

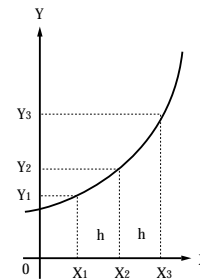
Ordinary Differential Equations

Enter the initial conditions (X, Y) with the step H and interval T. Use Runge Kutta Gill method to solve the ordinary differential equation of first order.

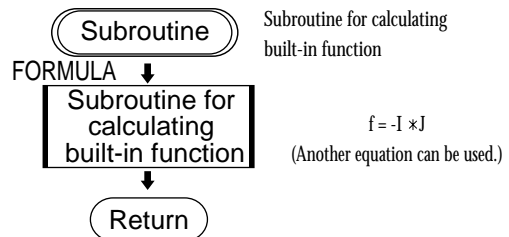
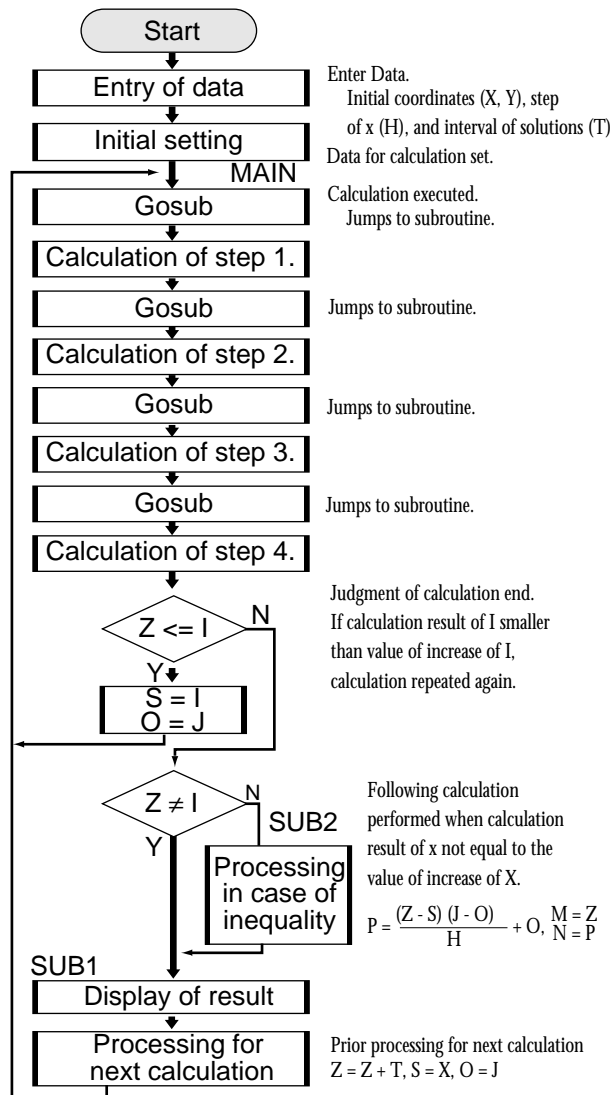
Calculation

Use the following four steps of Runge Kutta Gill method to find the equation X_{n+1} and Y_{n+1} from X_n and Y_n . Input $Q_0 = 0$ at the starting point X_0 .

1. $K_0 = Hf(X_n, Y_n)$, $R_1 = (1/2)(K_0 - 2Q_0)$, $Y^{(1)} = Y_n + R_1$
2. $Q_1 = Q_0 + 3R_1 - (1/2)K_0$
 $K_1 = Hf(X_n + H/2, Y^{(1)})$, $R_2 = (1 - \sqrt{1/2})(K_1 - Q_1)$, $Y^{(2)} = Y^{(1)} + R_2$
3. $Q_2 = Q_1 + 3R_2 - (1 - \sqrt{1/2})K_1$
 $K_2 = Hf(X_n + H/2, Y^{(2)})$, $R_3 = (1 + \sqrt{1/2})(K_2 - Q_2)$, $Y^{(3)} = Y^{(2)} + R_3$
4. $Q_3 = Q_2 + 3R_3 - (1 + \sqrt{1/2})K_2$
 $K_3 = Hf(X_{n+1}, Y^{(3)})$, $R_4 = (1/6)(K_3 - 2Q_3)$, $Y_{n+1} = Y^{(3)} + R_4$
 $Q_4 = Q_3 + 3R_4 - (1/2)K_3$



FLOWCHART



PROGRAMME LIST (REAL MODE)

Title : RUNGE

```

Rem INITIAL      I+H/2=>I          Goto MAIN
Print " Input X0  Rem 2          Label NEXT
Input X          Gosub FORMULA    If Z≠I Goto SUB2
Print " Input Y0 H*F=>K          I=>M
Input Y          B*(K-Q)>=R        J=>N
X=>I            J+R=>J             Label SUB1
Y=>J            Q+3*R-B*K=>Q       ClrT
Print " Input H  Rem 3          Print "XN=
Input H          Gosub FORMULA    Print M
Print " Input T  H*F=>K          Print "YN=
Input T          A*(K-Q)>=R        Print N
1+√(2^-1)>=A    J+R=>J             Wait
1-√(2^-1)>=B    Q+3*R - A*K=>Q    Z+T=>Z
I+T=>Z          I+H/2=>I          I=>S
O=>Q            Rem 4           J=>O
I=>S            Gosub FORMULA    Goto MAIN
Label MAIN      H*F=>K          Label SUB2
Rem 1           (K - 2*Q) /6 =>R  (Z-S)*(J-O) /H+O =>P
Gosub FORMULA  J+R=>J           Z=>M
H*F=>K          Q+3*R - K/2=>Q    P=>N
(K-2*Q) /2=>R  If Z<=I Goto NEXT Goto SUB1
J+R=>J         I=>S             Label FORMULA
Q+3*R-K/2=>Q  J=>O             -I*J=>F
Return
    
```

PARAMETERS

Name of parameter	Content	Name of parameter	Content
A	value of $1 + \sqrt{1/2}$	S	value of X_{n-1}
B	value of $1 - \sqrt{1/2}$	T	interval
F	f (I,J)	I	X_n
H	step	J	Y_n
K	calculating working area	Z	value of increase of X
O	value of Y_{n-1}	X	input of X_0
P	increase of J	Y	input of Y_0
Q	value of Q_n	M	indicates X_n
R	value of R_n	N	indicates Y_n

Exercise

Initial settings: $Y = 10$ when $X = 0$. Find J when $H = 0.01$, $T = 0.03$ and $I = 0.03, 0.06 \dots$.
 (The built-in differential equation is $F = -I * J$.)

Set up condition: angle unit in Rad Mode and decimal point in Float Pt Mode.

2ndF **SET UP** **B** **2** **C** **1** **CL**

Step

Key Operation

Display

1

Specify the programme mode.
 Select the title RUNGE.

PRGM **A**

```
RUNGE
Input X0
X=?
```

2

Enter the values of X_0 , Y_0 ,
 H and T .

0 **ENTER** **1** **0** **ENTER**
0 **.** **0** **1** **ENTER**
0 **.** **0** **3**

```
RUNGE
Input X0
X=
0
Input Y0
Y=
10
Input H
H=
0.01
Input T
T=
0.03
```

3

(Display of X_1)
 (Display of Y_1)

ENTER

```
XN=                0.03
YN=                9.995501012
```

4

(Display of X_2)
 (Display of Y_2)

ENTER

```
XN=                0.06
YN=                9.98201619
```

5

(Display of X_3)
 (Display of Y_3)

ENTER

```
XN=                0.09
YN=                9.959581902
```

Similar operation is performed hereafter.