# CHRIST (DEEMED TO BE UNIVERSITY)

DEPARTMENT OF MATHEMATICS

CALCULUS USING PYTHON

**MAT112-2**

# E-RECORD

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Getting Started with Python

## Variable

```
x=1
y=35.656222554887711
z=-325.e100
print(type(x))
print(type(y))
print(type(z))
```

```
<class 'int'>
<class 'float'>
<class 'float'>
```

```
x1=float(x)
y1=int(y)
print(x1)
print(y1)
```

```
1.0
35
```

```
name="Hii world"
print(type(name))
```

```
<class 'str'>
```

Write a Program to perform basic arthemetic operations of two numbers entered by the user.

```
n1=int(input("Enter a number:"))
n2=int(input("Enter a number:"))
s=n1+n2
d=n1-n2
p=n1*n2
q=n1/n2
r=n1%n2
print("Sum= ",s)
print("Difference= ",d)
print("Product= ",p)
print("Quotient= ",q)
print("Remainder= ",r)
```

```
Enter a number: 5
Enter a number:88
Sum=  93
Difference=  -83
Product=  440
Quotient=  0.056818181818181816
Remainder=  5
```

Write a Program to check the biggest of three numbers entered by user

```
a=int(input("Enter a number:"))
b=int(input("Enter a number:"))
c=int(input("Enter a number:"))
if a>b and a>c:
    print(a,"is greatest")
elif b>a and b>c:
    print(b,"is greatest")
elif c>a and c>b:
    print(c,"is greatest")
else:
    print("All are equal.")
a=3+4j
print(a.real)
print(a.imag)
```

## Data Structure

```
List
a=["gokul","is","dumb"]
print(type(a))
#tuple
b=("maybe","its beacause","he eats too much")
print(type(b))
for i in range(1,10):
print(i)
#dictionary
d={"gokul": "Dumb"}
print(d)
print(type(d))
```

Function

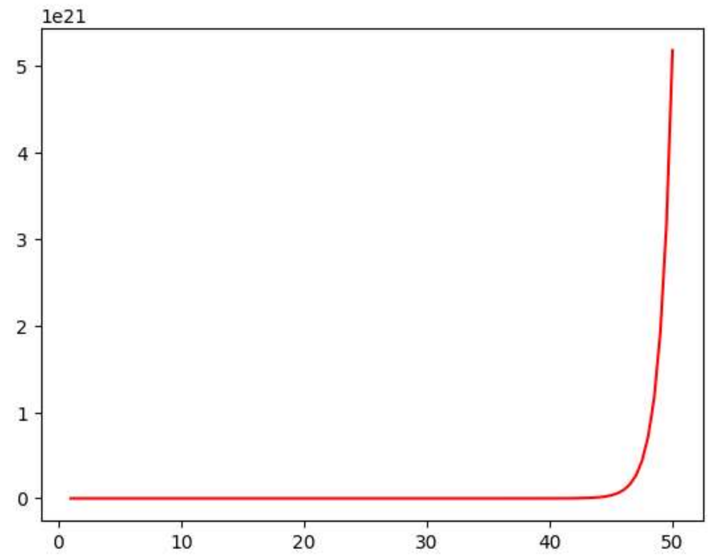
```
def my_function():
  print("Hello ")
```

```
def starkids(*kids):
  print("The name of the last kid is",kids[2])
  starkids("Harry","Hermione","Ron")
```

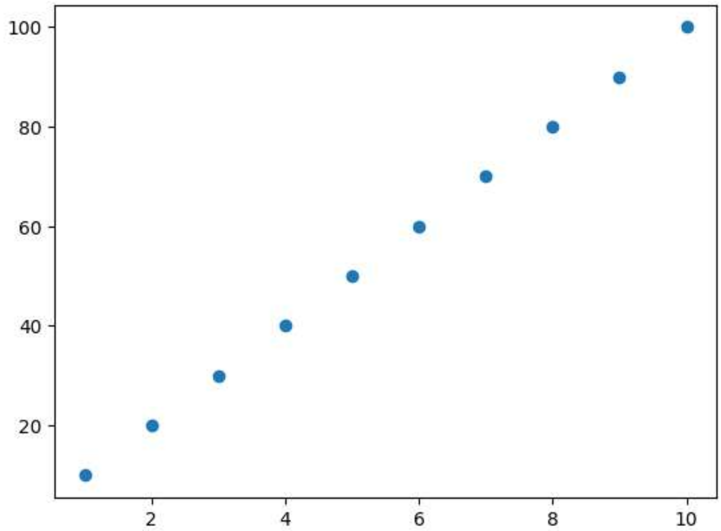
2d plots

```
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(1,50,100)
y=np.linspace(1,25,100)
z1=np.e**x
z2=np.exp(y)
print(x)
print(y)
print(z1)
print(z2)
print(type(x))
plt.plot(x,z1,color='red')
plt.show()
```

```
 5.89910195e+16 9.67697762e+16 1.58742630e+17 2.60403853e+17
 4.27170487e+17 7.00737040e+17 1.14949982e+18 1.88565720e+18
 3.09326109e+18 5.07423308e+18 8.32385003e+18 1.36545717e+19
 2.23991695e+19 3.67439423e+19 6.02753283e+19 9.88765761e+19
 1.62198657e+20 2.66073173e+20 4.36470527e+20 7.15992968e+20
 1.17452588e+21 1.92671033e+21 3.16060528e+21 5.18470553e+21]
[2.71828183e+00 3.46400087e+00 4.41429653e+00 5.62529127e+00
 7.16850389e+00 9.13507328e+00 1.16411409e+01 1.48347099e+01
 1.89043856e+01 2.40905147e+01 3.06993789e+01 3.91212840e+01
 4.98536099e+01 6.35301853e+01 8.09587199e+01 1.03168506e+02
 1.31471208e+02 1.67538323e+02 2.13499900e+02 2.72070332e+02
 3.46708666e+02 4.41822886e+02 5.63030237e+02 7.17488971e+02
 9.14321096e+02 1.16515110e+03 1.48479249e+03 1.89212260e+03
 2.41119749e+03 3.07267265e+03 3.91561339e+03 4.98980203e+03
 6.35867790e+03 8.10308393e+03 1.03260411e+04 1.31588325e+04
 1.67687569e+04 2.13690089e+04 2.72312697e+04 3.47017520e+04
 4.42216469e+04 5.63531794e+04 7.18128122e+04 9.15135588e+04
 1.16618904e+05 1.48611517e+05 1.89380813e+05 2.41334543e+05
 3.07540983e+05 3.91910148e+05 4.99424703e+05 6.36434232e+05
 8.11030229e+05 1.03352397e+06 1.31705546e+06 1.67836948e+06
 2.13880448e+06 2.72555277e+06 3.47326649e+06 4.42610403e+06
 5.64033797e+06 7.18767842e+06 9.15950806e+06 1.16722790e+07
 1.48743902e+07 1.89549517e+07 2.41549528e+07 3.07814946e+07
 3.92259268e+07 4.99869599e+07 6.37001178e+07 8.11752708e+07
 1.03444465e+08 1.31822872e+08 1.67986460e+08 2.14070976e+08
 2.72798074e+08 3.47636053e+08 4.43004687e+08 5.64536248e+08
 7.19408133e+08 9.16766751e+08 1.16826769e+09 1.48876406e+09
 1.89718371e+09 2.41764704e+09 3.08089153e+09 3.92608699e+09
 5.00314891e+09 6.37568629e+09 8.12475831e+09 1.03536615e+10
 1.31940302e+10 1.68136105e+10 2.14261674e+10 2.73041087e+10
 3.47945733e+10 4.43399323e+10 5.65039146e+10 7.20048993e+10]
<class 'numpy.ndarray'>
```



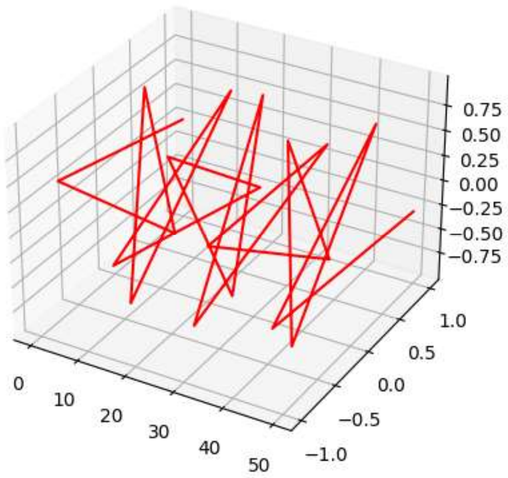
```
x=[1,2,3,4,5,6,7,8,9,10]
y=[10,20,30,40,50,60,70,80,90,100]
plt.scatter(x,y)
plt.show()
```



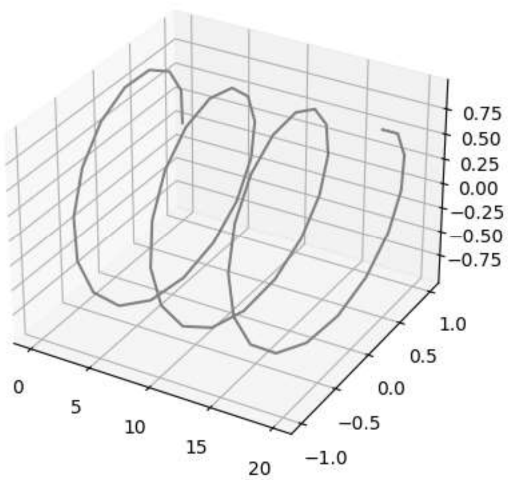

3D Plot

```
from mpl_toolkits import mplot3d
from matplotlib.pyplot import *
from numpy import *
x=linspace(0,50,20)
print(x)
y=cos(x)
z=sin(x)
print(y)
print(z)
ax=axes(projection="3d")
ax.plot3D(x,y,z,'red')
```

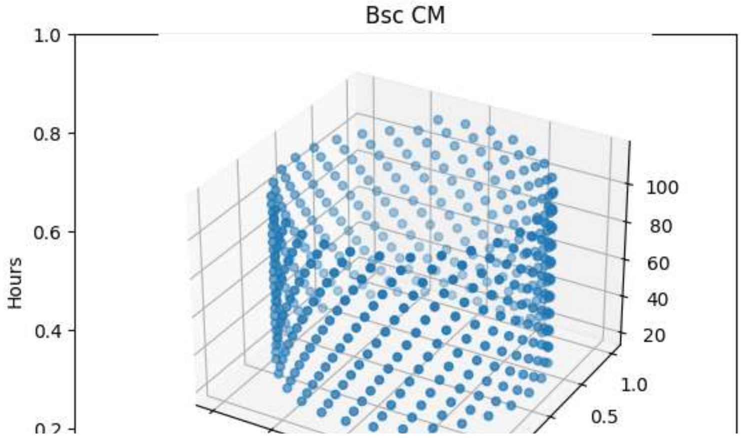
```
[ 0.          2.63157895  5.26315789  7.89473684 10.52631579 13.15789474
 15.78947368 18.42105263 21.05263158 23.68421053 26.31578947 28.94736842
 31.57894737 34.21052632 36.84210526 39.47368421 42.10526316 44.73684211
 47.36842105 50.        ]
[ 1.         -0.87273782  0.52334259 -0.04074393 -0.45222506  0.83009175
 -0.99667986  0.90958867 -0.59098499  0.12196123  0.37810463 -0.78193365
  0.98674151 -0.9403996   0.65470308 -0.20236868 -0.30147349  0.7285833
 -0.97025092  0.96496603]
[ 0.          0.48818921 -0.85212237  0.99916962 -0.89190386  0.55762683
 -0.08142019 -0.41550988  0.80668255 -0.99253487  0.92576287 -0.62336166
  0.16229972  0.34007145 -0.75588615  0.97930941 -0.95347456  0.6849572
 -0.24210155 -0.26237485]
[<mpl_toolkits.mplot3d.art3d.Line3D at 0x79ee8c24c220>]
```




```
x=linspace(0,20,50)
y=cos(x)
z=sin(x)
ax=axes(projection="3d")
ax.plot3D(x,y,z,'grey')
show()
```

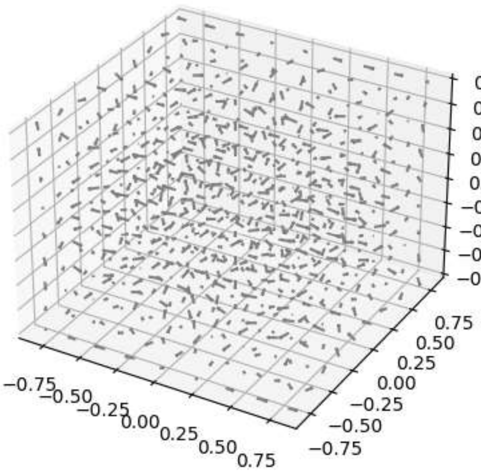



```
x=linspace(20,115,450)
y=cos(x)
z=sin(x)
title("Bsc CM")
xlabel("Class")
ylabel("Hours")
ax=axes(projection="3d")
ax.scatter3D(y,z,x)
show()
```




```
from numpy import *
from matplotlib.pyplot import *
from mpl_toolkits.mplot3d import *
x=arange(-0.8,1,0.2)
print(x)
ax=axes(projection="3d")
x,y,z=meshgrid(arange(-0.8,1,0.2),arange(-0.8,1,0.2),arange(-
0.8,1,0.2))
u=sin(x*pi)*cos(y*pi)*cos(z*pi)
v=-cos(x*pi)*sin(y*pi)*cos(z*pi)
w=sqrt(2/3)*cos(x*pi)*cos(y*pi)*sin(z*pi)
ax.quiver(x,y,z,u,v,w,color='grey',length=0.1)
show()
```

```
[-8.00000000e-01 -6.00000000e-01 -4.00000000e-01 -2.00000000e-01
 -2.22044605e-16  2.00000000e-01  4.00000000e-01  6.00000000e-01
  8.00000000e-01]
```



## UNIT 2 - ALGEBRA

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## Use of SymPy and NumPy package

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sympy

It is a Python library for symbolic mathematics

```
x=1
print(x+x+4)
```

```
6
```

### Symbol

To define one symbol to a variable we use **Symbol**

```
from sympy import Symbol
```

```
x=Symbol('x')
print(x+x+4)
```

```
2*x + 4
```

```
a=Symbol('x')
print(a+a+1)
a=a+1
print(a)
```

```
2*x + 1
x + 1
```

```
x=Symbol('x')
y=Symbol('y')
z=Symbol('z')
print(x,y,z)
```

```
x y z
```

### symbols

To define more than one symbol to diff variables we use **symbols**

```
from sympy import symbols
```

```
x,y,z=symbols('a,b,c')
print(x.name)
print(y.name)
print(z.name)
```

```
a
b
c
```

The output for below code is the **symbols** not the variables

```
x,y,z=symbols('x,y,z')
print(x.name)
print(y.name)
print(z.name)
```

```
x
y
z
```

---

### Basic algebraic operations with polynomials/rational functions

---

```
x=Symbol('x')
y=Symbol('y')
s=x*y+x*y
s
```

$$2xy$$

```
x=Symbol('x')
y=Symbol('y')
s=x*y+x*y
print(s)
```

```
2*x*y
```

```
p=x*(x+x)
p
```

$$2x^2$$

```
p=(x+2)*(x+3)
p
```

$$(x+2)(x+3)$$

```
from sympy import factor
```

### factor

It finds the factor of the given expression

```
expr=x**2-y**2
factor(expr)
```

$$(x - y)(x + y)$$

### expand

It is used to expand the factorised equation and viceversa depending on the equation provided

```
from sympy import expand
```

```
factors=factor(expr)
expand(factors)
```

$$x^2 - y^2$$

```
expr=x**3+3*x**2*y+3*x*y**2+y**3
factors=factor(expr)
factors
```

$$(x + y)^3$$

```
#viceversa case
f=expand(factors)
f
```

$$x^3 + 3x^2y + 3xy^2 + y^3$$

```
expand(f)
```

$$x^3 + 3x^2y + 3xy^2 + y^3$$

```
expr=x+y+x*y
factor(expr)
```

$$xy + x + y$$

### pprint()

The pprint module provides a capability to “pretty-print” arbitrary Python data structures in a form which can be used as input to the interpreter.

```
from sympy import pprint
```

```
expr=x*x+2*x*y+y*y
expr
```

$$y^2 + 2xy + x^2$$

```
pprint(expr)
```

```
 2           2
x  + 2⋅x⋅y + y
```

```
from sympy import init_printing
```

```
init_printing(order='rev-lex')
pprint(expr)
```

```
 2           2
y  + 2⋅x⋅y + x
```

## collect()

collects common power of a term in an expression

```
from sympy import *
```

```
x,y,z=symbols('x,y,z')
factor_list(x**2-y**2)
```

$$(1, [(-y + x, 1), (y + x, 1)])$$

```
expr=x*y+x-3+2*x**2-z*x**2+x**3
print(expr)
collected_expr=collect(expr,x)
collected_expr
```

```
x**3 - x**2*z + 2*x**2 + x*y + x - 3
```

$$-3 + x(1 + y) + x^2 \cdot (2 - z) + x^3$$

## ***coeff***

collects the coefficient of given parameters inside the function. Here, the coefficient of x power 2 is printed

```
collected_expr.coeff(x,2)
```

$$2 - z$$

### cancel

Cancels the common terms in numerator and denominator

```
cancel((x**2+2*x+1)/(x**2+x))
```

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

## Use of SymPy and NumPy package

```
from numpy import *
from sympy import *
```

```
a=Rational(5,8)
print(type(a))
print("The value of a is: "+str(a))

b=Integer(3.579)
print("The value of b is: "+str(b))
```

```
<class 'sympy.core.numbers.Rational'>
The value of a is: 5/8
The value of b is: 3
```

```
p=pi**3
print("The value of p is: "+str(p))
```

```
The value of p is: pi**3
```

```
#evalf method evaluates the expression to a floating-point number
q=pi.evalf()
print(q)
print(type(q))
print("The value of q is: "+str(q))
```

```
3.14159265358979
<class 'sympy.core.numbers.Float'>
The value of q is: 3.14159265358979
```

```
#equivalent to e^1 or e**1
r=exp(1).evalf()
print("The value of r is: "+str(r))
```

```
The value of r is: 2.71828182845905
```

```
s=(pi+exp(1)).evalf()
print("The value of s is: "+str(s))
```

```
The value of s is: 5.85987448204884
```

**oo** standes for infinity

```
rslt=oo+1000
print("The value of rslt is: "+str(rslt))
```

```
The value of rslt is: oo
```

```
if oo>9999999:
  print("True")
else:
  print("False")
```

```
True
```

```
y=Symbol('y')
x=Symbol('x')
z=(x+y)+(x-y)
print("The value of z is: "+str(z))
```

```
The value of z is: 2*x
```

## Trigonometric Simplifications

## Differentiation

```
ans1=diff(sin(x)*exp(x),x)
print("Derivative of sin(x)*e^x : ",ans1)
```

```
Derivative of sin(x)*e^x :  exp(x)*sin(x) + exp(x)*cos(x)
```

## Integrals

### Indefinite Integration

```
#Compute(e^x*sin(x)+e^x*cos(x))dx
ans2=integrate(exp(x)*sin(x)+exp(x)*cos(x),x)
print("Indefinite Integration is: ",ans2)
```

```
Indefinite Integration is:  exp(x)*sin(x)
```

### Definite Integration

```
#Compute definite integral of sin(x^2)dx
#in b/w interval of ? and ??
ans3=integrate(sin(x**2),(x,-oo,oo)).evalf()
print("Definite Integration is: ",ans3)
```

```
Definite Integration is:  1.25331413731550
```

## Limit of a function

```
#Find the limit of sin(x) / x given x tends to 0
ans4=limit(sin(x)/x,x,0)
print("Limit is : ",ans4)
```

```
Limit is :  1
```

```
#Solve Quadratic equation like, example: x^27=0
ans5=solve(x**2-2,x)
print("Roots are : ",ans5)
```

```
Roots are :  [-sqrt(2), sqrt(2)]
```

```
a=pi/6
b=3
c=4
```

### end

## removes default '\n'

```
#returning the value of tangent of pi/6
print("The value of tangent of pi/6 is : ",end="")
print(tan(a))
```

```
The value of tangent of pi/6 is : sqrt(3)/3
```

```
#returning the value of hypotenuse of 3 and 4
print("The value of hypotenuse of 3 and 4 is : ",end="")
print(hypot(b,c))
```

```
The value of hypotenuse of 3 and 4 is : 5.0
```

```
a=pi/6
b=30
```

```
#returning the converted value from radians to degree
print("The converted value from radians to degree is : ",end="")
print(math.degrees(a))
```

```
The converted value from radians to degree is : 30.000000000000004
```

```
#returning the converted value from degree to radians
print("The converted value from degree to radians is : ",end="")
print(math.radians(b))
```

```
The converted value from degree to radians is : 0.5235987755982988
```

## INVERSE TRIGNOMETRY FUNCTION

```
print(asin(1)) #gives sin inverse
print(acos(0)) #gives cos inverse
print(atan(1)) #gives tan inverse
```

```
pi/2
pi/2
pi/4
```

```
x=1.0
y=1.0
z=complex(x,y)
print(z)
print("The arc sine is : ",asin(z))
print("The arc cosine is : ",acos(z))
print("The arc tangent is : ",atan(z))
print("The hyperbolic sine is : ",sinh(z))
print("The hyperbolic cosine is : ",cosh(z))
print("The hyperbolic tangent is : ",tanh(z))
print("The inverse hyperbolic sine is : ",asinh(z))
print("The inverse hyperbolic cosine is : ",acosh(z))
print("The inverse hyperbolic tangent is : ",atanh(z))
```

```
(1+1j)
The arc sine is :  0.666239432492515 + 1.06127506190504*I
The arc cosine is :  0.904556894302381 - 1.06127506190504*I
The arc tangent is :  1.01722196789785 + 0.402359478108525*I
The hyperbolic sine is :  0.634963914784736 + 1.29845758141598*I
The hyperbolic cosine is :  0.833730025131149 + 0.988897705762865*I
The hyperbolic tangent is :  1.08392332733869 + 0.271752585319512*I
The inverse hyperbolic sine is :  1.06127506190504 + 0.666239432492515*I
The inverse hyperbolic cosine is :  1.06127506190504 + 0.904556894302381*I
The inverse hyperbolic tangent is :  0.402359478108525 + 1.01722196789785*I
```

## Exponential and Logarithms functions

```
import math as m
```

### math.log()

method returns the natural logarithm of a number, or the logarithm of number to base.

math.log(x, base) // default base is e

```
# Return the natural logarithm of different numbers
print(m.log(2.7183))
print(m.log(2))
print(m.log(1))
```

```
1.0000066849139877
0.6931471805599453
0.0
```

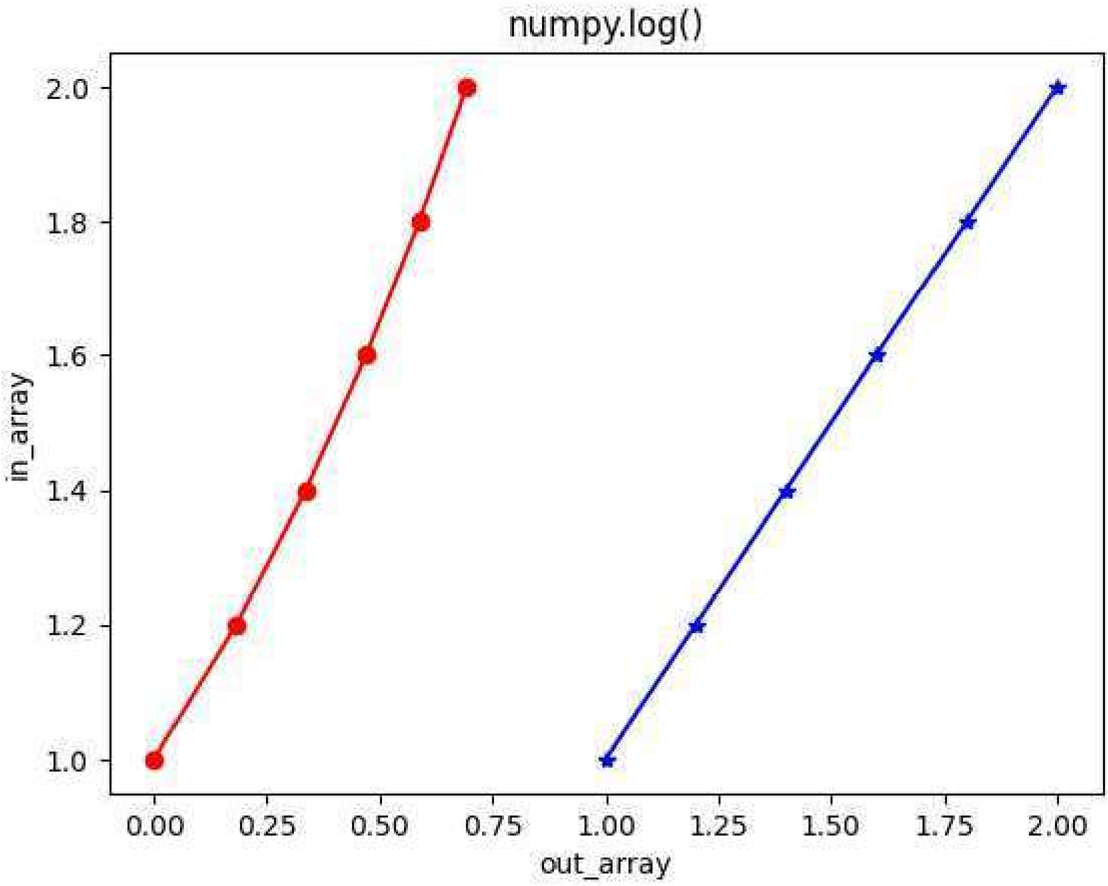
```
import numpy as np
import matplotlib.pyplot as plt
```

```
in_array = [1, 3, 5, 2**8]
print ("Input array : ", in_array)

out_array = np.log(in_array)
print ("Output array : ", out_array)


print("\nnp.log(4**4) : ", np.log(4**4))
print("np.log(2**8) : ", np.log(2**8))
```

```
Input array :  [1, 3, 5, 256]
Output array :  [0.         1.09861229 1.60943791 5.54517744]

np.log(4**4) :  5.545177444479562
np.log(2**8) :  5.545177444479562
```

```
in_array = [1, 1.2, 1.4, 1.6, 1.8, 2]
out_array = np.log(in_array)

print ("out_array : ", out_array)

plt.plot(in_array, in_array,
         color = 'blue', marker = "*")

# red for numpy.log()
plt.plot(out_array, in_array,
         color = 'red', marker = "o")

plt.title("numpy.log()")
plt.xlabel("out_array")
plt.ylabel("in_array")
plt.show()
```

```
out_array :  [0.         0.18232156 0.33647224 0.47000363 0.58778666 0.69314718]
```




```
#base - should be mentioned after log,
#if not given it is taken as e
print(np.log10(100))
print(np.log(e))
print(np.log10(e))
```

```
2.0
1.0
0.4342944819032518
```

```
from sympy import *
from numpy import *
```

```
print(log(100,10))
```

```
2
```

---

## Solving Algebraic Equations

---

### Linear Equation

### solve()

solves the equation passed inside it

solve returns a list

```
x=Symbol('x')
solve(x+4)
```

```
[-4]
```

### Quadractic Equation

```
solve(x**2+4)
```

```
[-2*I, 2*I]
```

```
solve(x**2+2*x+1)
```

```
[-1]
```

```
solve(x**3-1)
```

```
[1, -1/2 - sqrt(3)*I/2, -1/2 + sqrt(3)*I/2]
```

```
print(solve(x**3-1)[1])
```

```
-1/2 - sqrt(3)*I/2
```

### Discriminant - D

if D>0 : two diff real roots

if D<0 :complex roots

if D=0 :two equal real roots

```
x_value = float(input('The x value: '))
y_value = float(input('The y value: '))
z_value = float(input('The z value: '))
discriminant = (y_value**2) - (4*x_value*z_value)
if discriminant > 0:
        print('Two real Solutions.')
        print('Discriminant value is:', discriminant)
elif discriminant == 0:
        print('Two equal real Solutions.')
        print('Discriminant value is:', discriminant)
elif discriminant < 0:
        print('Complex Solutions.')
        print('Discriminant value is:', discriminant)
```

```
The x value: 1
The y value: 0
The z value: -1
Two real Solutions.
Discriminant value is: 4.0
```

```
from numpy import *
from sympy import *
```

```
x=Symbol('x')
```

## Calculus-Limits

### LIMIT OF A FUNCTION

```
expr1 =x**2-4
ans1=limit(expr1,x,2)
print(ans1)
```

```
0
```

```
expr2 =(x**3-4*x)/(2*x**2+3*x)
ans2=limit(expr2,x,0)
print(ans2)
```

```
-4/3
```

```
expr3 =(x**3)/((x+1)**2)
ans3=limit(expr3,x,1)
print(ans3)
```

```
1/4
```

```
expr4 =(x-2)/(x**2-3*x+2)
ans4=limit(expr4,x,2)
print(ans4)
```

```
1
```

```
expr5=(3*x+2*x**-1)/(x+4*x**-1)
ans5=limit(expr5,x,0)
print(ans5)
```

```
1/2
```

```
expr6=(x**2-3*x+2)/(x**2-2*x)
ans6=limit(expr6,x,2)
print(ans6)
```

```
1/2
```

```
expr7 =(x**3+3*x**2+2*x)/(x**2-x-6)
ans7=limit(expr7,x,2)
print(ans7)
```

    -6

```
expr8 =(x**2-2*x-1)/(x**3-x)
ans8=limit(expr8,x,1)
print(ans8)
```

    -oo

```
expr9 =(x**2+7*x-44)/(x**2-6*x+8)
ans9=limit(expr9,x,4)
print(ans9)
```

    15/2

## DERIVATIVES

```
y1=diff(x**2+2*x+1,x)
print(y1)
```

    2*x + 2

```
y2=diff(4*x**3-3*x**2+2*x-1,x)
print(y2)
```

    12*x**2 - 6*x + 2

```
y3=diff(1/4*x**4+1/3*x**3+1/2*x**2,x)
print(y3)
```

    1.0*x**3 + 1.0*x**2 + 1.0*x

```
y4=diff(x+x**(1/2)+x**(1/3)+x**(1/5),x)
print(y4)
```

    0.2/x**0.8 + 0.333333333333333/x**0.666666666666667 + 0.5/x**0.5 + 1

```
y5=diff(x**(8/3)-x**(7/4)+x**(6/5),x)
print(y5)
```

    1.2*x**0.2 - 1.75*x**0.75 + 2.66666666666667*x**1.66666666666667

```
y6=diff(1/((2*x**4)**(1/3))-1/((2*x**3)**(1/4)),x)
print(y6)
```

```
0.630672311440286/(x*(x**3)**0.25) - 1.0582673679788/(x*(x**4)**0.333333333333333)
```

```
y7=diff(sin(x)+cos(x)+tan(x),x,1)
print(y7)
```

```
-sin(x) + cos(x) + tan(x)**2 + 1
```

```
y8=diff(log(x,10)-ln(x)+log(x,5),x)
print(y8)
```

```
-1/x + 1/(x*log(10)) + 1/(x*log(5))
```

```
y9=diff(3*asin(x)-2*atan(x),x)
print(y9)
```

```
-2/(x**2 + 1) + 3/sqrt(1 - x**2)
```

## Calculus-limits

```
from sympy import *
```

```
x=Symbol('x')
a=limit(sin(x)/x,x,0)
b=limit(1/x,x,0) #default dir='+'
c=limit(1/x,x,0,dir='-') #dir='-' ----> LHL
d=limit(1/x,x,0,dir='+-')
e=limit(1/x,x,oo)
print(a,b,c,d,e)
```

```
1 oo -oo zoo 0
```

```
type(zoo)
```

```
sympy.core.numbers.ComplexInfinity
```

## Series Expansion

POWER SERIES

```
#Macluarian's series
#centered at 0
series(cos(x),x)
```

$$1-\frac{x^{2}}{2}+\frac{x^{4}}{24}+O\left(x^{6}\right)$$

TAYLOR SERIES

```
"""
centered at 2
6 terms will display
+ indicates the value will be always greater than 2
"""
f=tan(x)
series(f,x,2,6,'+')
```

$$\tan(2) + \left(1 + \tan^2(2)\right)(x-2) + (x-2)^2\left(\tan^3(2) + \tan(2)\right) + (x-2)^3 \cdot \left(\frac{1}{3} + \frac{4\tan^2(2)}{3} + \tan^4(2)\right) + (x-2)^4\left(\tan^5(2) + \frac{5\tan^3(2)}{3} + \frac{2\tan(2)}{3}\right) + (x-2)^5 \cdot \left(\frac{2}{15} + \frac{17\tan^2(2)}{15} + 2\tan^4(2) + \tan^6(2)\right) + O\left((x-2)^6; x \to 2\right)$$

```
"""
centered at 2
6 indicates the degree of the polynomial and number of terms it is gonna display
- indicates the value will be always lesser than 2
"""
f=tan(x)
series(f,x,2,6,'-')
```

$$\tan(2) + (2-x)\left(-\tan^2(2) - 1\right) + (2-x)^2\left(\tan^3(2) + \tan(2)\right) + (2-x)^3\left(-\tan^4(2) - \frac{4\tan^2(2)}{3} - \frac{1}{3}\right) + (2-x)^4\left(\tan^5(2) + \frac{5\tan^3(2)}{3} + \frac{2\tan(2)}{3}\right) + (2-x)^5\left(-\tan^6(2) - 2\tan^4(2) - \frac{17\tan^2(2)}{15} - \frac{2}{15}\right) + O\left((x-2)^6; x \to 2\right)$$

```
series(f,x,5,10,'-')
```

$$\tan(5) + (5-x)\left(-\tan^2(5) - 1\right) + (5-x)^2\left(\tan^3(5) + \tan(5)\right) + (5-x)^3\left(-\tan^4(5) - \frac{4\tan^2(5)}{3} - \frac{1}{3}\right) + (5-x)^4\left(\tan^5(5) + \frac{5\tan^3(5)}{3} + \frac{2\tan(5)}{3}\right) + (5-x)^5\left(-\tan^6(5) - 2\tan^4(5) - \frac{17\tan^2(5)}{15} - \frac{2}{15}\right) + (5-x)^6\left(\tan^7(5) + \frac{7\tan^5(5)}{3} + \frac{77\tan^3(5)}{45} + \frac{17\tan(5)}{45}\right) + (5-x)^7\left(-\tan^8(5) - \frac{8\tan^6(5)}{3} - \frac{12\tan^4(5)}{5} - \frac{248\tan^2(5)}{315} - \frac{17}{315}\right) + (5-x)^8\left(\tan^9(5) + 3\tan^7(5) + \frac{16\tan^5(5)}{5} + \frac{88\tan^3(5)}{63} + \frac{62\tan(5)}{315}\right) + (5-x)^9\left(-\tan^{10}(5) - \frac{10\tan^8(5)}{3} - \frac{37\tan^6(5)}{9} - \frac{424\tan^4(5)}{189} - \frac{1382\tan^2(5)}{2835} - \frac{62}{2835}\right) O\left((x-5)^{10}; x \to 5\right)$$

```
series(f,x,2,3,'-')
```

$$\tan(2) + (2-x)\left(-\tan^2(2) - 1\right) + (2-x)^2\left(\tan^3(2) + \tan(2)\right) + O\left((x-2)^3; x \to 2\right)$$

```
#series expansion should have integral terms to be displayed
#series(f,x,2,oo,'+') is an error bcz infinity is not an integer
```

```
a1=O(x+x**2)
a2=O(x+x**2,(x,0))
a3=O(x+x**2,(x,0))
print(a1,a2,a3)
```

```
O(x) O(x) O(x)
```

WAP to find the Taylor polynomial expansion of exponential function of x

f(x)=f(a)+ f'(a)(x-a) + f"(x)(x-a)^2/2! +.......+ f^n(a)(x-a)**n/n!

```
from sympy import *
x=Symbol('x')
func=exp(x) #input the function here

n=int(input("Enter the number of times differentiating ")) #no.of times differentia
a=float(input("Enter the center of series ")) #center of series
result=func.subs(x,a) #substituting x with a to find derivative of f(a)

#generation of series
for i in range(1,n):
  result+= diff(func,x,i).subs(x,a)*(x-a)**i/factorial(i)

pretty_print(result)
```

```
Enter the number of times differentiating 10
Enter the center of series 2
                                                    9
7.38905609893065·x + 0.0104254759773272·(0.5·x - 1)  + 0.0469146418979724·(0.5

       8                                7                                6
·x - 1)  + 0.18765856759189·(0.5·x - 1)  + 0.656804986571613·(0.5·x - 1)  + 1.

                             5                                 4
97041495971484·(0.5·x - 1)  + 4.9260373992871·(0.5·x - 1)  + 9.8520747985742·(

         3                               2
0.5·x - 1)  + 14.7781121978613·(0.5·x - 1)  - 7.38905609893065
```

In [1]:
```
from sympy import *
x = Symbol('x')
d = diff(x**2, x,1)
d
```

Out[1]: $\displaystyle 2 x$

In [6]:
```
d = diff(sin(x),x,1)
d
```

Out[6]: $\displaystyle \cos{\left(x \right)}$

In [4]:
```
d = diff(exp(x),x,1)
d
```

Out[4]: $\displaystyle e^{x}$

In [9]:
```
y = Symbol('y')
d = diff(2*x**2 + 2*y**2, x,1)
d
```

Out[9]: $\displaystyle 4 x$

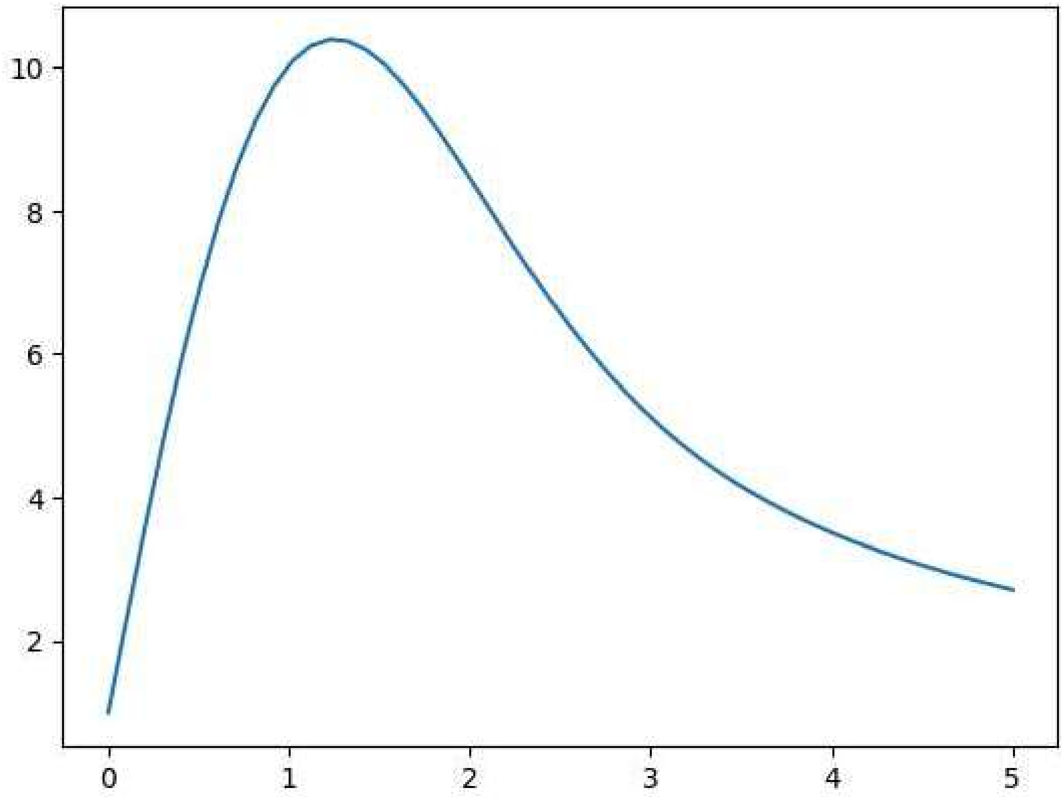
In [10]:
```
d = diff(sqrt(x**3)+4*x**2, x, 1)
d
```

Out[10]: $\displaystyle 8 x + \frac{3 \sqrt{x^{3}}}{2 x}$

In [11]:
```
d = diff((x**2)/ 8 - log(x), x,1)
d
```

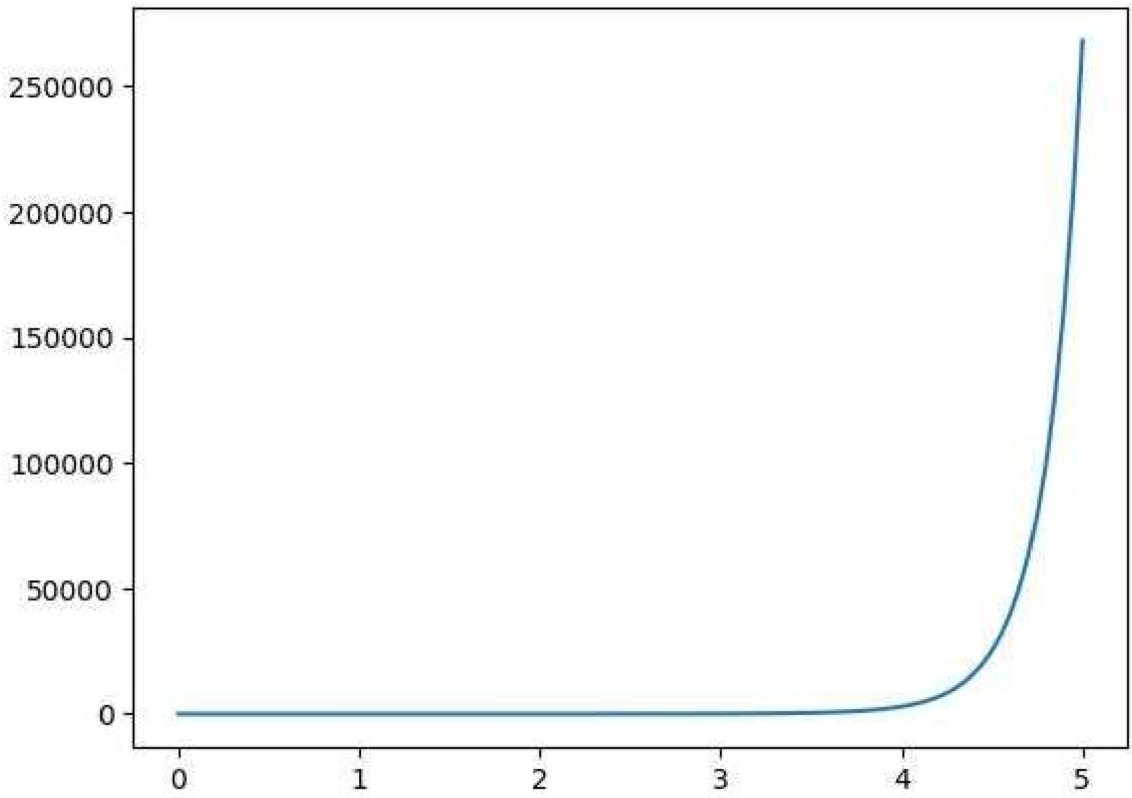
Out[11]: $\displaystyle \frac{x}{4} - \frac{1}{x}$

In [2]:
```
import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt

y=1

t = np.linspace(0,5)

def returns_dydt(y, t):
    dydt = -y * t + 13
    return dydt

y = odeint(returns_dydt, y, t)

plt.plot(t,y)
plt.show()
```

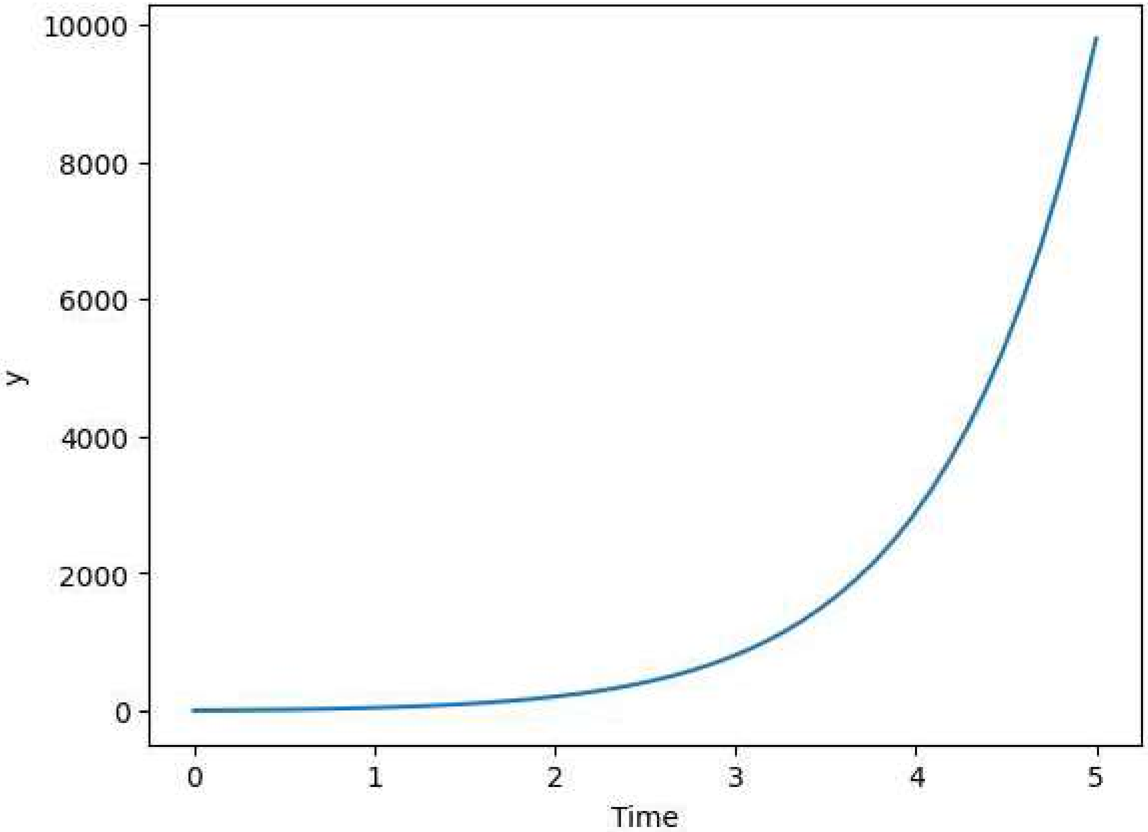



In [3]:

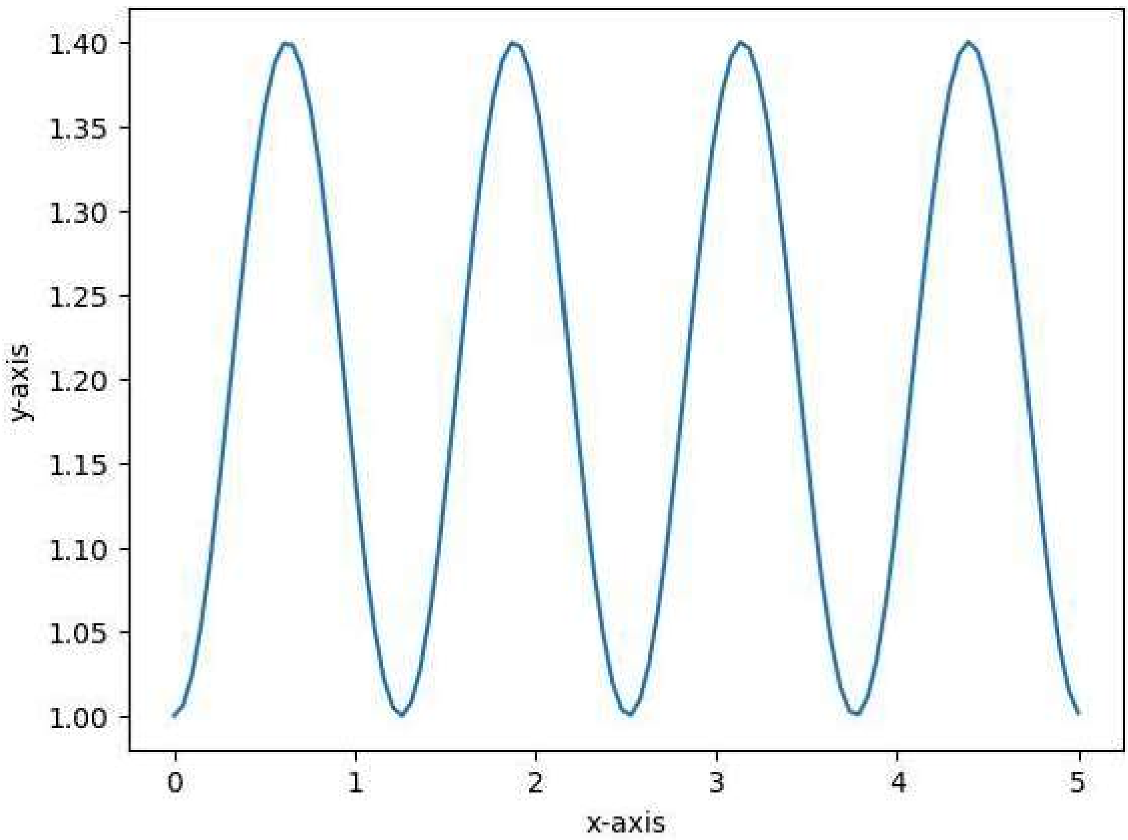
```
def dy_dx(y,x):
    return x*y

y = 1.0
x = np.linspace(0,5,100)
y = odeint(dy_dx, y,x)
plt.plot(x,y)
plt.show()
```



In [3]:
```
import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt

y0=1
#values of time
t=np.linspace(0,5)
def returns_dydt(y,t):
    dydt=13*np.exp(t)+y
    return dydt

y=odeint(returns_dydt,y0,t)

plt.plot(t,y)
plt.xlabel("Time")
plt.ylabel("y")
plt.show()
```



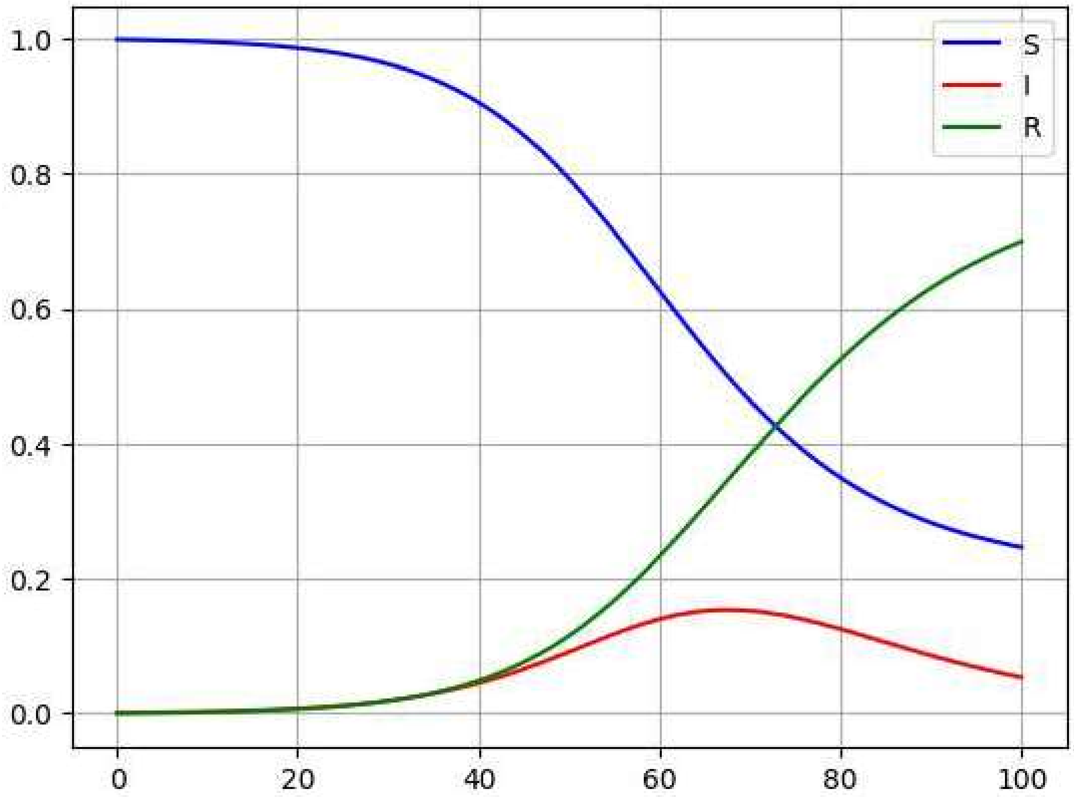

In [4]:
```
y0=1
x=np.linspace(0,5,100)
def dy_dx(y,x):
    return np.sin(5*x)
y=odeint(dy_dx,y0,x) #odeint -inbuilt function
#plot results
plt.plot(x,y)
plt.xlabel("x-axis")
plt.ylabel("y-axis")
plt.show()
```




In [8]:

```
from scipy.integrate import odeint
import numpy as np
import matplotlib.pyplot as plt


beta = .2
gamma = .1
N = 1000

I0 = 1
R0 = 0
S0 = N - I0 - R0

t = np.linspace(0,100,100)

def df(y,t,n, beta,gamma):
    S,I,R = y
    dsdt = -beta*S*I/N
    dIdt = beta*S*I/N - gamma*I
    dRdt = gamma*I
    return dsdt,dIdt,dRdt

y0 = S0,I0,R0
ret = odeint(df,y0,t,args=(N,beta,gamma))
S = ret[:,0]
I = ret[:,1]
R = ret[:,2]

plt.plot(t,S/N,color='blue',label='S')
plt.plot(t,I/N,color='red',label='I')
plt.plot(t,R/N,color='green',label='R')

plt.legend()
```

```
plt.grid()
plt.show()
```




In [ ]: