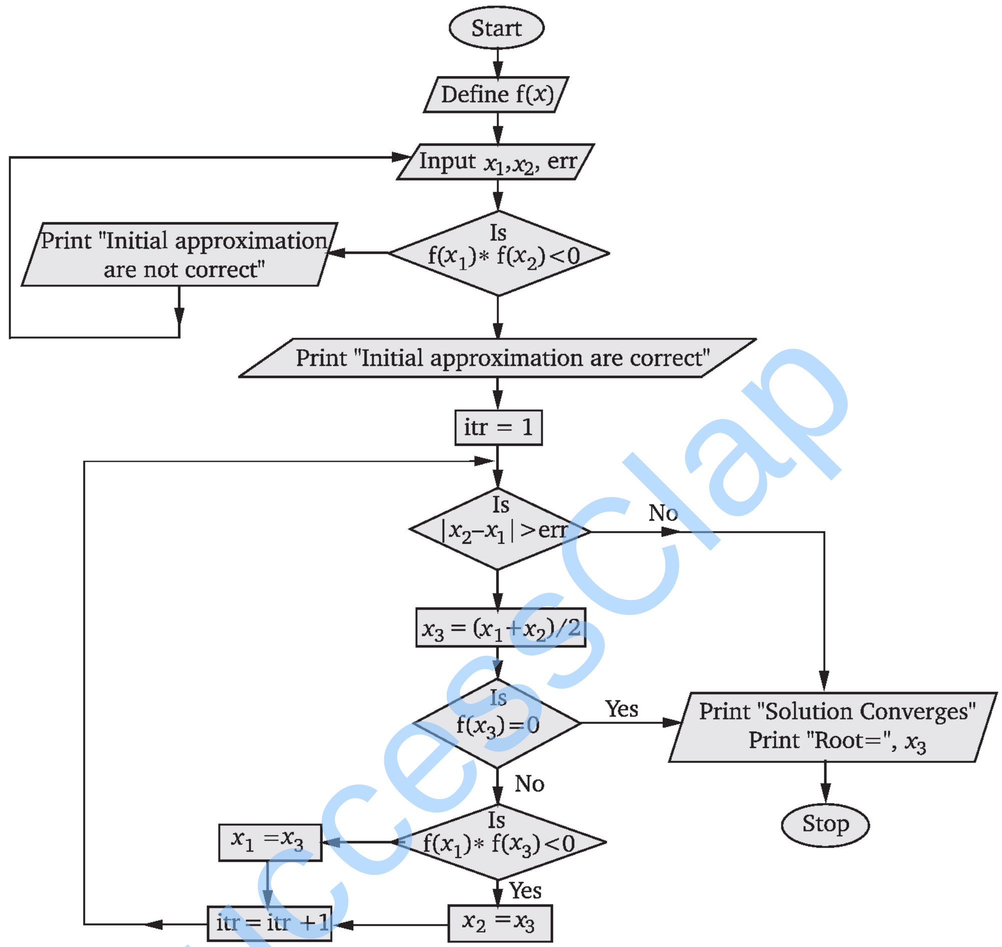
SYMBOL USED

x_1, x_2 = Initial approximations in which root lies.
err = allow error
x_3 = New approximation of the root in each iteration
itr = a counter which keeps track of the no. of iterations performed.

ALGORITHM : BISECTION METHOD

Step 1. Start
Step 2. Define $f(x)$
Step 3. Input x_1, x_2, err
Step 4. If $(f(x_1) * (f(x_2)) < 0$
        print "Initial approximations are correct"
    else
        print "Initial approximations are not correct"
        go to step 3
Step 5. itr = 1
Step 6. Perform steps 7 to 10 while $(|x_2 - x_1| > \text{err})$
Step 7. $x_3 = (x_1 + x_2)/2$
Step 8. if $f(x_3) = 0$
    Print "Solution converges in iteration", i
    Print "Root =", x_3
    go to step 13
Step 9. If $(f(x_1) * (f(x_3)) < 0$
        $x_2 = x_3$
    else
        $x_1 = x_3$
Step 10. itr = itr +1
Step 11. Print "Solution converges in iteration", i
Step 12. Print "Root=", x_3
Step 13. STOP

FLOW CHART : BISECTION METHOD



PROGRAM. *Following is a C program to find the root of the equation $f(x) = x^3 - 4 * x - 9$ by Bisection method.* (UPTU B.Tech. 2003)

```
// Bisection Method
/*Bisection Method to find root of x*x*x-4*x-9=0 */
# include<stdio.h>
# include<conio.h>
# include<math.h>
# include<process.h>

float f(float x)
 {
      return(x*x*x-4*x-9 );
  }
```

```
 void  main()
{
  clrscr();
int itr=1;
float x1,x2,x3, err;

start: printf("Enter the value of x1, x2,"
                     "allowed error\n");
       scanf("%f%f%f", &x1,&x2,&err);

if(f(x1)*f(x2)<0)
    printf("\n initial approximations are correct\n");
else
   { printf("\n initial approximations are  not correct\n");
      goto start;
    }
while(fabs(x2-x1)>err)
{
   x3=(x1+x2)/2;
   if(f(x3)==0)
      {
      printf("\nsolution converges in iteration=%d",itr);
      printf("\n Root=%f",x3);
      exit(0);
      }
     if(f(x1)*f(x3)<0)
        x2=x3;
     else
        x1=x3;
   itr++;
 }
    printf("\n solution converges in iteration=%d",itr);
    printf("\n Root=%f",x3);
    getch();
}
```

Output: BISECTION METHOD TO FIND ROOT OF x*x*x-4*x-9=0

```
Enter the value of x1, x2, allowed error
3     2       .0005
initial approximations are correct
solution converges in iteration =12
Root=2.7065
```

LAB ASSIGNMENT : BISECTION METHOD

1. Write a C program to find the root of the equation by using Bisection method correct to two places of decimal.

$$f(x) = x^3 - x - 11 = 0$$

Hint: Define a function $f(x) = x * x * x - x - 11$

Input: $x_1 = 2, x_2 = 3$, err $= 0.5 \times 10^{-2} = 0.005$

Output: Root = 2.38

2. Write C program to find root for the given function by Bisection method correct to two decimal places.

$$f(x) = 3x - \sqrt{1 + \sin x}$$

Hint: Define $f(x) = 3 * x -$ sqrt $(1 + \sin(x))$

Input : $x_1 = 0$, $x_2 = 1$ err $= 0.005$

Output: Root = 0.39

3. Write a C program to find root using Bisection method correct to two decimal places for following function.

$$f(x) = x^2 - 4x - 10 = 0$$

Hint: Define $f(x) = x * x - 4 * x - 10$

Input $x_1 = 5, x_2 = 6$ and err $= 0.005$

Output Root = 5.738

4. Write a C program to find root using Bisection method correct to two decimal places for following function.

$$x \log_{10} x = 1.2$$

Hint: Define $f(x) = x * \log_{10}(x) - 1.2$

Input $x_1 = 2, x_2 = 3$, err $= 0.005$

Output Root = 2.74.

2. ITERATION METHOD

SYMBOLS USED

x_1 = Initial approximations of the root

x_2 = New approximation of root in each iteration

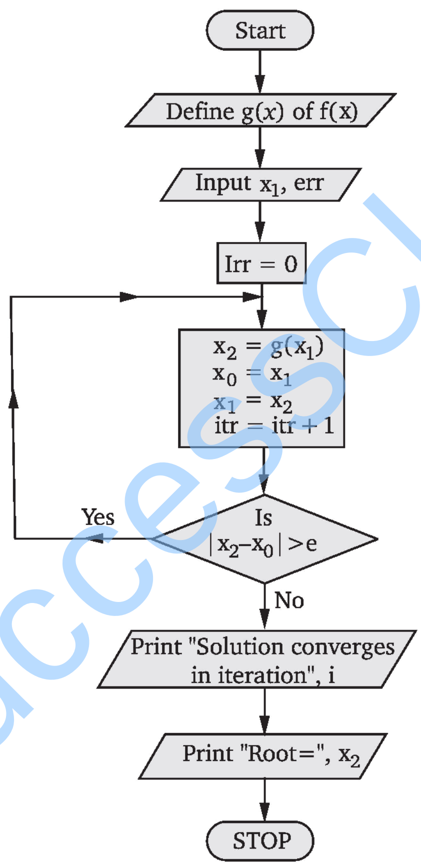
x_0 = Used to store the previous value of x_1

ALGORITHM : ITERATION METHOD

Step 1. Start
Step 2. For given function $f(x)$ defined $g(x)$
Step 3. Input x_1, err
Step 4. itr = 0
Step 5. Perform steps 6 to 9 while $(|x_2 - x_0| > \text{err})$
Step 6. $x_2 = g(x_1)$

Step 7. $x_0 = x_1$
Step 8. $x_1 = x_2$
Step 9. itr = itr + 1
Step 10. Print "Solution converges in iteration", i
Step 11. Print "Root=", x_2
Step 12. STOP

FLOW CHART : ITERATION METHOD



PROGRAM. *Following is a C program to find the root of the equation* $f(x)=2x-\log_{10}x-7=0$ *by using iteration method correct to 4 decimal places.*

We have $f(x)=2x-\log_{10}x-7=0$

It can be written as

$$x=\frac{1}{2}(\log_{10}x+7)$$

Define $g(x) = (\log_{10}(x)+7)/2$

Program for iteration method

/*Iteration Method to find root of $2x$-$\log_{10}$x-7=0 */

```
# include<stdio.h>
# include<conio.h>
#include<math.h>
#include<process.h>

float g(float x)
{
      return((log10(x)+7)/2);
}

void  main()
{
  clrscr();
int itr=0;
float x1,x2,xo, err;

      printf("Enter the value of x1, allowed error\n");
      scanf("%f%f", &x1,&err);
  do
    {
      x2=g(x1);
      xo=x1;
     x1=x2;
     itr++;
      } while(fabs((x2-xo)>err));

      printf("\n solution converges in iteration =%d",itr);
      printf("\n Root=%f",x2);
     getch();
  }
```

Output: ITERATION METHOD TO FIND ROOT OF 2x-log10x-7=0

```
Enter the value of x1, allowed error
3     .00005

solution converges in iteration = 5

Root= 3.789278
```


LAB ASSIGNMENTS : ITERATION METHOD

1. Write a C program to find root of the equation $f(x) = x^3 - 2x + 1 = 0$ using iteration method correct to 3 decimal places.

Hint : $f(x) = x^3 - 2x + 1 = 0$

$$g(x) = \quad x = \frac{x^3+1}{2}$$

Define $g(x) = (x * x * x + 1)/2$
Input $x_1 = 0$, err = 0.0005
Output Root = 0.6175

2. Write C program to write real root of the equation cos x = 3x –1 correct to three decimal places using iteration method.

Hint : $f(x) = \cos x = 3x - 1$

$$x = \frac{\cos x + 1}{3} = g(x)$$

Define $g(x) = (\cos(x) + 1)/3$
Input : $x_1 = 0$, err = 0.0005
Output : Root = 0.607

3. Write C program to find real root of the equation by iteration method upto 4 decimal places

$$f(x) = x^3 + x^2 - 1 = 0$$

Hint :

$$x = \frac{1}{\sqrt{1+x}}$$

Define g(x) = (1/sqrt (1+x))
Input $x_1 = 0.5$, err = 0.00005
Output Root = 0.7548

3. REGULA-FALSI METHOD

SYMBOLS USED

x_1, x_2 = Initial approximations near to the root
x_3 = New approximation in each iteration
err = allowed error
max itr = Maximum no. of iterations
itr = iteration counter

ALGORITHM : REGULA-FALSI METHOD

Step 1. Start
Step 2. Define function $f(x)$
Step 3. Input x_1, x_2, err, maxitr
Step 4. If $(f(x_1) * f(x_2)) \leq 0$
    Print "Initial approximation are correct"
  else
    Print "Initial approximation are not correct".
  goto step 3
Step 5. itr = 1
Step 6. Repeat steps 7 to 9 while (ite <= maxitr)
Step 7. $x_3 = (x_1 * f(x_2) - x_2 * f(x_1))/f(x_2) - f(x_1))$

if $(|f(x_3) < \text{err}\,|)$
Print "Solution converges in iteration", itr
Print "Root=", x_3
goto step 11

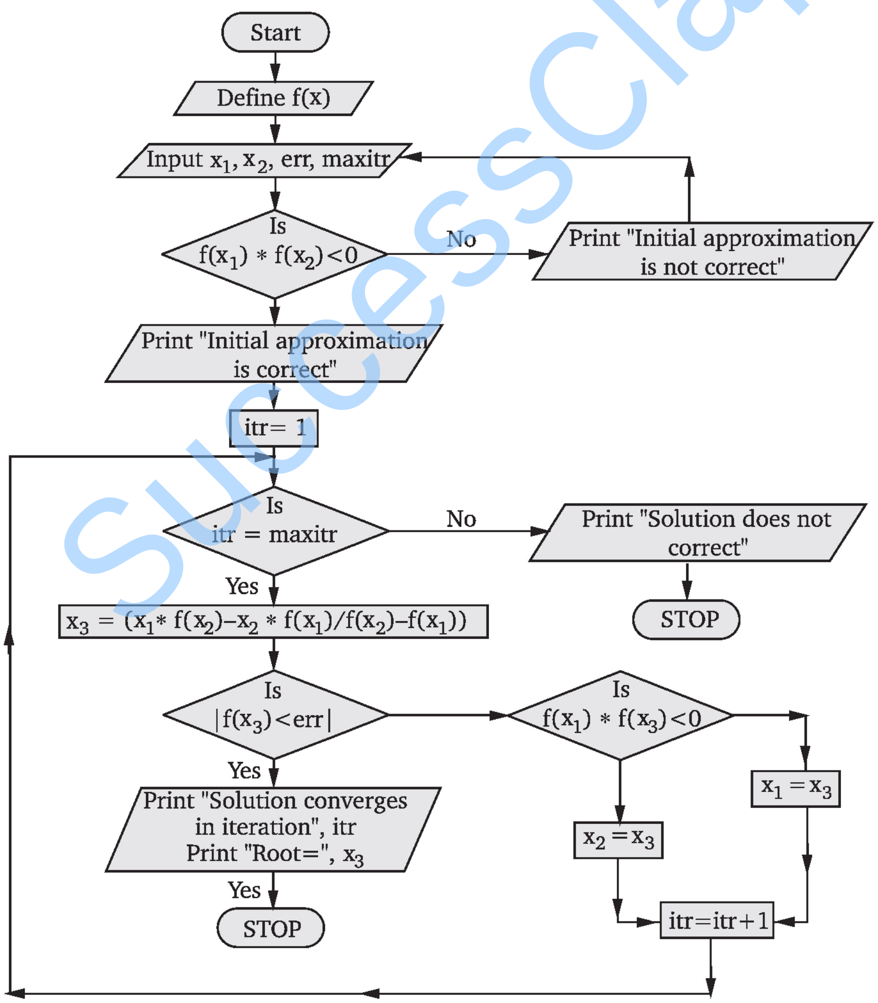
Step 8. if $(f(x_1) * f(x_3)) < 0$
$x_2 = x_3$
else
$x_1 = x_3$

Step 9. itr = itr + 1

Step 10. Print "Solution does not converges, iterations not sufficient"

Step 11. STOP

FLOW CHART : REGULA-FALSI METHOD



PROGRAM. *Following is a C program to find the root of the equation* $f(x) = \cos x - xe^x$ *by using Regula-Falsi method.* (UPTU B.Tech. 2002)

REGULA FALSI METHOD

/* REGULA FALSI METHOD FOR cos(x)-xe^x */

```
#include<stdio.h>
#include<conio.h>
#include<math.h>
float f(float x)
{
return cos(x)-x*exp(x);
}
void main()
{
      int itr, maxitr;
      float x1,x2,x3,err;
      clrscr();
   start: printf("enter the value of x1,x2, allowed error,
maximum iteration\n");
      scanf("%f%f%f%d", &x1,&x2,&err, &maxitr);

      if(f(x1)*f(x2)<0)
          printf("\n inital approximation are correct");
       else
        {
         printf("\n inital approximation are not correct\n");
          goto start;
         }
    for(itr=1;itr<=maxitr;itr++)
     {
       x3= (x1*f(x2)-x2*f(x1))/(f(x2)-f(x1));
      if(fabs(f(x3))<=err)
      {
        printf("\n Solutions converges in iterations =%d",
          itr);
         printf("\n Root=%f",x3);
         getch();
         exit(0);
      }
     if (f(x1)*f(x3)<0)
         x2=x3;
     else
         x1=x3;
    }
    printf("\n Solution does not converge,"
      "iterations not Sufficient\n");
     getch();
    }
```

Output: REGULA FALSI METHOD FOR COS(X)-X*eX

```
enter the value of x1,x2, allowed error, maximum iteration

0    1       .00005   20

Solutions converges in iterations = 10

Root = 0.517748
```

LAB ASSIGNMENTS

1. Write C program to find root of the equation $x^3 - 9x + 1 = 0$ by Regula-Falsi method.

Hint : Define $f(x) = x * x * x - 9 * x + 1$

Input $x_1 = 2$, $x_2 = 3$, err = 0.00005, maxitr = 8

Output Root = 2.9428

2. Write C program to find root of the equation $xe^x - 3 = 0$ by Regula-Falsi method correct to three decimal places.

Input : $x_1 = 1$, $x_2 = 1.5$, err = 0.0005, maxitr = 10

Output : Root = 1.049

3. Write C program to find real root of the equation by Regula-Falsi method

$$f(x) = x^2 - \log_e x - 12$$

Hint : Define $f(x) = x * x - \log(x) - 12$

Input : $x_1 = 3$, $x_2 = 4$, err = 0.0005, maxitr = 8

4. NEWTON-RAPHSON METHOD

SYMBOLS USED

x_1 = Initial approximation of the root
x_2 = New approximation of the root in each iteration
itr = iteration counter
err = allowed error
x_0 = old value of x_1 and x_1 is changed in each iteration
df(x) = first derivative of $f(x)$

ALGORITHM : NEWTON-RAPHSON METHOD

Step 1. Start
Step 2. Define function $f(x)$ and $df(x)$
Step 3. Input x_1, err
Step 4. itr = 0
Step 5. Repeat steps 6 to 10 until ($|x_2 - x_0| < e$)

Step 6. if df(x_1) = 0
Print "Initial approximation is not correct"
goto step 3

Step 7. $x_2 = x_1 - (f(x_1)/\ df(x_1))$

Step 8. $x_0 = x_1$

Step 9. $x_1 = x_2$

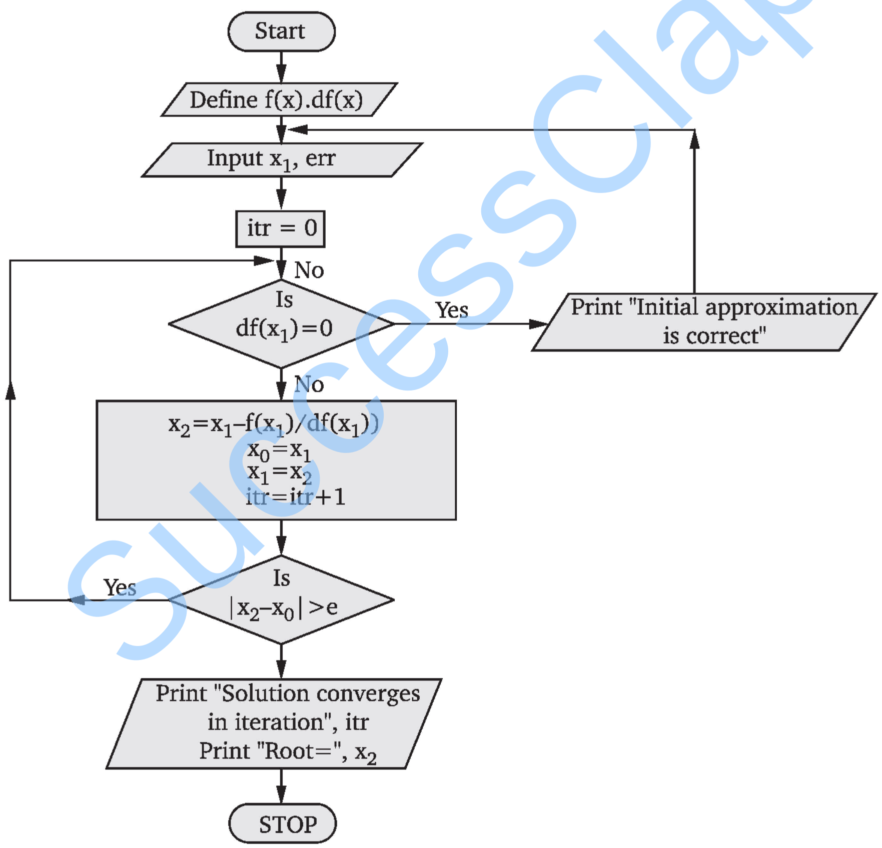
Step 10. itr = itr + 1

Step 11. Print "Solution converges in iterations", itr

Step 12. Print "Root=", x_2

Step 13. STOP

FLOW CHART : NEWTON-RAPHSON METHOD



PROGRAM. *Following is a C program to find the root of the equation $f(x) = x^4 - x - 10$ by using Newton-Raphson method.*

We have $f(x) = x^4 - x - 10$

$\Rightarrow \quad df(x) = 4x^3 - 1$

NEWTON RAPHSON METHOD

/*NEWTON RAPHSON METHOD TO FIND ROOT OF $x^4 - x - 10$ */

```
#include<stdio.h>
#include<conio.h>
#include<math.h>

float f(float x)
{
      return  x*x*x*x-x-10;
}
float df (float x)
{
      return 4*x*x*x-1;
}
void main ()
{
      int itr=0;
      float x1,x2,err,xo;
      clrscr();

 start:      printf("\n Enter the value of x1,allowed error\
n\n");
      scanf("%f%f",&x1,&err);

     do
      {
       if(df(x1)==0)
           {
          printf("\n Initial approximation is not correct");
            goto start;
           }
       x2=x1-f(x1)/df(x1);
       xo=x1;
       x1=x2;
       itr++ ;
      } while(fabs(x2-xo)>err);
```

```
printf("\n Solution converges in iteration = %d\n",itr);
printf("\nRoot =%f",x2);
getch();
}
```

Output : NEWTON RAPHSON METHOD TO FIND ROOT OF x4-x-10

```
Enter the value of x1,allowed error
1.6   .0005
Solution converges in iteration = 4
Root=1.855585
```

LAB ASSIGNMENTS : NEWTON-RAPHSON METHOD

1. Write C program to find root of the equation $f(x) = x^3 - 2x - 5$ correct to 3 decimal places by Newton-Raphson method.

Hint : Define $f(x) = x * x * x - 2 * x - 5$

and $f(x) = 3 * x * x - 2$

Input $x_1 = 2$, err = 0.0005

Output Root = 2.09455

2. Write C program to find root of the equation $x \log_{10} x = 1.2$ by Newton-Raphson method correct to four decimal places.

Hint : Define $f(x) = x * \log_{10}(x) - 1.2$

$df(x) = \log_{10}(x) + 0.4343$

Input : $x_1 = 2$, err = 0.00005

Output : Root = 2.7408

3. Write C program to find square root of 12 correct to three decimal places by Newton-Raphson method.

Hint : Define $f(x) = x^2 - 12 = 0$

$f(x) = x * x - 12$

$df(x) = 2 * x$

Input : $x_1 = 3.4$, err = 0.0005

Output : Root = 3.464

5. MULLER'S METHOD

SYMBOLS USED

x_1, x_2, x_3 = Initial approximation

x_4 = New iteration in each step

err = allowed error

itr = iteration counter

ALGORITHM : MULLER'S METHOD

Step 1. Start

Step 2. Define $f(x)$

Step 3. Input x_1, x_2, x_3, err

Step 4. $f_1 = f(x_1), f_2 = f(x_2), f_3 = f(x_3)$, itr = 0

Step 5. Repeat steps 6 to 17 until ($|h| < e$)

Step 6. itr = itr + 1

Step 7. $h_1 = x_1 - x_3$, $h_2 = x_2 - x_3$

Step 8. $d_1 = f_1 - f_3$, $d_2 = f_2 - f_3$

Step 9. $a_1 = f_1$

Step 10. $d = h_1 * h_2 * (h_1 - h_2)$

Step 11. $a_2 = (d_2 * h_1^2 - d_1 * h_2^2)/\text{d}$

Step 12. $a_3 = (d_1 * h_2 - d_2 * h_1)/\text{d}$

Step 13. if $(a_2 > 0)$

$h = -2 * a_1 / (a_2 + \sqrt{a_2^2 - 4 * a_1 * a_3})$

else

$h = -2 * a_1 / (a_2 - \sqrt{a_2^2 - 4 * a_1 * a_3})$

Step 14. $x_4 = x_3 + h$

Step 15. $f_4 = f(x_4)$

Step 16. $x_1 = x_2, x_2 = x_3, x_3 = x_4$

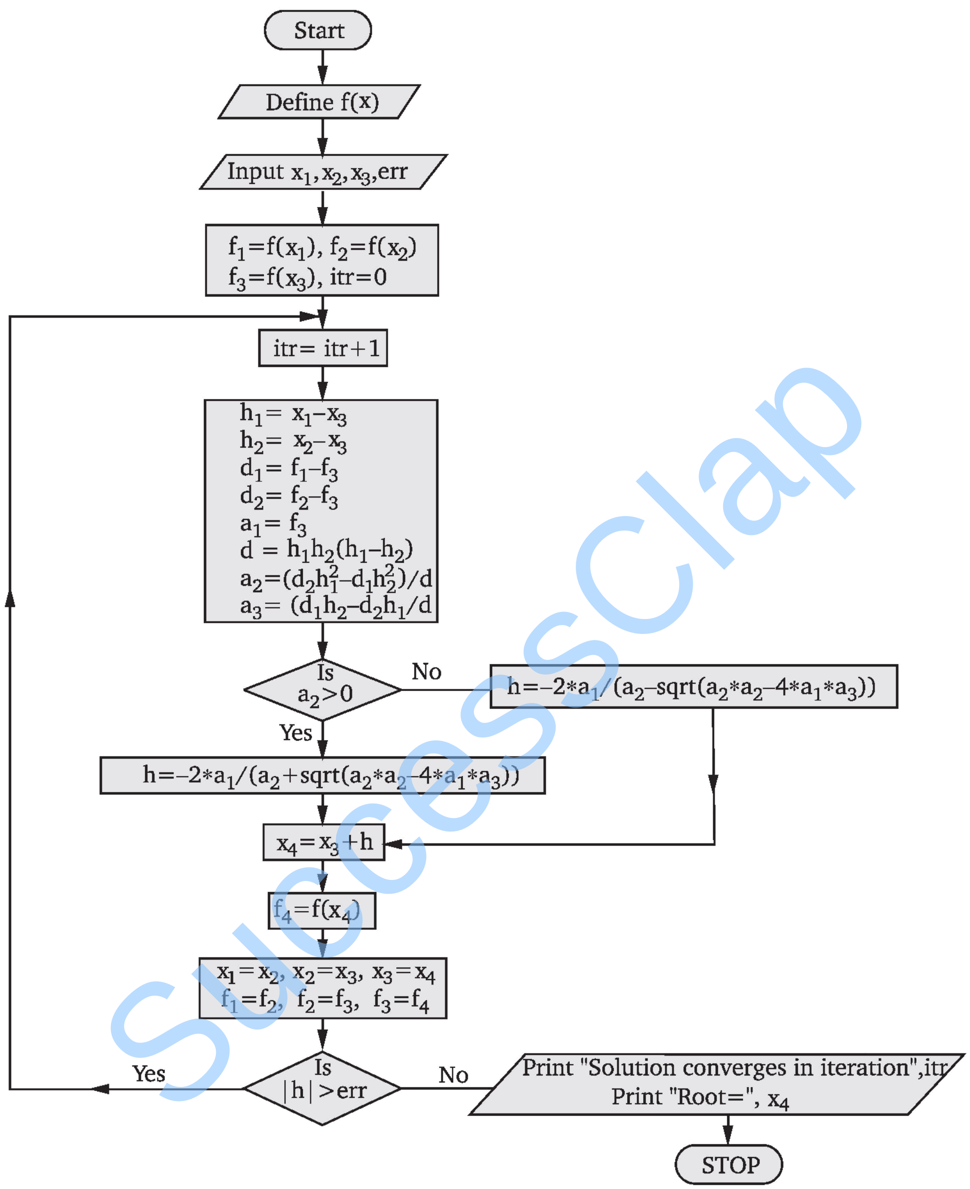
Step 17. $f_1 = f_2, f_2 = f_3, f_3 = f_4$

Step 18. Print "Solution converges in iteration", itr

Step 19. Print "Root=", x_4

Step 20. STOP

FLOW CHART : MULLER METHOD



PROGRAM. *Following is a C program to find the root of the equation* $f(x) = \cos x - xe^x$ *by Muller's method.*

MULLER'S METHOD

/* MULLER'S METHOD cos(x)-x*ex */

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

```
#include<math.h>

float f(float x)
{
return cos(x)-x*exp(x);
}
void main()
   {
     int  itr=0;
     float x1,x2,x3,x4,err,d,d1,d2,h1,h2,a1,a2,a3,h;
     float f1,f2,f3,f4;
     clrscr();

   printf("\n Enter initial approximation x1,x2,x3 \n");
   scanf("%f%f%f",&x1,&x2,&x3);
   printf("\n  Enter the allowed error\n");
   scanf("%f", &err);
   f1=f(x1), f2=f(x2), f3=f(x3);
    do
     {
       itr++ ;
       h1=x1-x3;
       h2=x2-x3;
       d1=f1-f3;
       d2=f2-f3;
       a1=f3;
       d=h1*h2*(h1-h2);
       a2=(d2*h1*h1-d1*h2*h2)/d;
       a3=(d1*h2-d2*h1)/d;
       if(a2>0)
            h=-2*a1/(a2+sqrt(a2*a2-4*a1*a3));
       else
            h=-2*a1/(a2-sqrt(a2*a2-4*a1*a3));
       x4=x3+h;
       f4=f(x4);
       x1=x2,   x2=x3,   x3=x4 ;
       f1=f2,   f2=f3,   f3=f4 ;
     } while(fabs(h)>err);

     printf("\n  Solution converges in iterations=%d",itr);
     printf("\n\n Root =%f",x4);
     getch();
      }
```

Output: MULLER'S METHOD FOR cos(x)-x*ex

```
Enter initial approximation x1,x2,x3
-1    0       1

Enter the allowed error
.0005

Solution converges in iterations =4

Root = 0.517757
```

LAB ASSIGNMENTS : MULLER'S METHOD

1. Write C program to find the root of the equation $x^3 - x - 4 = 0$ by Muller method correct to 4 decimal places.

Hint : Define $f(x) = x * x * x - x - 4$

Input : $x_1 = 0, x_2 = 1, x_3 = 2$

err = 0.00005

Output Root = 1.7963

2. Write a C program to find root of the equation $3x + \sin x - e^x$ by Muller's method.

Hint : Define $f(x) = 3 * x - \sin(x) - \exp(x)$

Input : $x_1 = 0.5, x_2 = 1.0, x_3 = 0.0$

Output : Root = 0.36042

3. Write C program to find the root of the equation

$f(x) = x^3 + 2x^2 + 10x - 20 = 0$ by Muller method.

Hint : Define $f(x) = x * x * x + 2 * x * + 10 * x - 20$

Input : $x_1 = 0, x_2 = 1, x_3 = 2$, err = 0.0005

Output : Root = 1.3688

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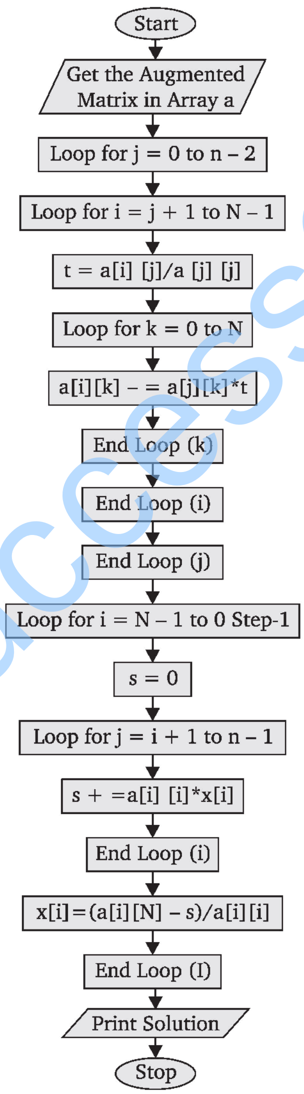
COMPUTATIONAL TECHNIQUE LAB

1. GAUSS ELIMINATION METHOD

FLOW CHART FOR GAUSS-ELIMINATION METHOD



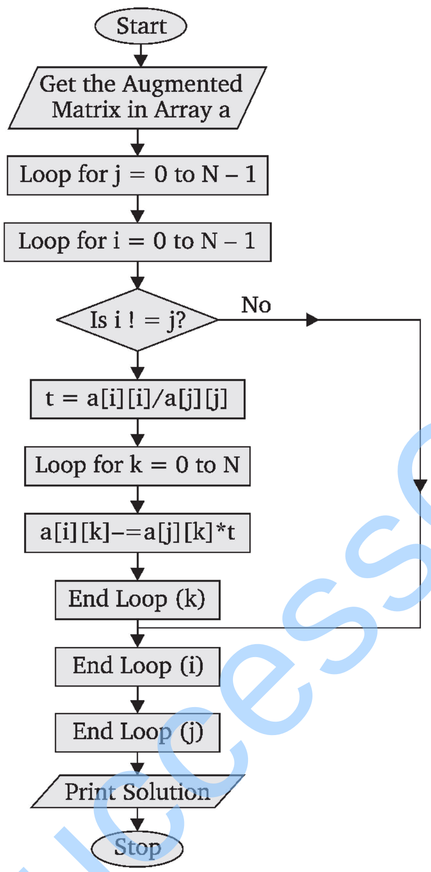
PROGRAM

/* Gauss elimination method */

```
# include <studio .h>
# define N 4
main ( )
{
        float a [N] [N + 1], x  [N], t, s;
        int i, j, k;
        printf ("Enter the elements of the"
             augmented matrix rowwise/n");
        for (i = 0; i < N; i++)
             for (j = 0; j < N + 1; J++)
             scanf (" %", &a [i] [j]);
        for (j = 0 ; j < N − 1; j++)
             for i = j + 1; i < N; i++)
        {
                     t = a [i] [j] / a [j] [j] ;
        for (k = 0 ; k < n + 1 ; k++)
                     a [i] [k] − = a [j] [k] * t;
                }
        printf ("The upper triangular matrix"
               is :-\n") ;
        for ( i = 0; i < N; j++)
{
        for (j = 0 ; j < N; i++)
               printf (" %8 . 4f ", a [i] [j] ;
        printf (" \ n ") ;
}
for (i = N − 1 ; i > = 0; i − −)
{
        s = 0;
        for ( j = i + 1; j < N; j++)
            s + = a [i] [j] *x [j];
        x [i] = (a [i] (N) − S) / a [i] [i] ;
}
printf ( "The solution is : − \n") ;
        for (i = 0; i < N; i++)
             printf ("x [% 3d] = % 7.4f\n",  i + 1,
x [i]);
        }
```

2. GAUSS-JORDAN METHOD

FLOW CHART



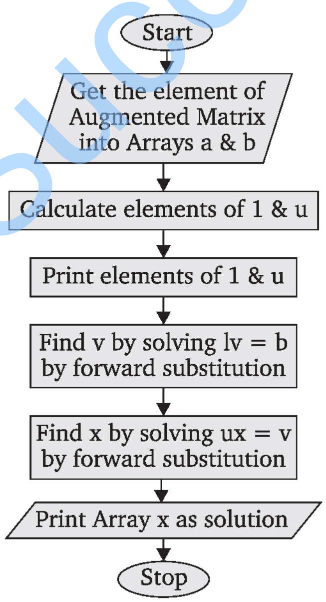
PROGRAM

```
/ * Gauss jordan method */
                  # include <studio.h>
                  #define N 3
                  main ( )
                  {
                     float a [N]  [N + 1], t ;
                     int i, j, k;
                     printf (Enter the elements of the"
                          "augmented matrix rowwise\n") ;
                     for (i = 0; i < N; i++)
                          for (j = 0 ; j < N + 1 ; j ++)
```

```
            scanf ( " % f " , &a [i] [j]) ;
for (j = 0; j < N ; j++)
      for (i = 0; i < N; i++)
             if (i ! = j)
             {
               t = a [i] [j]/ a [j] [j];
               for (k = 0; k < N + 1; k++)
               a [i] [k] - = a [j] [k] * t ;
             }
printf ("The diagonal matrix is :-\n") ;
for (i = 0; i < N; i++)
{
      for (j = 0; j < N + 1 ; j++)
               print f (% 9.4f ", a [i] [j] ;
      printf ( "\n") ;
}
printf ( " The solution is : - \n") ;
for (i = 0; i < N; i++)
      printf ("x [% 3d] = % 7.4 f \ n" , i + 1, a [i]
                                        [N] a [i] [i] ;
}
```

3. CROUT'S TRI-ANGULARISATION METHOD

(1) Flow Chart



PROGRAM

/* Crout triangularization method */

```
# include <studio .h>
# define N 4
typedef float matrix [N] [N] ;
matrix 1, u, a ;
float b [N], x [N], v [N] ;
void urow (int i)
{
     float s ;
     int j, k ;
     for (j = 1; j < N; j++)
     {
     s = 0;
     for (k = 0 ; k < N – 1 ; k++)
   s + = u [k] [j] * 1 [i] [k] ;
     u [i] [j] = a [i] [j] – s ;
}
}
void lcol (int j)
{
     float s ;
     int i, k ;
     for (i = j + 1 ; i < N; i++)
{
          s = 0 ;
     for (k = 0; k < = j – 1 ; k++)
          s + = u [k] [j] * 1 [i] [k];
     1 [i] [j] = (a [i] [j] – s) / u [j] [j] ;
     }
          }
void printmat (matrix x)
{
     int i, j ;
     for (i = 0 ; i < N ; i ++)
{
     for (j = 0; j < N; j++)
     printf ( " % 8 . 4f", x [i] [j] ;
     printf ("\n") ;
}
}
main (  )
{
int i, j, m;
float s;
printf ("Enter the elements of augmented"
                    "matrix rowwise \n") ;
```

```
        for  (i = 0; i < N; i++)
        {
                for (j = 0; j < N; j++)
                    scanf (" % f " , & a [i] [j]) ;
                    scanf ( "% f" , & b [i]) ;
        }
1 and u */
for (i = 0; i < N;          i++)
        1 [i] [i] = 1 . 0 ;
for (m = 0 ; m < N; m++)
{
        uprow (m);
        if (m < N – 1) lcol (m) ;
}
printf ("\t\tU\n") ; printmat (u);
printf ("\t\tL\n") ; printmat (l);
for (i = 0; i < N; i++)
{
        s = 0;
        for (j = 0; j < = i – 1; j++)
                s + = 1 [i] [j] * v [j];
        v [i] = b [i] – s ;
}
for (i = N – 1 ; i > = 0 ; i – )
{
        s = 0 ;
        for (j = i + 1 ; j < N; j++)
                s + = u [i] [j] * x [j] ;
        x [i] = (v [i] – s/u [i] [i] ;
}
printf , ( "The solution is : – \n") ;
for (i = 0 ; i < N ; i++)
        printf (" X [%  3d] = % 6 . 4f/n" , i + 1, x [i]) ;
```

4. /* LU DECOMPOSITION METHOD */

```
# include <conio .h>
# include <studio. h>
# include <math .h.>
main (  )
{
        float a [15] [15] a1 [15] [15], b [15], X [15], au [15] [15], z [15];
                float sum, t, big, ab, p ;
                int n, m, 1i, 1j, k, j, i, 1k, 13, m2, jj, kpl, kk, l ;
                clrscr (   ) ;
                printf ("enter the value of n/n") ;
                scanf (" % d", & n) ;
                printf ("enter the matrix row wise /n") ;
                for (i = 1 ; j < = n ; i++)
                for (j = 1 ; j < = n; j++)
```

```
        scanf ("% f " , & a [i] [j] ) ;
        printf ("enter the matrix B\n" ) ;
        for (j = 1 ; j < = n; j++)
        scanf ( " % f" , & b [j] ) ;
for (i = 1 ; i < = n; i++)
for (j = 1 ; j < = n ; j++)
{
        a1 [i] [j] = 0 ;
        au [i] [j] = 0 ;
}
for (i = 1 ; i < = n ; i++)
{
          au [i] [i] = 1 ;
          a1 [i] [1] = a [i] [1] ;
        au [1] [i] = a [1] [i] / a1 [1] [1];
}
for (j = 2 ; j < = n; j++)
{
for (i = j ; i < = n ; i++)
{
        sum = 0 ;
             for (k = 1 ; k ≤ j – 1 ; k++)
             sum=sum+a1 [i] [k] * au [k] [j] ;
             a1 [i] [j] = a [i] [j] – sum ;
}
if ( j ! =n)
(
        for (jj = j + 1; jj < = n; jj++)
        {
             sum=0;
             for (kk = 1; kk < j – 1 ; jj++)
             sum=sum + a1 [j] [kk] * au [kk] [jj];
            au [j] [jj] = (a [j][jj] – sum) / a1 [j][j];
               }
                    }
}
z [1] = b [1] / a1 [1] [1] ;
for (i = 2; i < = n; i++)
{
        sum=0;
        for (k = 1; k < i – 1; k++)
        sum=sum+a1 [i] [k] * z [k];
        z [i] = (b [i] – sum)/a1 [i] [i] ;
}
```

```
            x [n] = z [n] ;
            for (i = 2 ; i < = n ; i++)
            {
               1 = n - i + 1;
                    sum=0;
               for (k = 1 + 1; k < = n; k++)
                   sum= sum+au [1] [k] * x [k];
               x [1] = z [1] - sum;
  }
       printf ("\n") ;
       printf ( "lower triangular matrix \n") ;
       for (i = 1; i < = n ; i++)
       {
              for (j = 1 ; j < = n; j++)
              printf ("% 5. 2f ", a1 [i] [j]) ;
              printf ("\n") ;
       }
       printf ( "upper triangular matrix \n") ;
       for ( i = 1 ; i < = n ; i++)
       {
              for (j = 1; j < = n; j++)
              printf ( "% 5. 3f " , au [i] [j]) ;
              printf ( ''\n'' ) ;
       }
       printf ( "solution vector\n") ;
       for (i = 1 ; i < = n ; i++)
       printf ( "% 5. 2f " , x [i] ) ;
       printf ( "\n") ;
       getch ( ) ;
       }
```

5. SOLUTION OF SYSTEM OF EQUATIONS USING GAUSS SEIDAL METHOD

```
  */
       # include <conio .h>
       # include <studio .h>
       # include <math .h>
       main (  )

       {
              float a [15] [15] , b [15] , x [15] , oldx [15], eps,
  c , big, sum;
              int n, niter1, i, j, k, l, ii ;
              clrscr (  ),
              printf ( "enter the value of N, NITHER, ESP\n") ;
              scanf ( "% d% d% f" , &n, &niteral, &eps) ;
```

```
printf ("enter the matrix A\n") ;
for (i = 1 ; i < = n; i++)
for (j = 1; j < = n; j++)
     scanf "%f", a[i][j];
     scanf ("enter the array B\n") ;
     for (i = 1; i < = n; i++)
scanf ( " % f, & b [i] ;
     printf ("enter the array 01dx1n"
   for (i = 1; i < = n; i ++);
         {
     for (j = 1; j < = n, j + 1)
        {
   printf  ( " % f " , a [i] , [j] ) ;
        }
    print ( " % / n") ;
printf (" the array B/n") ;
for (i = 1, i < = n; i ++)
   {
         x (i) = 0/dx [i] ;
        printf ( "% f " , b [i]) ;
   }
      printf ("\n") ;
      for (i = 1 ; i < = n; i ++) ;
               {
   for (i = 1 ; i < = n iter ; i ++)
   {
      sum = 0
   for (j = 1 : j < = n ; j + j)
   if ([i - j] ; = 0)
   sum = sum + a [i] [j] *x [j] ;
   x [i] = b [i] - sum/ a [i] [i] ;
}
printf (n iter = % d, i) ;
for (i = 1 ; i < = n; i ++)
printf (" % 12.6 f" , x [i]) ;
printf ("\n") ;
big = abb (x [i] - old x [i]) ;
for (k = 2; k < = n, k++)
{
        c = abb (xck) - old x [k] ;
        if (big < = c)
        big = c;
}
For (i = 1; i < = n ; i++)
old x [i] = x [i] ;
}
}
```

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COMPUTATIONAL TECHNIQUE LAB

1. NEWTON'S FORWARD INTERPOLATION FORMULA

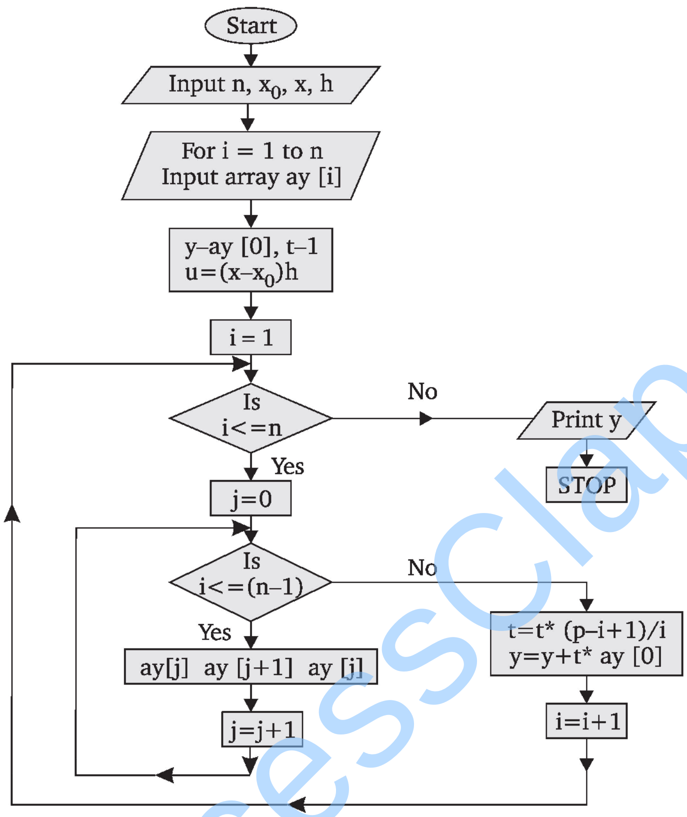
SYMBOLS USED

x_0 = initial value of x
h = length of interval
n = number of subintervals
x = value of x at which we have to find the value of y
y = value of y at x
ay = array to store the different values of y
t = temporary variable

ALGORITHM : NEWTON'S FORWARD INTERPOLATION FORMULA

Step 1. Start
Step 2. Input n, x_0, h, x
Step 3. Input values of ay
Step 4. y = ay [0], t = 1
Step 5. u = (x–x_0)/h
Step 6. For i = 1 to n
Step 7. For j = 0 to (n–i)
Step 8. y [j] = y [j+1] – y [j]
Step 9. End of j loop.
Step 10. t = t * (p – i + 1)/i
Step 11. y = y + t * ay [0]
Step 12. End of i loop
Step 13. Print y
Step 14. STOP

FLOW CHART : NEWTON'S FORWARD INTERPOLATION FORMULA



PROGRAM . *Following is a program to show the Newton's forward interpolation formula.*

NEWTON'S FORWARD INTERPOLATION FORMULA (UPTUMCA-2004)

```
# include<studio.h>
#include<conio.h>
 void main ( )
     {
     clrscr  (  );
     float ay [30], x0, h, x, y, t = 1, u;
     int n, i, j;
     printf ("Enter the value of n\n");
     scanf ("% d", & n);
     printf ("Enter the initial value of x\n");
     scanf ("%d", &x0);
     printf ("\n enter length of each interval\n");
     scanf ("%f", &h);
     for (i = 0; i < n; i++)
```

```
{       print f ("Enter the value of y (%d) = " , i);
        scan f ( "%f", & ay [i]);
}
printf("Enter the value of x for which value of y is wanted \n");
scanf ("%f", &x)';
y=ay [0];
u=(x-x0)/h;
for (i=1; i<=n; i++)
        {
                for (j=0; j<=n-1; j++)
                ay [j] = ay [j+1]-ay [j];
                t=t* (u-i+1)/i;
                y=y+t*ay [0]
        }
printf ("\n Value of y at x=%. 2 fis is % .2f " , x, y); getch ( ) ;
                }
```

Output : NEWTON'S FORWARD INERPOLATION FORMULA

```
Enter the value of n
6
Enter the initial value of x
0
enter length of each interval
1
Enter the value of     y (0)  =     1
Enter the value of     y (1)  =     3
Enter the value of     y (2)  =     11
Enter the value of     y (3)  =     31
Enter the value of     y (4)  =     69
Enter the value of     y (5)  =     131
Enter the value of     y (6)  =     223
Enter the value of x for which value of y is wanted
3.4
Value of y at x = 3.40 is 43.70
```

LAB ASSIGNMENT : NEWTON'S FORWARD INTERPOLATION FORMULA :

1. Write a C program for the Newton's forward interpolation formula to find the value of y at $x = 2.7$ from the following data

x	1	2	3	4	5	6	7	8
$f(x)$	1	8	27	64	125	216	343	512

Hint: Input $x_0 = 1, h = 1, n = 7$

Output $f(2.7) = 50.65$

2. Write a C program to find f (3.4) using the following values by Newton's forward interpolation formula

x	0	1	2	3	4	5	6
f(x)	1	3	11	31	69	131	223

Hint: Input $x_0 = 0, h = 1, n = 6$

Output $f(3.4) = 43.704$

2. NEWTON'S BACKWARD INTERPOLATION FORMULA

SYMBOLS USED

n = number of sub-intervals

h = length of interval

x_n = last value of x_i

x = values of x at which we have to find the value of y

a [y] = an array to store different values of y

y = value of y at x

ALGORITHM : NEWTON'S BACKWARD INTERPOLATION FORMULA

Step 1 : Start

Step 2 : Input n, x_n, h, x

Step 3 : For i = 0 to n

Step 4 : Input ay [i]

Step 5 : ay = ay [n], t = 1

Step 6 : $u = (x-x_n)/h$

Step 7 : For i = 1 to n

Step 8 : For j = 0 to (n–i)

Step 9 : ay [j] = ay [j+1] – ay [j]

Step 10 : End of j loop

Step 11 : t = t* (u+i–1)/i

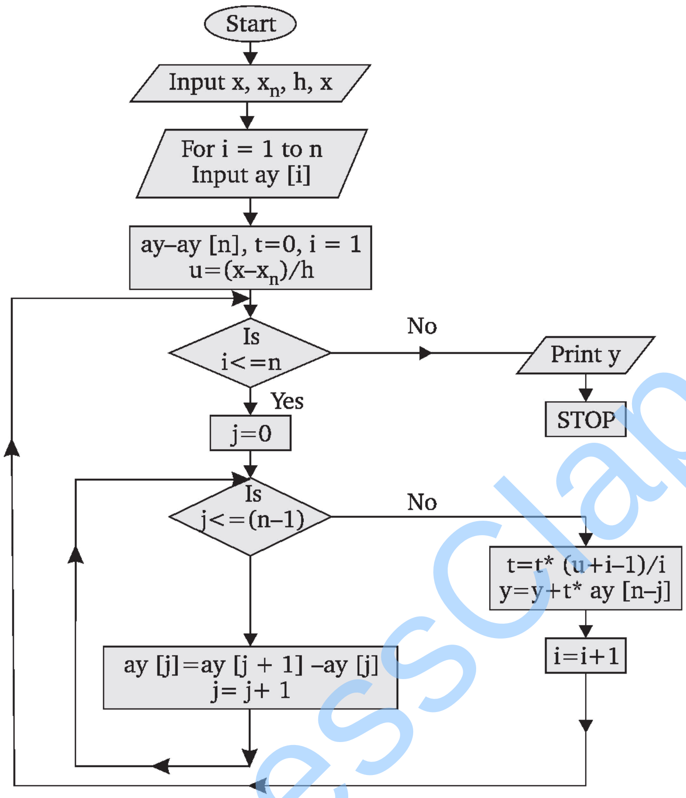
Step 12 : y = y + t* ay [n – i]

Step 13 : End of j loop

Step 14 : Print y

Step 15 : STOP.

FLOW CHART : NEWTON'S BACKWARD INTERPOLATION FORMULA



PROGRAM : *Following is a program to demonstrate the Newton's Backward Interpolation Formula.*

NEWTON'S BACKWARD INTERPOLATION FORMULA

```
#include<studio.h>
#include<conio .h>
void main ( )
     {
     clrscr ( );
     float ay [30], xn, h, x, y, t=1, u;
     int n, i, j;
     printf ("Enter the value of n\n");
     scanf ("%d", &n) ;
     printf ("Enter the last value of x\n");
     scanf  ("%f " , & xn);
     printf ("\n enter length of each interval\n") ;
     scanf ("%f " , &h) ;
     for (i=0; i<=n; i++)
```

```
        {      print f ("Enter the value of y(%d) = ", i) ;
               scanf ("% f ", & ay [i]) ;
        }
printf  ("\n Enter  the  value  of  x  for  which  value  of  y  is
watned\n");
        scanf ("%f", &x) ;
        y=ay [n] ;
        u=(x-xn)/h;
        for (i=1; i = n;i++)
            {
                for (j=0; j<=n-i; j++)
               ay [j]=ay[j+1]-ay [j];
                t =t* (u+i-1)/i;
                y=y+t*ay [n-i];
            }
printf ("\n value of y at x = % .2f   is%.2f", x,  y)  ;  getch
( ) ;
             }
```

Output : NEWTON'S BACKWARD INTERPOLATION FORMULA

```
Enter the value of n
4
Enter the last value of x
60
   Enter length of each interval
10
Enter the value of    y (0)   =      42
Enter the value of    y (1)   =      87
Enter the value of    y (2)   =      126
Enter the value of    y (3)   =      174
Enter the value of    y (4)   =      193

   Enter the value of x for which value of y is wanted
44
value of y at x=44.00 is  145.06
```

LAB ASSIGNMENT : NEWTON'S BACKWARD INTERPOLATION FORMULA

1. Write a C program for Newton's Backward Interpolation formula to find the value of f (7.5) for the data given below :

x	1	2	3	4	5	6	7	8
$f(x)$	1	8	27	64	125	216	343	512

Hint: Input $x_n = 5, h = 1, n = 7.\ x = 7.5$

Output $f(7.5) = 421.875$

2. Write a C program to find f (4.4) by the Newton backward interpolation formula from the given data.

x	0	1	2	3	4	5
y	5	20	81	224	485	900

Hint: Input : $x_n = 5$, h = 1, n = 5, x = 4.4

Output: y (4.4) = 630.5041

3. GAUSS FORWARD INTERPOLATION FORMULA

SYMBOLS USED

n = number of subintervals

h = length of interval

x = value of x at which we have to find the value of y

k = location of x_0.x_0 is that value which is closed to x

y = value of y at x

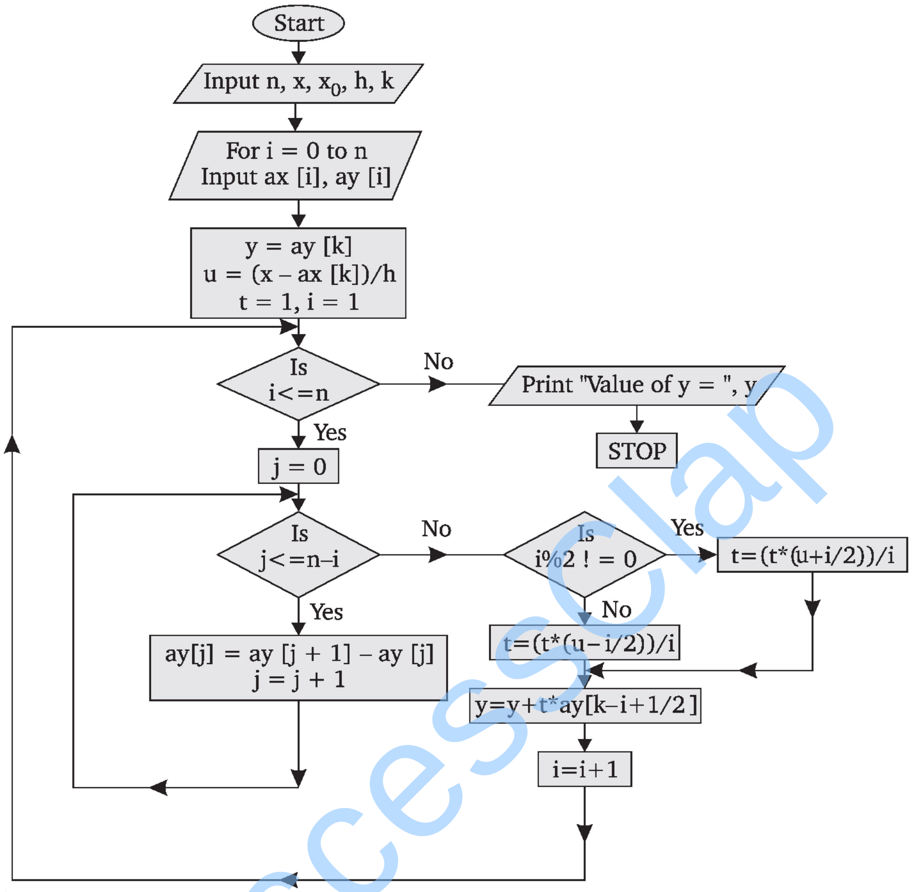
a [x] = an array to store different values of x

a [y] = an array to store the different values of y

ALGORITHM : GAUSS FORWARD INTERPOLATION FORMULA

Step 1 : Start
Step 2 : Input n, h, x, k
Step 3 : For i = 0 to n
Step 4 : Input ax [i], ay [i]
Step 5 : y = ay [k], t = 1
Step 6 : u = (x–ax [k])/h
Step 7 : For i = 1 to n
Step 8 : For j = 0 to n – i
Step 9 : ay [j] = ay [j + 1] – ay [j]
Step 10 : End of j loop
Step 11 : If (i% 2! = 0)
t = (t * (u + i/2))/i
else
t = (t * (u – i/2))/i ;
Step 12 : y = y + t * ay [k – i/2]
Step 13 : End of i loop
Step 14 : Print "Value of y at x is" . y
Step 15 : STOP

FLOW CHART : GAUSS FORWARD INTERPOLATION METHOD



PROGRAM : *Following is a C program to show the working of Gauss Forward Interpolation formula.*

//GAUSS FORWARD INTERPOLATION FORMULA

```
#include<studio .h>
#include<conio ,h>
void main ( )
      {
      clrscr ( ) ;
      float ax [30], ay [30] , h, x, y, t=1, u;
      int n, i, j, k;
      printf ("Enter the value n\n");
      scanf ("%d", &n) ;
      printf ("\n enter length of each interval\n");
      scanf ("%f", &h) ;
             printf ("Enter the value of x and y/n") ;
```

```
        for (i=0; i<=n; i++)
                scanf ("%f %f ", & ax [i], & ay [i] ;
        printf ("\n Enter the value of x for which value of y
is wanted\n");
        scanf ("%f", &x);
        printf ("\n enter the location of x0 i.e. k/n");
        scanf ("%d", &k);
        y=ay [k];
        u=(x-ax [k]) /h;
        for (i=1; i<=n; i++)
           {
                for (j=0; j<=n-i; j++)
                  ay [j]=ay[j+1]-ay [j];
                if (i%2 ! = 0)
                         t=(t* (u+i/2))/i;
                else
                         t=(t*(u-i/2))/i;
                y=y+t*ay[k-i/2];
                      }
                printf ("\n value of y at x=%. 2f is % .2f ", x,
y) ; getch ( ) ;
                }
```

Output : GAUSS FORWARD INTERPOLATION FORMULA

```
Enter the value of n
5
   enter length of each interval
.5
Enter the value of x and y
2.5   24.145
3     22.043
3.5   20.225
4     18.644
4.5   17.262
5     16.047
Enter the value of x for which value of y is wanted
3.75
  enter the location of x0 i.e. k
2
value of y at x=3.75 is 19.41
```

LAB ASSIGNMENT : GAUSS FORWARD INTERPOLATION FORMULA

1. Write a C program to find value of y (30) by Gauss Forward Interpolation formula from the data given below :

x	21	25	29	33	37
f(x)	18.4708	17.8144	17.1070	16.3432	15.5154

Hint :Input : n = 4, h = 4, x = 30, k = 2

Output : Value of y = 16.92

2. Write a C program for Gauss Forward interpolation formula to find value of f (2.3) from the given data

x	1	2	3	4	5
f(x)	1	–1	1	–1	1

Hint: Input : n = 4, h = 1, x = 2.3, k = 1

Output: Value of y = – 0.146600.

4. GAUSS BACKWARD INTERPOLATION FORMULA

SYMBOLS USED

(Note : same as used in Gauss forward Interpolation formula).

ALGORITHM: GAUSS BACKWARD INTERPOLATION FORMULA

Step 1 : Start

Step 2 : Input x, h, x_0, k

Step 3 : For i = 0 to n

Step 4 : Input ax [i], ay [i]

Step 5 : y = ay [k], t = 1

Step 6 : u = (x–ax [k])/h

Step 7 : For i = 1 to n

Step 8 : For j = 0 to n – i

Step 9 : ay [j] = ay [j + 1] – ay [j]

Step 10 : End of j loop

Step 11 : if (1%2 ! = 0)
t = (t * (u – i/2))/i
else
t = (t * (u + i/2))/i

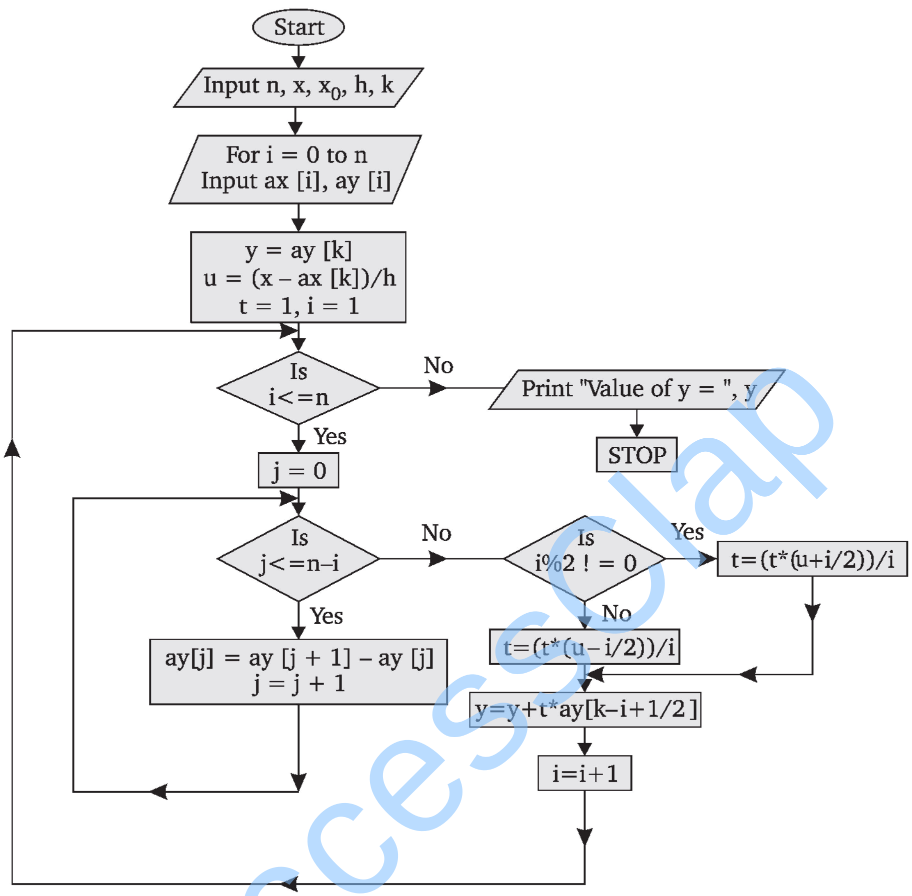
Step 12 : y = y + t * ay [k – (i + 1)/2]

Step 13 : End of i loop.

Step 14 : Print "value of y=", y

Step 15 : Stop.

FLOW CHART : GAUSS BACKWARD INTERPOLATION METHOD



PROGRAM : *Following is a C program to show the working of Gauss Backward Interpolation Method.*

GAUSS BACKWARD INTERPOLATION FORMULA

```
#include<studio .h>
#include<conio .h>
void main ( )
      {
      clrscr ( ) ;
      float   ax [30], ay [30] , h, x, y, t = 1, u;
      int n, i, j, k;
      printf ("Enter the value of n\n") ;
      scanf ("%d", &n) ;
      printf ("\n enter length of each interval\n") ;
      scanf ("%f", &h) ;
              printf ("Enter the value of x and y\n ") ;
      for (i=0; i<=n;i++)
      {
              scanf ("%f %f", &ax [i], &ay [i]);
      }
```

```
        printf ("\n Enter the value of x for which value of y
is wanted\n") ;
        scanf ("%f", &x) ;
        printf ("\n enter the location of x0 i.e., k\n") ;
        scanf ("%d", &k) ;
        y=ay [k] ;
        u=(x-ax [k])/h ;
        for (i=1;i<= n; i++)
            {
                for (j=0; j<=n-i; j++)
            ay [j] = ay [j+1] - ay [j];
                if (i % 2 ! = 0)
                    t=(t* (u-i/2))/i;
            else
                    t=(t* (u+i/2))/i;
            y=y+t*ay [k- (i+1)/2];
            }
        printf ("\n Value of y at x=% .2f is % .2f", x, y) ;
        getch ( ) ;
        }
```

Output : GAUSS BACKWARD INTERPOLATION FORMULA

```
Enter the value of n
3
   enter length of each interval
1
Enter the value of x and y
4     270
5     648
6     1330
7     2448
  Enter the value of x for which value of y is wanted
5.8
  enter the location of x0 i.e. k
1
Value of y at  x=5.80  is 1169.28
```

LAB ASSIGNMENT : GAUSS BACKWARD INTERPOLATION METHOD

1. Write a C program for Gauss Backward interpolation method to find y (1.15) form data given below :

x	1	1.10	1.20	1.30
y	1.0	1.04881	1.09544	1.14017

Hint : Input : n = 3, h = 0.10, k = 1, x = 1.15

Output : Value of y = 1.072397

2. Write a C program for Gauss Backward Interpolation Method to find the value for 1936 from the given data.

x	1901	1911	1921	1931	1941	1951
f(x)	12	15	20	27	39	52

Hint : Input : n = 5, h = 10, x = 1936, k = 3

output : Value of y = 32.3437.

5. STIRLING'S DIFFERENCE FORMULA

SYMBOLS USED

n = number of subintervals

h = length of interval

x = value of x at which we have to find the value of y

k = location of x_0. x_0 is that value which is closed to x

y = value of y at x

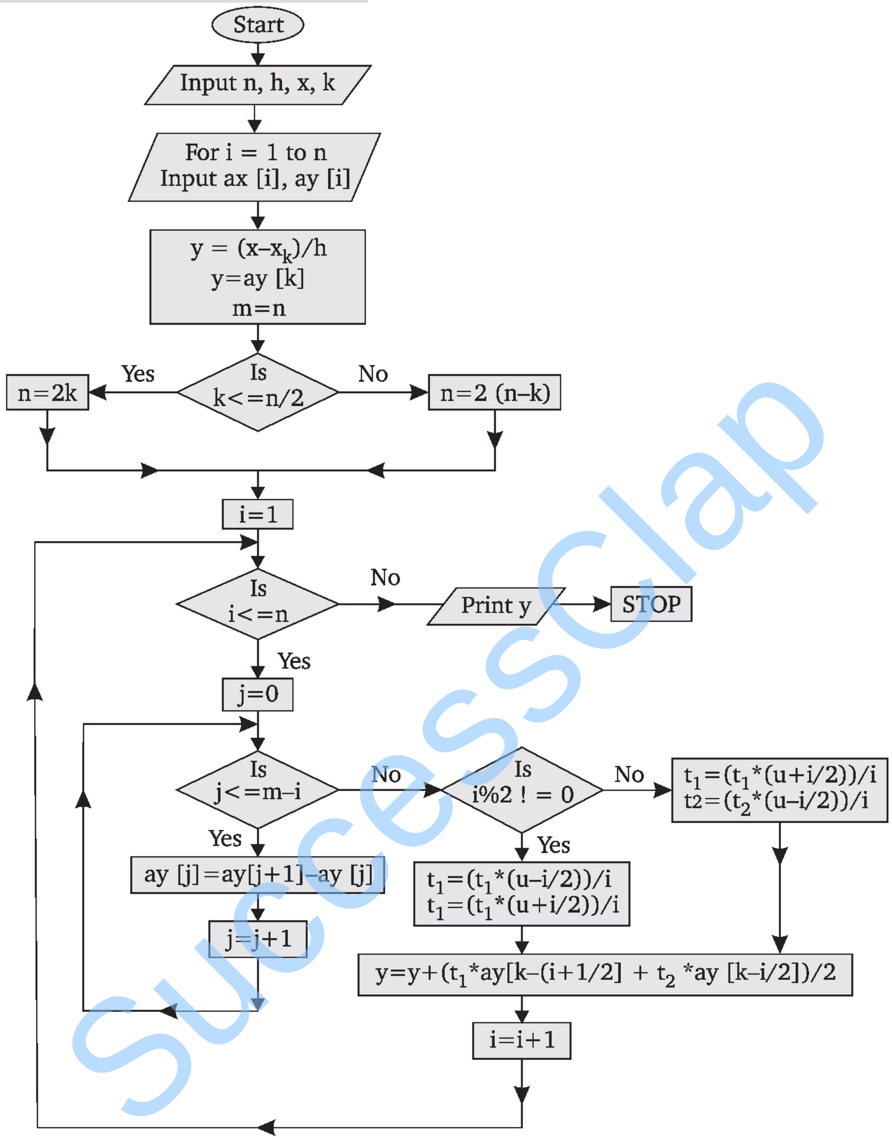
a [x] = an array to store the different values of x

a [y] = an array to store the different values of y

ALGORITHM : STERLING'S DIFFERENCE FORMULA

Step 1 : Start
Step 2 : Input n, h
Step 3 : For i = 1 to n
Step 4 : Input ax [i], ay [i]
Step 5 : Input x, k
Step 6 : u = $(x-x_k)/h$
Step 7 : y = ay [k], m = n
Step 8 : if (k<=n/2)
n = 2k
else
n = 2 (n – k)
Step 9 : For i = 1 to n
Step 10 : For j = 0 to (m – i)
Step 11 : ay [j] = ay [j + 1] – ay [j]
Step 12 : End of j loop
Step 13 : if (i%2 ! = 0)
$t_1 = (t_1 * (u - i/2))/i$
$t_2 = (t_2 * (u + i/2))/i$
else
$t_1 = (t_1 * (u + i/2))/i$
$t_2 = (t_2 * (u - i/2))/i$
Step 14 : y = y + (t_1 * ay [k – (i + 1)/2] + t_2 * ay [k – i/2])/2
Step 15 : End of i loop
Step 16 : Print y
Step 17: Stop

FLOW CHART : STERLING DIFFERENCE FORMULA



PROGRAM : *Following is a C program showing the working of Stirling Difference Formula for interpolation.*

//STIRLING'S INTERPOLATION FORMULA

```
#include<studio.h>
#include<conio.h>
void main ( )
      {
      clrscr ( );
      float ax [30], ay [30], h, x, y, t1=1, t2=1, u;
      int n, i, j, m, k;
```

```
        printf ("Enter the value of n\n");
        Scanf ("%f", & h);
        printf ("\n enter length of each interval\n");
        scanf ("%f", &n);
               printf ("Enter the value of x and y\n ") ;
        for (i=0, i< = n;++)
        {
               scanf ("%f %f ", &ax [i], &ay [i]) ;
        }
        printf ("Enter the value of x for which value of y is
wanted\n") ;
        scan ("%f", &x) ;
        printf ("\n enter the location of x0 i.e. k\n") ;
        scanf ("%d", & k);
        printf ("\n enter the location of x0 i.e. k\n') ;
        scanf ("%d", &k) ;
        y=ay [k] ;
        u=(x-ax [k])/h;
        m=n;
        if    (k< = n/2)
        n=2*k;
        else
          n = 2* (n-k);
        for (i=1; i<=n; i++)
          {
                  for (j=0; j<=m-i; j++)
               ay[j]=ay [j+1]-ay [j];
                  if (i%2 ! = 0)
           {   t1=(t1*(u-i/2)) /i;
               t2=(t2* (u+i/2)) /i;
           }
        else
            {
               t1=(t1*(u+i/2))/i;
               t2=(t2*(u-i/2))/i;
             }
        y=y+(t1*ay[k-(i+1) / 2] + t2*ay[k-i/2)) /2 ;
          }
      print f ("\n Value of y at x=% .2f is    % .2f ", x, y) ;
      getch ( ) ;
    }
```

Output : STIRLING'S INTERPOLATION FORMULA

```
Enter the value of n
4
enter length of each interval
5
Enter the value of x and y
  10  492
15    483
20    472
25    459
```

```
30    453
Enter the value of x for which value of y is wanted
19
    enter the location of x0  i.e.  k
2
    Value of y at x=19.00  is  474.49
```

LAB ASSIGNMENT : STIRLING DIFFERENCE FORMULA

1. Write a C program to find the value of y [28] from the given data using Stirling Difference Formula.

x	20	25	30	35	40
y	49225	48316	47236	45926	44306

Hint : Input : x = 28, n = 4, h = 5, x_0 = 30, k = 2
Output : y (28) = 47692.

2. Using Stirling difference formula, write a C program to find y (25) by given data :

x	20	24	28	32
y	24	32	34	40

Hint : Input : h = 4, n = 3, x = 25, k = 1
Output : y (25) = 32.945287

6. LAGRANGE'S INTERPOLATION FORMULA FOR UNEQUAL INTERVAL

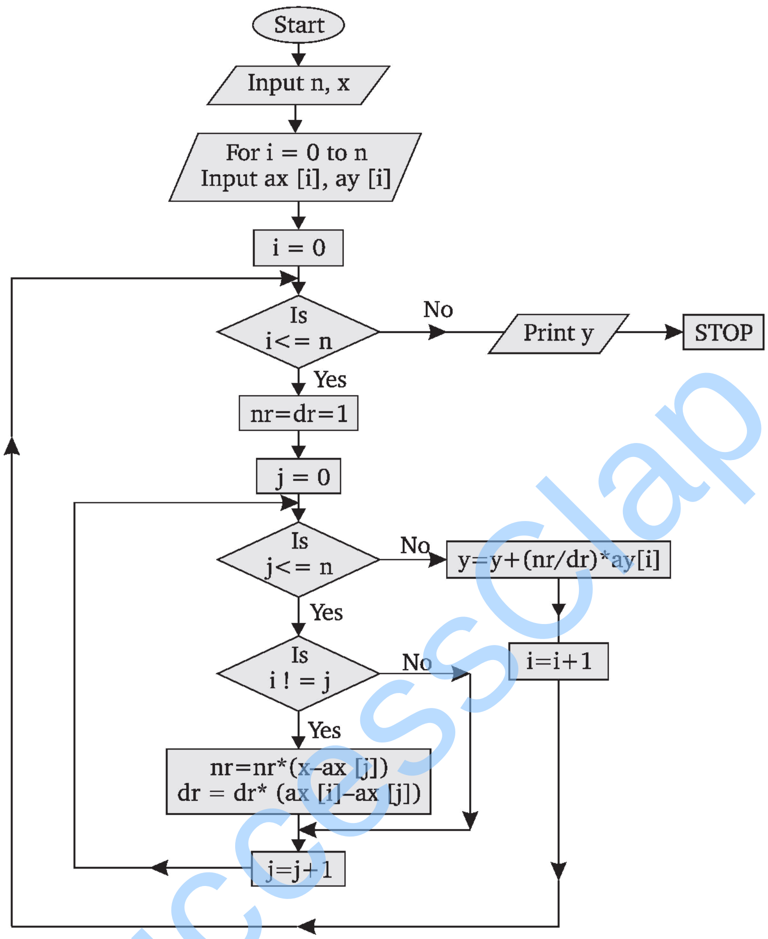
SYMBOLS USED

n = number of subintervals
x = value of x at which we have to find the value of y
nr = numerator of each term of Lagrange's formula
dr = denominator of each term of Lagrange's formula
y = value of y at x
a [x] = an array to store different values of x
a [y] = an array to store the difference vaues of y'

ALGORITHM : LAGRANGE'S INTERPOLATION FORMULA

Step 1 : Start
Step 2 : Input n, x
Step 3 : For i = 0 to n
Step 4 : Input ax [i], ay [i]
Step 5 : For i = 0 to n
Step 6 : nr=dr=1
Step 7 : For j = 0 to n
Step 8 : if (i ! = j)
nr = nr * (x–ax [j])
dr = dr * (ax [i] – ax [j])
Step 9 : End of j loop.
Step 10 : y = y + (nr/dr) * ay [i]
Step 11 : End of i loop
Step 12 : Print y
Step 13 : Stop.

FLOW CHART : LAGRANGE'S INTERPOLATION FORMULA



PROGRAM : *Following is a program for the Lagrange's interpolation formula.*

//Lagrange's Interpolation Method

```
#include<<conio .h>
#include<studio .h>
#define MAX 100
void main ( )
{
      float ax [MAX+1], ay [MAX+1], nr, dr, x, y=0;
      int i, j, n ;
      clrscr ( ) ;
      printf ("\n\Enter the value of n\n") ;
      scanf ("%d", &n) ;
      printf ("Enter the set of values of x and y\n") ;
      for (i=0; i< = n =; i++)
              scanf ("%f%f", &ax [i], &ay [i]);
      puts ("\nEnter the value of x for which value of y is
required");
```

```
        scanf ("%f", &x);
        for (i=0; i<=n;'i++)
        {
               nr=dr=1;
               for (j=0; j<= n; j++)
              if (i ! = j)
               {
                        nr*=x-ax [j];
                        dr*=ax [i] -ax[j] ;
              }
              y=(nr/dr) *ay [i] ;
        }
        printf ("\n when x=%f,    y=%f", x, y) ;
        getch ( ) ;
}
```

OUTPUT : LAGRANGE'S INTERPOLATION METHOD

```
  Enter the value of n
4
Enter the set of values of x and y
1     8
2     15
4     19
8     32
10    40
Enter the value of x for which value of y is required
5
when x = 5, y = 22.7460
```

LAB ASSIGNMENT : LAGRANGE'S INTERPOLATION FORMULA

1. Write a C program using Lagrange's formula to find f (4) by the given data

x	0	1	2	5
f(x)	2	5	7	8

Hint : Input : n=3, x=4
Output : f (4)=8.4

2. Write a C program to find y (5) using Langrange's interpolation formula for the data given below :

x	1	3	4	8	10
f(x)	8	15	19	32	40

Hint : Input : n = 4, x=5
Output : y (5)= 11.318

7. NEWTON'S DIVIDED DIFFERENCE FORMULA

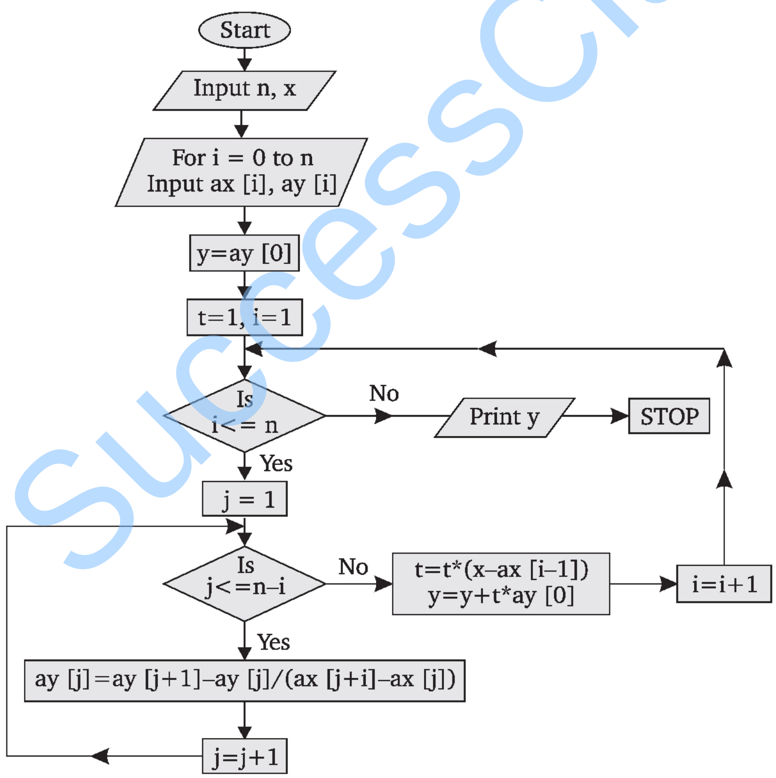
SYMBOLS USED :

n = number of subintervals
x = value of x at which we have to find the value of y
y = value of y at x
a [x] = an array to store the different values of x
a [y] = an array to store the different values of y.

ALGORITHM : NEWTON'S DIVIDED DIFFERENCE FORMULA

Step 1 : Start
Step 2 : Input n, x
Step 3 : For i = 0 to n
Step 4 : Input ax [i], ay [i]
Step 5 : y = ay [0], t = 1
Step 6 : For i = 1 to n
Step 7 : For j = 0 to (n–i)
Step 8 : ay [j] = (ay [j + 1] – ay [j])/ax [j + 1] – ax [j])
Step 9 : End of j loop
Step 10 : t = t* (x – ax [i – 1])
Step 11 : y = y + t* ay [0]
Step 12 : End of i loop
Step 13 : Print "value of y=", y
Step 14 : Stop.

FLOW CHART : NEWTON'S DIVIDED DIFFERENCE FORMULA



PROGRAM : *Flowing program shows the working of Newton's Divided Difference formula for interpolation.*

//NEWTON'S DIVIDED DIFFERENCE INTERPOLATION FORMULA

```
#include<studio .h>
#include<conio .h>
```

```
void main ( )
      {
      clrscr ( ) ;
      float  ax [30], ay [30], x, y, t=1;
      printf ("Enter the value of n\n") ;
      scanf ("%d", &n) ;
      printf ("\n enter value of x \n") ;
      scanf (" %f ", &x) ;
       printf ("Enter the value of x and y\n ") ;
      for (i=0; i<=n;i++)
      {
       scanf ("%f  %f", &ax [i],  &ay [i]) ;
      }
      y=ay [0] ;
      for (i=1; i<=n; i++)
        {
       for (j=0;j<=n;j++)
               ay [j]=(ay [j+1] – ay [j]/ (ax [j+i] – ax [j]) ;
       t = t* (x–ax [i–1]) ;
       y=y+t*ay [0] ;
      }
      printf ("\n Value of y at x=% .2f is % .2f ", x, y) ;
      getch ( ) ;
      }
```

Output : NEWTON'S DIVIDED DIFFERENCE INTERPOLATION FORMULA

```
Enter the value of n
3
enter value of x
1.6
Enter the value of x and y
1     3.49
1.4   4.82
1.8   5.96
2.2   6.5
Value of y at x=1.60 is 5.44
```

LAB ASSIGNMENT: NEWTON'S DIVIDED DIFFERENCE FORMULA

1. Write a computer program in C language to find value of f (15) by using Newtons divided difference formula from the following table :

x	4	5	7	10	11	13
$f(x)$	48	100	294	900	1210	2028

Hint : Input : $n = 5, x = 15$

Output : Value of y at x = 15 is 3150.

2. Write a C program for the Newton's divided difference formula to find value of $f(10)$ from the following data :

x	5	6	9	11
$f(x)$	12	13	14	16

Hint : Input : $n = 3, x = 10$

Output : Value of y at $x = 10 = 14.667$.

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COMPUTATIONAL TECHNIQUE LAB

1. TRAPEZOIDAL RULE

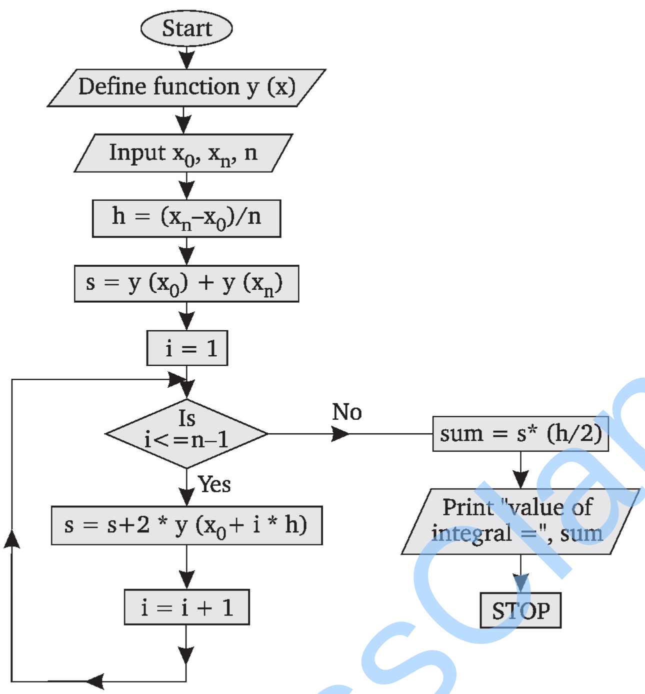
SYMBOLS USED

n = number of subdivision
x_0 = lower limit of integral
x_n = upper limit of integral
h = length of subinterval
$y(x)$ = function to be integrated

ALGORITHM : TRAPEZOIDAL RULE

Step 1 : Start
Step 2 : Input x_0, x_n, n
Step 3 : h = $(x_n - x_0)/n$
Step 4 : s = y (x_0) + y(xn)
Step 5 : For i = 1 to n – 1
Step 6 : s = s + 2 * y $(x_0$ + i * h)
Step 7 : End of i loop
Step 8 : Sum = s * (h/2)
Step 9 : Print "Value of integral = ", sum
Step 10 : Stop.

FLOW CHART : TRAPEZOIDAL RULE



PROGRAM : *Following is a C program to find the value of the integral* $\int_0^6 \frac{dx}{1+x^2}$ *by trapezoidal rule.*

Define a function *y* as 1/(1+x*x)

```
// Trapezoidal Rule
# include<stdio.h>
#include<conio.h>
float y (float x)
{
    return 1/(1+x*x);
}
void main()
{
    float x0,xn,s,h,sum;
    int i,n;
    clrscr();

    puts("\n Enter number of subdivisions i.e n  ");
    scanf(" %d",&n);
    puts("\n Enter lower limit of integral i.e. x0 ");
    scanf(" %f",&x0);
    puts("\n Enter upper limit of integral i.e. xn ");
```

```
        scanf(" %f",&xn);

h=(xn-x0)/n;
        s=y(x0)+y(xn);
        for(i=1;i<=n-1;i++)
           s+=2*y(x0+i*h);
        sum=s*(h/2);
        printf("\n Value of Integral is %.3lf\n",sum);
        getch();

}
```

Output: TRAPEZOIDAL RULE

```
enter number of subdivisions i.e. n
6
enter lower limit of integral i.e. x0
0
enter upper limit of integral i.e. xn
6
Value of Integral is  1.411
```

LAB ASSIGNMENT : TRAPEZOIDAL RULE

1. Write a C program to solve the following integral by trapezoidal rule

$$\int_{0.2}^{1.4} (\sin x - \log_e x + e^x)\, dx$$

Hint : Define a function y

sin (x – loge (x) + exp (x)

Input : $x_0 = 0.2$ $x_n = 1.4$ n = 12

Output : Value of integral = 4.056174

2. Write a C program to calculate the value of integral $\int_4^{5.2} \log x\, dx$ by trapezoidal rule.

Hint : Define function y = log (x)

Input : $x_0 = 4$, $x_n = 5.2$ n = 6

Output : Value of integral = 1.827648

2. SIMPSON'S 1/3 RULE

SYMBOLS USED

x_0 = lower limit of integral

x_n = upper limit of integral

n = no. of subdivisions

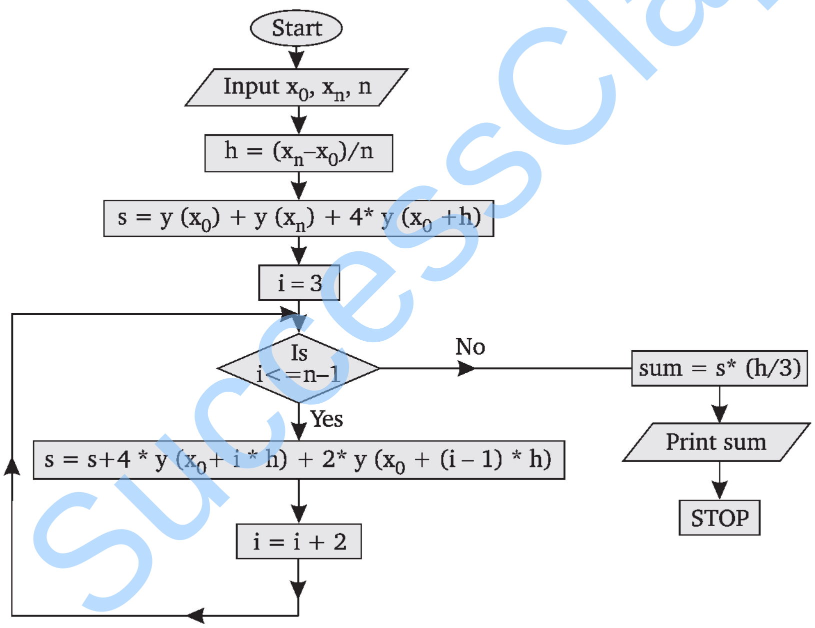
h = length of subinterval

y (x) = function to be integrated

ALGORITHM : SIMPSON'S 1/3 RULE

Step 1 :	Start
Step 2 :	Input x_0, x_n, n
Step 3 :	h = $(x_n - x_0)/n$
Step 4 :	s = y (x_0) + y (x_n) + 4 * y $(x_0 + h)$
Step 5 :	For i = 3 to (n – 1)
Step 6 :	s = s + 4 * y $(x_0$ + i * h) + 2 * y $(x_0$ + (i – 1) * h
Step 7 :	i = i + 2
Step 8 :	End of i loop.
Step 9 :	Sum = s * (h/3)
Step 10 :	Print "Value of integral = ", sum
Step 11 :	Stop.

FLOW CHART : SIMPSON'S 1/3 RULE



PROGRAM : *Following is a C program to the integral* $\int_0^6 \frac{dx}{1+x^2}$ *by Simpson's 1/3 rule.*

```
//SIMPSON 1/3rd RULE
#include<stdio.h>
#include<conio.h>
float y(float x)
{
   return 1/(1+x*x);
}
void main()
```

```
{
        float x0,xn,h,s,sum;
        int i,n;
        clrscr();
        puts("\n enter number of subdivisions i.e. n ");
        scanf("%d",&n);
        puts("\n enter lower limit of integral i.e. x0 ");
        scanf("%f",&x0);
        puts("\n enter upper limit of integral i.e. xn ");
        scanf("%f",&xn);

        h=(xn-x0)/n;
        s=y(x0)+y(xn)+4*y(x0+h);

        for(i=3;i<=n-1;i+=2)
            s+=4*y(x0+i*h)+2*y(x0+(i-1)*h);
        sum=s*(h/3);
        printf("\n Value of Integral is %.3lf\n",sum);
        getch();
}
```

Output: SIMPSON 1/3 rd RULE

```
enter number of subdivisions i.e. n
6
enter lower limit of integral i.e. x0
0
enter upper limit of integral i.e. xn
6
Value of Integral is  1.366
```


LAB ASSIGNMENT : SIMPSON'S 1/3 RULE

1. Write a C program to solve the integral $\int_0^4 e^x\,dx$ using Simpson's 1/3 rule.
Hint : Define function y = exp (x)
Input : $x_0 = 0$, $x_n = 4$, n = 4
Output : Value of integral = 53.87

2. Write a C program to solve the integral $\int_0^7 \frac{1}{x}.dx$ using Simpson's 1/3 rule.
Hint : Define function y = (1/x)
Input : $x_0 = 1, x_n = 7, n = 6$
Output : Value of integral = 1.9587

3. Write a C program to solve the integral $\int_{0.5}^{0.7} x^{1/2} e^{-x}\,dx$ by Simpson's 1/3 rule.
Hint : Define function y = sqrt (x) * exp (–x)
Input : $x_0 = 5$, $x_n = 0.7$, n = 4
Output : Value of integral = 0.08483

3. SIMPSON'S 3/8 RULE

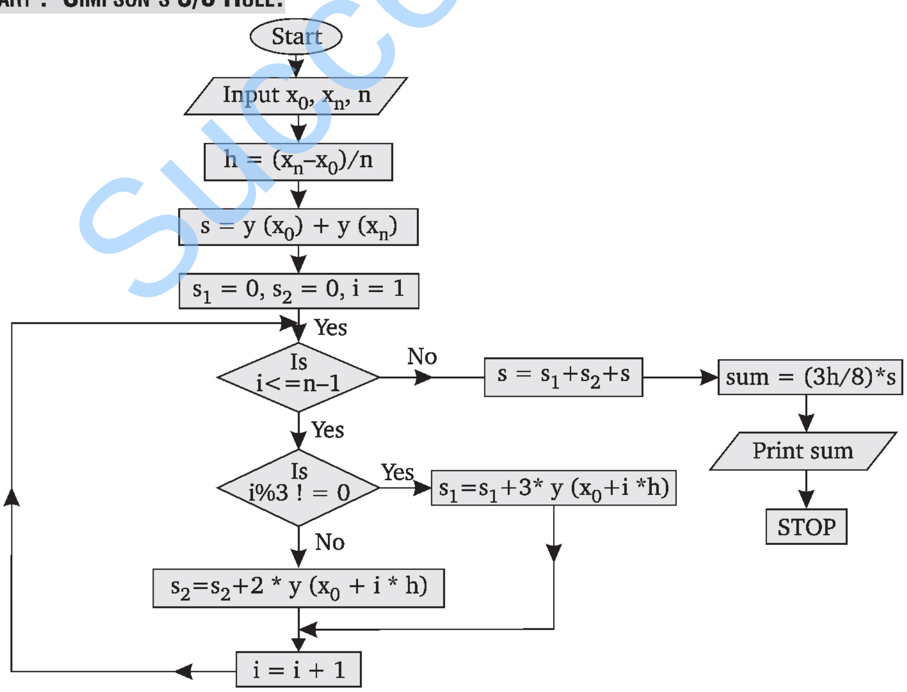
SYMBOLS USED

n = number of subdivisions
x_0 = lower limit of integral
x_n = upper limit of integral
h = length of each subinterval
y (x) = function to be integrated

ALGORITHM : SIMPSON'S 3/8 RULE

Step 1 : Start
Step 2 : Input x_0, x_n, n
Step 3 : h = $(x_n - x_0)/n$, $s_1 = 0$, $s_2 = 0$
Step 4 : s = y (x_0) + y (x_n)
Step 5 : For i = 1 to (n – 1)
Step 6 : If (i%3 ! = 0)
  $s_1 = s_1 + 3 * y\ (x0 + i * h)$
else
  $s_2 = s_2 + 2 * y\ (x_0 + i * h)$
Step 7 : End of i loop
Step 8 : $s = s + s_1 + s_2$
Step 9 : Sum = s * (3 * h)/8
Step 10 : Print "Value of integral = ", sum
Step 11 : STOP.

FLOW CHART : SIMPSON'S 3/8 RULE.



PROGRAM : *Following is a C program to the integral* $\int_0^1 \frac{dx}{1+x}$ *by Simpson's 3/8 rule.*

//SIMPSON 3/8th RULE

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

float y(float x)
{
   return 1/(1+x);
 }
 void main()
{
      float x0,xn,h,s,s1=0,s2=0,sum;
      int i,n;
      clrscr();
      puts("\n enter number of subdivisions i.e. n ");
      scanf("%d",&n);
      puts("\n enter lower limit of integral i.e. x0 ");
      scanf("%f",&x0);
      puts("\n enter upper limit of integral i.e. xn ");
      scanf("%f",&xn);
      h=(xn-x0)/n;
      s=y(x0)+y(xn);
      for(i=1;i<=n-1;i++)
         if(i%3!=0)
          s1+=3*y(x0+i*h);
         else
           s2+= 2*y(x0+i*h);
      s=s+s1+s2;
      sum=s*(3*h/8);
      printf("\n Value of Integral is %.3lf\n",sum);
      getch();
}
```

Output: SIMPSON 3/8th RULE

```
enter number of subdivisions i.e. n
6
enter lower limit of integral i.e. x0
0
enter upper limit of integral i.e. xn
1
Value of Integral is  0.693
```

LAB ASSIGNMENT : SIMPSON'S 3/8TH RULE

1. Write a C program to solve the integral $\int_0^1 \frac{dx}{1+x^2}$ using Simpson 3/8 rule.

Hint : Define function y = 1/(1 + x * x)

Input : $x_0 = 0$, $x_1 = 1$, n = 6

Output : Value of integral = 0.785396

2. Write a C program to solve the integral $\int_0^6 (1+x^2)dx$ using Simpson 3/8th rule.

Hint : Define function y (x) = (1 + x * x)

Input : $x_0 = 0$, $x_n = 6$, n = 6

Output : Value of integral = 78

4. BOOLE'S RULE

SYMBOLS USED

n = number of subdivision

x_0 = lower limit of integral

x_n = upper limit of integral

h = length of subinterval

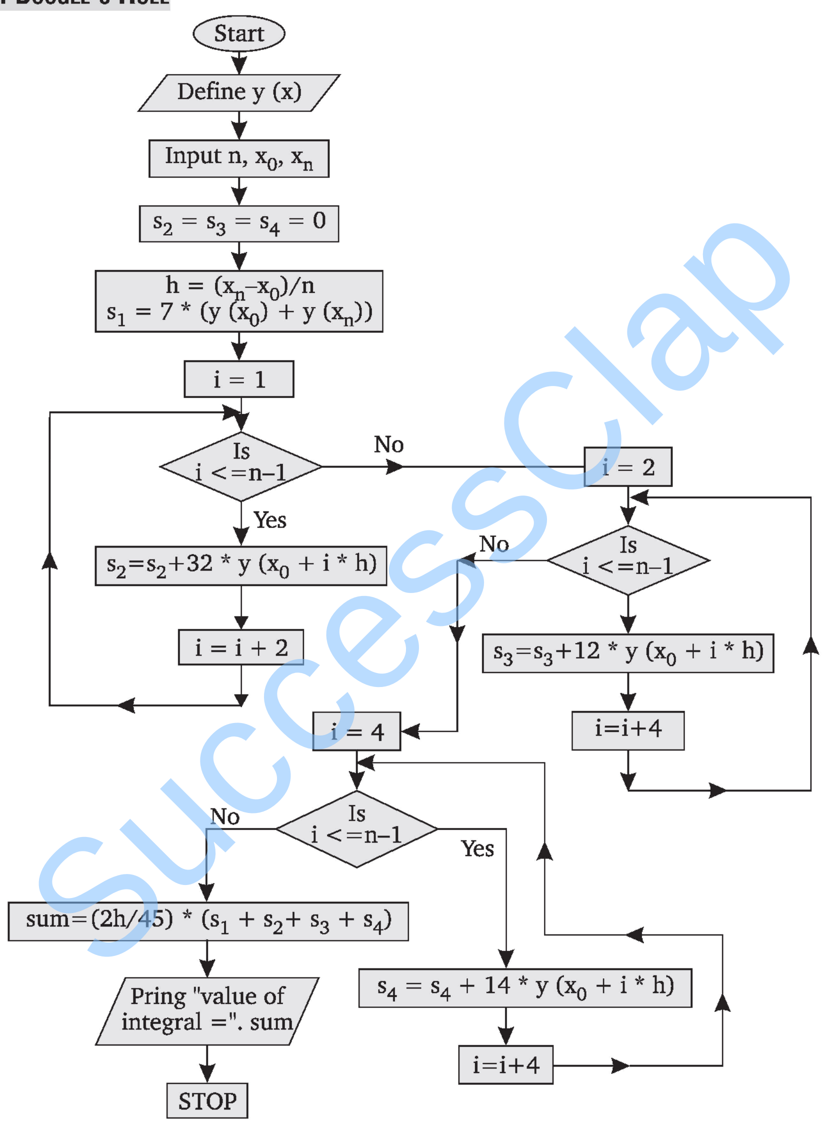
y (x) = function to be integrated

ALGORITHM : BOOLE'S RULE

Step 1 :	Start
Step 2 :	Define function y (x)
Step 3 :	Input n , x_0, x_n
Step 4 :	$s_2 = s_3 = s_4 = 0$
Step 5 :	h = $(x_n - x_0)/n$
Step 6 :	s_1 = 7 * y (x_0) + y (x_n)
Step 7 :	For i = 1 to (n – 1)
Step 8 :	$s_2 = s_2$ + 32 * y (x_0 + i * h)
Step 9 :	i = i + 2
Step 10 :	End of i loop
Step 11 :	For i = 2 to (n – 1)
Step 12 :	$s_3 = s_3$ + 12 * y (x_0 + i */ h)
Step 13 :	i = i + 4
Step 14 :	End of i loop
Step 15 :	For o = 4 to (n – 1)
Step 16 :	$s_4 = s_4$ + 14 * y (x_0 + i * h)
Step 17 :	i = i + 4

Step 18 : End of i loop
Step 19 : Sum = $(s_1 + s_2 + s_3 + s_4) * (2 * h) / 45$
Step 20 : Print "Value of integral = ", sum
Step 21 : STOP.

FLOW CHART : BOOGLE'S RULE



PROGRAM : *Following is a C program to solve the integral* $\int_0^6 (1 + x^2)\,dx$ *by the Boole's rule.*

```
// BOOLE's RULE
#include<stdio.h>
#include<conio.h>
```

```
float y(float x)
{
   return (1+x*x);
 }
 void main()
{
      float x0,xn,h,s1,s2=0,s3=0,s4=0,s,sum;
      int i,n;
      clrscr();
      puts("\n enter number of subdivisions i.e. n ");
      scanf("%d",&n);
      puts("\n enter lower limit of integral i.e. x0 ");
      scanf("%f",&x0);
      puts("\n enter upper limit of integral i.e. xn ");
      scanf("%f",&xn);

      h=(xn-x0)/n;
      s1=7*y(x0)+y(xn);


      for(i=1;i<=n-1;i+=2)
            s2+=32*y(x0+i*h);
      for(i=1;i<=n-1;i+=4)
           s3+= 12*y(x0+i*h);

      for(i=4;i<=n-1;i+=4)
            s4+=14*y(x0+i*h);

      s=s1+s2+s3+s4;
      sum=s*(2*h/45);
      printf("\n Value of Integral is %.3lf\n",sum);
      getch();
}
```

Output: BOOLE's RULE

```
enter number of subdivisions i.e. n
8
enter lower limit of integral i.e. x0
0
enter upper limit of integral i.e. xn
6
Value of Integral is  67.450
```

LAB ASSIGNMENT : BOOLE'S RULE

1. Write a C program to solve the integral $\int_0^4 \frac{dx}{1+x^2}$ by Boole's rule. Divide the interval into 4 equal parts.

   Hint : Define a function y (x) = 1/(1 + x * x)

   Input : $x_0 = 0$, $x_n = 4$, n = 4

   Output : Value of integral = 1.28941

2. Write a C program to solve the integral $\int_1^7 \frac{1}{x}$ dx by Boole's rule.

   Hint : Define a function y (x) = (1/x)

   Input : $x_0 = 1$, $x_n = 7$, n = 8

   Output : Value of integral = 1.949018

5. WEDDLE'S RULE

SYMBOLS USED

n = number of subdivision
x_0 = lower limit of integral
x_n = upper limit of integral
h = length of subinterval
y (x) = function to be integrated

ALGORITHM : WEDDING'S RULE

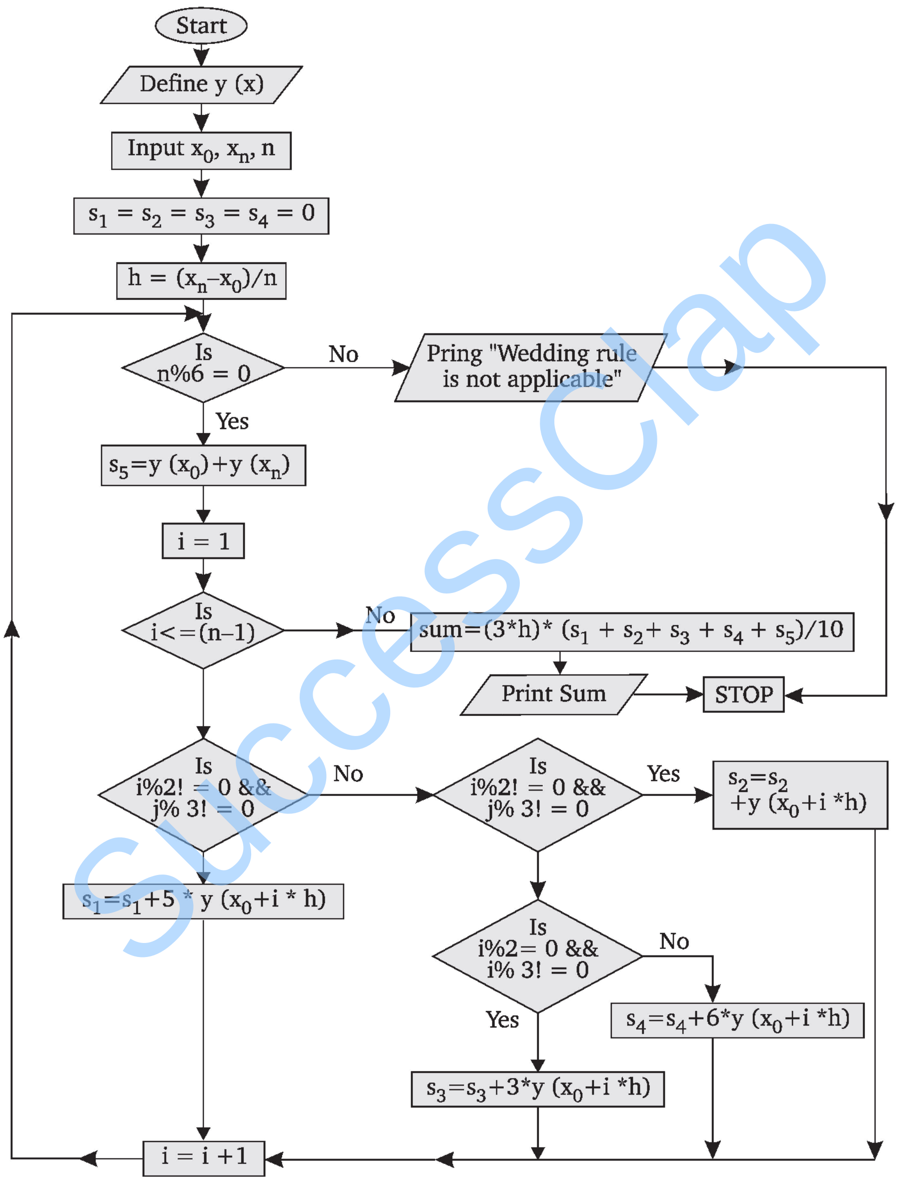
Step 1 :	Start
Step 2 :	Define function y (x)
Step 3 :	Input x_0, x_n, n
Step 4 :	$s_1 = s_2 = s_3 = s_4 = 0$
Step 5 :	$h = (x_n - x_0)/n$
Step 6 :	If (n %6 = 0)
Step 7 :	s_5 = y (x0) + y (xn)
Step 8 :	For i = 1 to n – 1

Step 9 :	If (1% 2! = 0 and i% 3! = 0)
	$s_1 = s_1 + 5 * y (x_0 + i * h)$
	else
	if (i%2 = 0 and i%3 ! = 0)
	$s_2 = s_2 + y (x_0 + i * h)$
	else
	if (i%2 = 0 and i%3 = 0)
	$s_3 = s_3 + 3 * y (x_0 + i * h)$
	else
	$s_4 = s_4 + 6 * y (x_0 + i * h)$

Step 10 :	End of i loop
Step 11 :	$Sum = 3 * h * (s_1 + s_2 + s_3 + s_4 + s_5)/10$
Step 12 :	print "Value of integral = ", sum

Step 13 : else
Step 14 : Print "Weedle's rule is not applicable"
Step 15 : Stop.

FLOW CHART : WEDDLE'S RULE



PROGRAM : *Following is a C program to solve the integral* $\int_0^6 (1+x^2)dx$ *by the Weddle's rule.*

```
// WEDDLE's RULE
#include<stdio.h>
#include<conio.h>
float y(float x)
{
   return (1+x*x);
 }
 void main()
{
      float x0,xn,h,s1=0,s2=0,s3=0,s4=0,s5,s,sum;
      int i,n;
      clrscr();
      puts("\n enter number of subdivisions i.e. n ");
      scanf("%d",&n);
      puts("\n enter lower limit of integral i.e. x0 ");
      scanf("%f",&x0);
      puts("\n enter upper limit of integral i.e. xn ");
      scanf("%f",&xn);
      h=(xn-x0)/n;
      if(n%6==0)
        s5=y(x0)+y(xn);
      else
        {printf("\n Weddle's rule is not applicable\n");
         goto end;
        }
      for(i=1;i<=n-1;i++)
      {
           if(i%2!=0 && i%3!=0)
              s1+=5*y(x0+i*h);
           else
                if(i%2==0 && i%3=0)
                  s2+=y(x0+i*h);
                else
                    if(i%2==0 && i%3==0)
                         s3+= 3*y(x0+i*h);
                     else
                           s4+=6*y(x0+i*h);
        }
      s=s1+s2+s3+s4+s5;
      sum=s*(3*h/10);
      printf("\n Value of Integral is %.3lf\n",sum);
```

```
end:   getch();
}
```

Output: WEDDLE's RULE

```
 enter number of subdivisions i.e. n
6

 enter lower limit of integral i.e. x0
0

 enter upper limit of integral i.e. xn
6

 Value of Integral is 78.000
```

LAB ASSIGNMENT : WEDDLE'S RULE

1. Write a C program to solve the integral $\int_0^1 \frac{dx}{1+x^2}$ by Weddle's rule. Divide the range into six equal parts.

Hint : Define function y (x) = 1/(1 + x * x)

Input : $x_0 = 0$, $x_n = 1$, n = 6

Output : Value of integral = 0.7854

2. Write a C program to solve the integral $\int_0^{1.5} \frac{x^3}{e^x - 1}$ dx by dividing the interval into six equal parts using Weddle's rule.

Hint : Define function y (x) = (x * x * x)/exp (x) – 1)

Input : $x_0 = 0$, $x_n = 1.5$, n = 6

Output : Value of integral = 0.6155

3. Write a C program to solve the integral $\int_0^5 \frac{dx}{4x+5}$ by Weddle's rule.

Hint : Define function y (x) = 1/(4 * x + 5)

Input : $x_0 = 0$, $x_0 = 5$, n = 12

Output : Value of integral = 0.4023.

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COMPUTATIONAL TECHNIQUE LAB

1. EULER'S METHOD

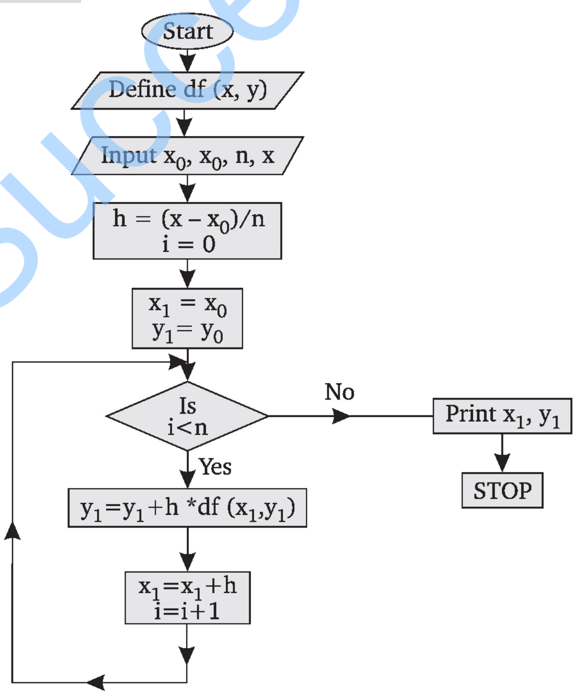
SYMBOLS USED

x_0, y_0 = Initial values of x and y
h = length of subintervals of step
x = the value of x at which we have to find y
n = number of subintervals

ALGORITHM : EULER'S METHOD

Step 1 : Start
Step 2 : Define df (x, y)
Step 3 : Input n, x_0, y_0, x
Step 4 : $h = (x-x_0)/n$
Step 5 : $x_1 = x_0$, $y_1 = y_0$, $i = 0$
Step 6 : Perform steps 7 to 9 while ($i < n$)
Step 7 : $y_1 = y_1 + h * df(x_1, y_1)$
Step 8 : $x_1 = x_1 + h$
Step 9 : $i = i + 1$
Step 10 : Print x_1, y_1
Step 11 : Stop.

FLOW CHART : EULER'S METHOD



PROGRAM : *Following is a C program to find the value of y at x for the equation* $\frac{dy}{dx} = df(x, y) = x + y$ *by the Euler's method.*

```
// EULER'S METHOD  TO FIND VALUE OF Y AT X=1 FOR EQUATION dy/dx = X+Y

#include<stdio.h>
#include<conio.h>
 float df(float x, float y)
 {
 return x+y;
 }

 void main()
   {
   clrscr();
   float x0,y0,h,x,x1,y1,n,i;

   puts("\n enter value of x0 ");
   scanf("%f", &x0);
   puts("\n enter the value of y0 ");
   scanf("%f", &y0);
   puts("\n enter the value of n ");
   scanf("%f", &n);
   puts("\n enter the value of x ");
   scanf("%f", &x);
   h=(x-x0)/n;
   x1=x0;
   y1=y0;

  for(i=0;i<n;i++)
   {
     y1+=h*df(x1,y1);
     x1+=h;
   }
     printf(" When x =%3.1f   y = %4.2f\n",x1,y1);
     getch();

   }
```

Output: EULER'S METHOD TO FIND THE VALUE OF Y(X)=1 FOR EQUATION X+Y = (dy/dx)

```
enter value of x0
0

enter value of y0
1
```

```
enter value of n
10
enter value of x
1

When x = 1  y = 3.18748
```

LAB ASSIGNMENT : EULER'S METHOD

1. Write a C program to find y for x = 0.1 for the equation $\frac{dy}{dx} = \frac{y-x}{y+x}$ with initial condition $y = 1$ at $x = 0$, dividing the interval into 5 equal parts.

Hint : Define df = (y–x)/(y+x)

Input : n = 5, $x_0 = 0$, $y_0 = 1$, x = 0.10

Output : y (0.10) = 1.09283

2. Write a C program for the Euler's method to solve the differential equation $\frac{dy}{dx} = y^2 - x^2$ for y (0.5) with y = 1 when x = 0.

Hint : Define df = y* y – x * x

Input : $x_0 = 0$, $y_0 = 1$, x = 0.5, n = 5

Output : y (0.5) = 1.76393

2. MODIFIED EULER'S METHOD

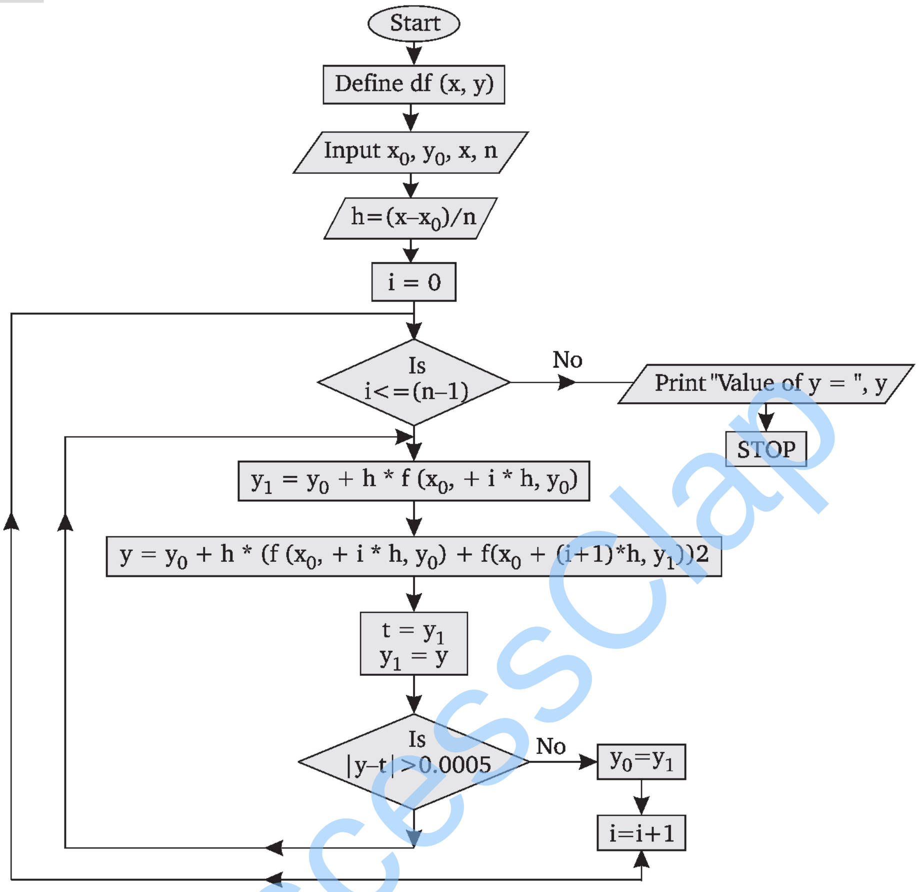
SYMBOLS USED

x_0, y_0 = Initial values of x and y
x= value of x at which we have to find y
n = number of subintervals
h = step size

ALGORITHM: MODIFIED EULER'S METHOD

Step 1 :	Start
Step 2 :	define df (x, y)
Step 3 :	Input x_0, y_0, x, n
Step 4 :	$h = (x - x_0)/n$
Step 5 :	for i = 0 to n – 1
Step 6 :	$y_1 = y_0 + h * f(x_0 + i * h, y_0)$
Step 7 :	$y = y_0 + h * (f(x_0 + i * h, y_0) + (f(x_0 + (i + 1) * h, y_1))/2$
Step 8 :	$t = y_1$
Step 9 :	$y_1 = y$
Step 10 :	Repeat step 7 to 9 until (|y – t| <=0.0005)
Step 11 :	$y_0 = y_1$
Step 12 :	End of for loop
Step 13 :	Print y
Step 14 :	Stop.

FLOW CHART



PROGRAM. *Following is a C program to find the value of y at x = 0.05 for the equation* $\frac{dy}{dx} = x + y$ *by modified Euler's method with initial condition* $y(0) = 1$.

```
 // Modified Euler's method for df = x + y.
 // EULER'S MODIFIED METHOD  TO FIND VALUE OF Y AT X =1 FOR
// EQUATION dy/dx = X+Y
#include<stdio.h>
#include<conio.h>
#include<math.h>
 float df(float x, float y)
 {
 return  x+y;
 }
 void main()
   {
      clrscr();
   float x0,y0,h,x,x1,y1,y,t;
   int n,i;
```

```
puts("\n enter value of x0 ");
scanf("%f", &x0);
puts("\n enter the value of y0 ");
scanf("%f", &y0);
puts("\n enter the value of n ");
scanf("%f", &n);
puts("\n enter the value of x ");
scanf("%f", &x);
h=(x-x0)/n;
 for(i=0;i<n;i++)
 {
    y1=y0+h*df(x0+i*h,y0);

    do
   {  y=y0+h*(df(x0+i*h,y0)+df(x0+(i+1)*h,y1))/2;
      t=y1;
      y1=y;
    } while (fabs(y-t)>0.0005);
   y0=y1;
 }
  printf("\n When x =%3.1f  y = %4.2f\n",x,y);
  getch();

}
```

Output: EULER'S MODIFIED METHOD TO FIND VALUE OF Y(X)=1 FOR EQUATION X+Y = (dy/dx)

```
enter value of x0
0
enter value of y0
1
enter value of n
5
enter value of x
.05

When x = .05  y = 1.116388
```


LAB ASSIGNMENT : MODIFIED EULER'S METHOD

1. Write a C program to find y (2.2) by Euler's modified method for $\frac{dy}{dx} = -xy^2$ where y (2) = 1.

Hint : Define df = – x * y * y

Input : $x_0 = 2, y_0 = 1, x = 2.2, n = 2$

Output : y (2.2) = 0.7018

2. Write a C program to find y (0.2) for $\frac{dy}{dx} = \log_{10}(x + y)$ with initial condition y = 1 for x = 0 by modified Euler's method.

Hint : Define df = log 10 (x + y)

Input : $x_0 = 0, y_0 = 1, x = 0.2, n = 1$

Output : y (0.2) = 1.0082

3. RUNGE-KUTTA METHOD

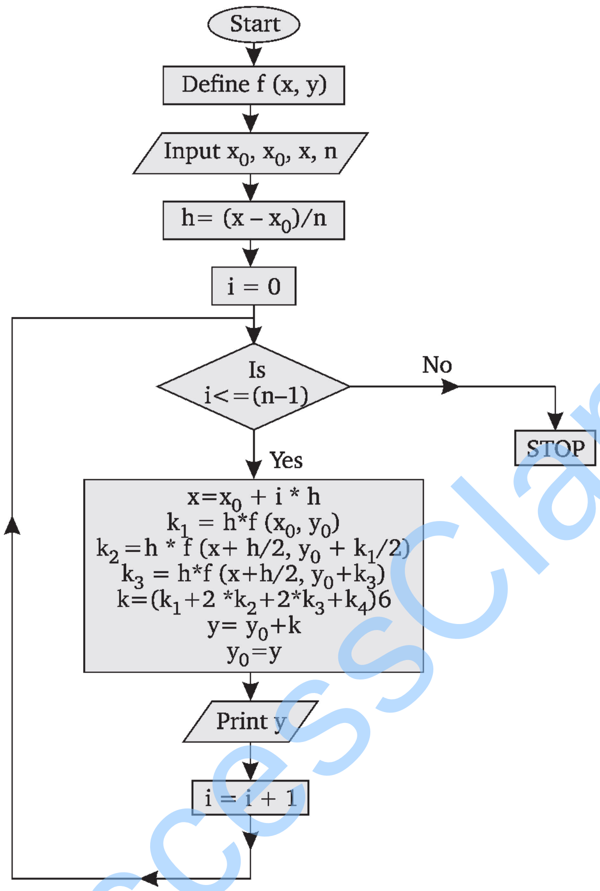
SYMBOLS USED

x_0, y_0 = initial values of x and y
h = length of subinterval
x = value of x at which we have to find y
n = number of subdivision

ALGORITHM : RUNGE-KUTTA 4TH ORDER

Step 1 :	Start
Step 2 :	Define f (x, y)
Step 3 :	Input n, x_0, y_0, x
Step 4 :	$h = (x - x_0)/n$
Step 5 :	For i = 0 to (n – 1)
Step 6 :	$x = x_0 + i * h$
Step 7 :	$k_1 = h * f(x, y_0)$
Step 8 :	$k_2 = h * f(x + h/2), y_0 + k_1/2)$
Step 9 :	$k_3 = h* f(x + h/2, y_0 + k_2/2)$
Step 10 :	$k_4 = h * f(x + h, y_0 + k_3)$
Step 11 :	$k = (k_1 + 2 * k_2 + 2 * k_3 + k_4)/6$
Step 12 :	$y + y_0 + k$
Step 13 :	$y_0 = y$
Step 14 :	Print y
Step 15 :	End of For Loop.
Step 16 :	Stop.

FLOW CHART : RUNGE-KUTTA 4TH ORDER



PROGRAM . *Following is a C program to find the value of the equation x+y for x = 0.2 for initial condition y = 1 at x = 0 by Runga Kutta 4th order.*

```
 /* RUNGE KUTTA 4th ORDER METHOD FOR dy/dx = X+y^2*/
#include<stdio.h>
#include<conio.h>

float f(float x, float y)
{
return x+y*y;
}
void main()
   {
   clrscr();
   float x0,y0,h,x,y,k1,k2,k3,k4,k;
   int i,n;
   puts("\n enter the value of x0 ");
   scanf("%f", &x0);
   puts("\n enter the value of y0 ");
   scanf("%f", &y0);
```

```
    puts("\n enter the value of n ");
    scanf("%f", &n);
    puts("\n enter the value of x ");
    scanf("%f", &x);
    h=(x-x0)/n;
      for(i=0;i<=n-1;i++)
      {
       x=x0+i*h;
       k1=h*f(x,y0);
       k2=h*f(x+h/2,y0+k1/2);
       k3=h*f(x+h/2,y0+k2/2);
       k4=h*f(x+h,y0+k3);
       k=(k1+2*(k2+k3)+k4)/6;
       y=y0+k;
       y0 =y;
       printf("\n  When x = %8.4f"
        "   y = %8.4f\n",x,y);
        getch();
       }
    }
```

Output: RUNGE KUTTA 4th ORDER METHOD FOR X+Y2

```
enter the value of x0
0
enter the value of y0
1
enter the value of n
2
enter the value of x
.2
When x = .2   y = 1.27356
```

LAB ASSIGNMENT : RUNGE-KUTTA 4TH ORDER

1. Write a C program to find y (0.4) dy/dx = – $2xy^2$ with y (0) = 1 by Runga-Kutta 4th order.

Hint : Define f (x, y) = – 2 * x * y * y

Input : x_0 = 0, y_0, y = 1, x = 0.4, n = 2

Output : y (0.4) = 0.86205

2. Write a C program to find the solution of the differential equation $\frac{dy}{dx} = 3x + \frac{1}{2}y$ with y_0 = 1 at x = 0.1 by Runge-Kutta 4th Order.

Hint : Define f (x, y) = 3 * x + y/2

Input : x_0 = 0, y_0 = 1, x = 0.1, n =1

Output : y (0.1) = 1.06665

3. Write a C program using Runga-Kutta 4th order method to solve $\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2}$ with y (0) = 1 at x = 0.2, 0.4.

Hint : Define f (x, y) = (y * y – x * x)/(y * y + x * x)

(a) **Input :** x_0 = 0, y_0 = 1, x = 0.2, n = 1

Output : y (0.2) = 1.1960

(b) **Input :** x_0 = 0, y_0 = 1, x = 0.4, n = 2

Output : y (0.4) = 1.37527

4. MILNE'S PREDICTOR CORRECTOR METHOD

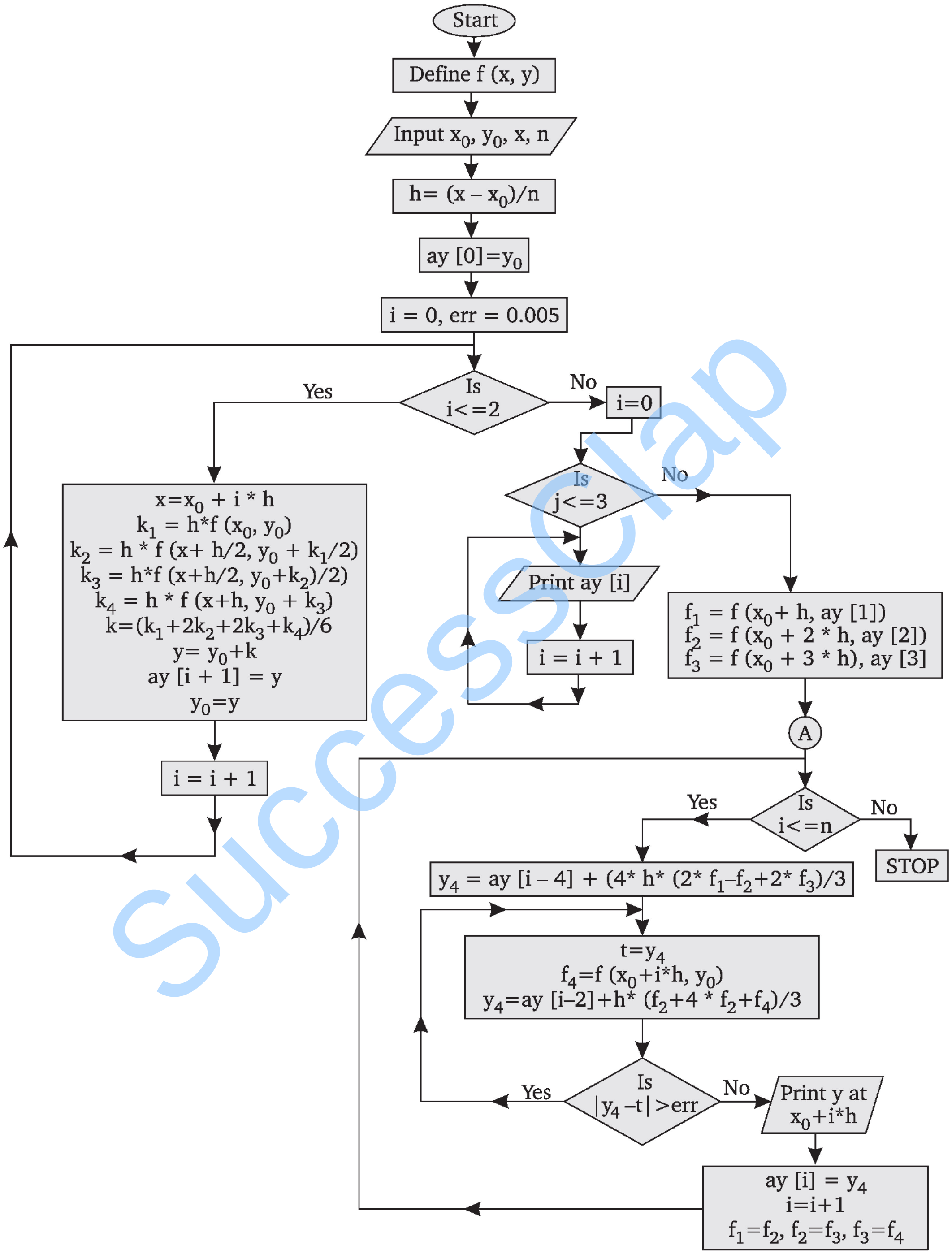
SYMBOLS USED

x_0, y_0 = initial values of x and y
h = length of subinterval
x = the value of x at which we have to find y
n = number of subdivision
err = allowed error.

ALGORITHM : MILNE'S PREDICTOR-CORRECTOR METHOD

Step 1 : Start
Step 2 : define f (x, y)
Step 3 : Input x_0, y_0, x, n
Step 4 : h $(x - x_0)/n$
Step 5 : ay [0] = y_0, err = 0.0005
Step 6 : For i to 2
Step 7 : $x = x_0 + i * h$
Step 8 : $k_1 = h * f(x, y_0)$
Step 9 : $k_2 = h * f(x + h/2, y_0 + k_1/2)$
Step 10 : $k_3 = h * f(x + h/2, y_0 + k_2/2)$
Step 11 : $k_4 = h * f(x + h, y_0 + k_3)$
Step 12 : $k = (k_1 + 2 * k_2 + 2 * k_3 + k_4)/6$
Step 13 : $y = y_0 + k$
Step 14 : ay [i + 1] = y
Step 15 : $y_0 = y$
Step 16 : End of For loop
Step 17 : Print "Starting fair values for the Milne's method by Runga-Kutta method of order 4 are"
Step 18 : For i = 0 to 3
Step 19 : Print ay [i]
Step 20 : $f_1 = f(x_0 + h, ay[i])$
Step 21 : $f_2 = f(x_0 + 2 * h, ay[2])$
Step 22 : $f_3 = f(x_0 + 3 * h, ay[3])$
Step 23 : Repeat steps 24 to 31 until (i > n)
Step 24 : $y_4 = ay[i-4] + (4 * h * (2 * f_1 - f_2 + 2 * f_3))/3$
Step 25 : Repeat steps 26 to 28 until $([y_4 - t| < err)$
Step 26 : $t = y_4$
Step 27 : $f_4 = f(x_0 + i * h, y_4)$
Step 28 : $y_4 = ay[i-2] + h*(f_2 + 4 * f_3 + f_4)/3$
Step 29 : print "Value of y at x =", $x_0 + i * h$, ay [i]
Step 30 : i = i + 1
Step 31 : $f_1 = f_2, f_2 = f_3, f_3 = f_4$
Step 32 : Stop.

FLOW CHART : MILNE'S PREDICTOR CORRECTOR METHOD



PROGRAM. *Following program shows the Milne's Predictor-Corrector Method to find the approximate value of y for x = 0.4 for the equation $dy/dx=xy+y^2$ with initial condition y = 1 at x = 0 dividing the range into four equal parts.*

```
/* MILNE'S PREDICTOR CORRECTOR  METHOD FOR dy/dx = X*Y+Y*Y    */

#include<stdio.h>
#include<math.h>
#include<conio.h>


float f(float x,float y)
{
return x*y+y*y;
}

void main()
{
     clrscr();
      float ay[5],x0,y0,x,y,h,t,k1,k2,k3,k4,k,err=.0005;
      float f1,f2,f3,f4,y2,y4;
      int i,n;

      puts("Enter the value of x0,y0,x,n\n");
      scanf(" %f %f %f %d", &x0,&y0,&x,&n);
      h=(x-x0)/n;
      ay[0]=y0;

  for(i=0;i<n;i++)
   {
      x=x0+i*h;
      k1=h*f(x,y0);
      k2=h*f(x+h/2,y0+k1/2);
      k3=h*f(x+h/2,y0+k2/2);
      k4=h*f(x+h,y0+k3);
      k=(k1+2*(k2+k3)+k4)/6;
      y=y0+k;
      ay[i+1]=y;
      y0=y;
   }

 printf("\n Starting 4 values  by runge -kutta mrthod are\n");
```

```
for(i=0;i<=3;i++)
  printf("\n y= %d= %.5f",i,ay[i]);

  f1=f(x0+h,ay[1]);
  f2=f(x0+2*h,ay[2]);
  f3=f(x0+3*h,ay[3]);


while(i<=1)
    {
       y4=ay[i-4]+(4*h*(2*f1-f2+2*f3))/3;
       do
        {
           t=y4;
           f4=f(x0+i*h,y4);
           y4=ay[i-2]+h*(f2+4*f3+f4)/3;
           } while (fabs(y4-t)>err);
      printf("\n\n value of y at x=%.2f= %.5f",x0+i*h,y4);
      ay[i]=y4;
      i++;
      f1=f2; f2=f3, f3=f4;
     }
      getch();
      }
```

Output: MILNE'S PREDICTOR CORRECTOR METHOD FOR X*Y+Y*Y

```
Enter the value of x0,y0,x,n

0     1     .4     4

Starting 4 values  by runge -kutta mrthod are

 y= 0= 1.00000
 y= 1= 1.11689
 y= 2= 1.27739
 y= 3= 1.50412

 Value of y at x=0.40   is  1.83941
```

LAB ASSIGNMENT : MILNE'S PREDICTOR CORRECTOR METHOD

1. Write a C program for Milne's Predictor Corrector method to find value of y for x = 0.5 for dy/dx= $2e^x - y$ with initial condition x = 0, y = 2 by dividing range into 5 equal parts.

Hint : Define f (x, y) = 2 * exp (x) – y

Input : $x_0 = 0$, $y_0 = 2$, x = 0.5, n = 5

Output : y (0.50) = 2.25525

2. Write a C program to find value of y at x = 0.5 of the differential equation dy/dx = x + y with initial condition y (0) = 1 by predictor-corrector method.

Hint : Define f (x, y) = x + y

Input : $x_0 = 0$, $y_0 = 1$, x = 0.5, n = 5

Output : y (0.5) = 1.7968

3. Write a C program for Milne's method to find y (1) for the equation dy/dx = $x - y^2$ with initial condition y (0) = 0.

Hint : Define f (x, y) = x – y * y

Input : $x_0 = 0$, $y_0 = 0$, x = 1, n = 5

Output : y (1) =0.45552

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