S.Y.BSc Computer

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Python Programming Practical Workbook

(2 credits)

Name of Student:	
Roll Number:	

SSR College of Arts Commerce and Science

Silvassa

S.Y.BSc Computer Science

Python Programming Practical Workbook

Certificate

This is to certify that,

Mr./Ms. ______________________________ has satisfactorily completed _______ out of ________ assignments of Mathematics Practical in class S.Y.BSc Computer Semester I during the academic year _______________________.

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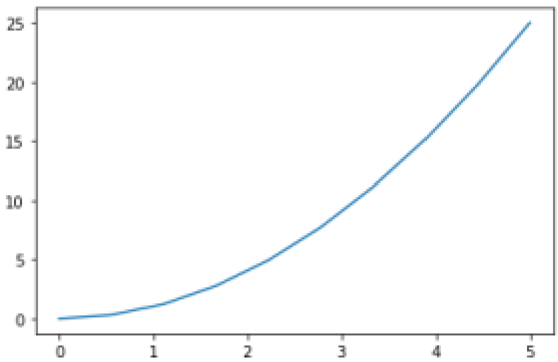
PRACTICAL 1: GRAPH PLOTTING

#1. Plot the graph of f(x)=x2 in [0,5].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(0,5,10)
y=x**2
plot(x,y)
show()
```

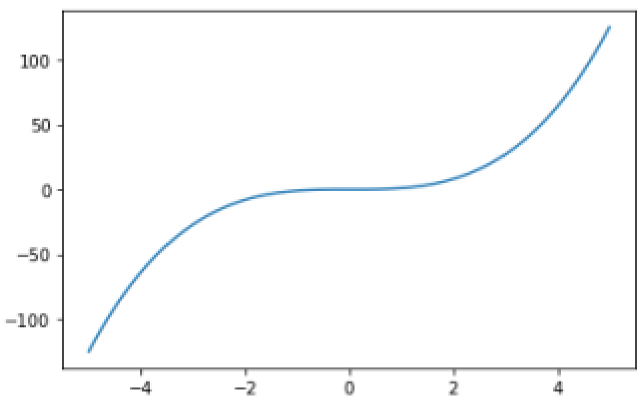
Output :



#2. Plot the graph of f(x)=x3 in [-5,5].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-5,5,100)
y=x**3
plot(x,y)
show()
```

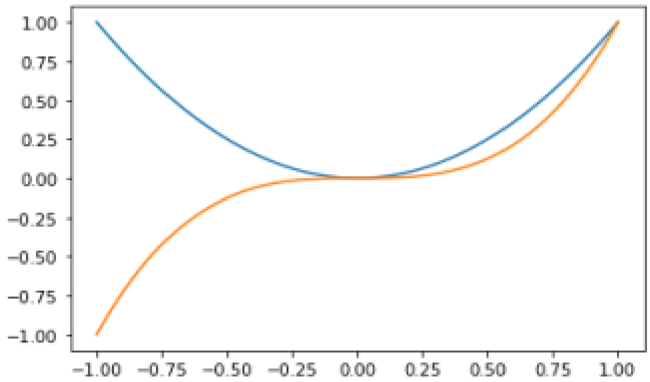
OUTPUT :



#3. Plot the graph of f(x)=x2 and g(x)=x3 in [-1,1].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-1,1,100)
f=x**2 g=x**3
plot(x,f)
plot(x,g)
show()
```

OUTPUT:

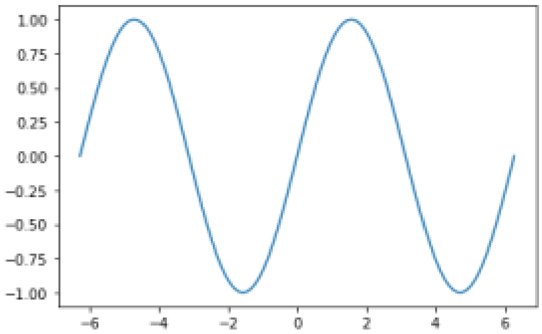


PRACTICAL 2: GRAPH PLOTTING

#1.Plot the graph of f(x)= sinx in [-2π,2π].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-2*pi,2*pi,100)
f=np.sin(x)
plot(x,f)
show()
```

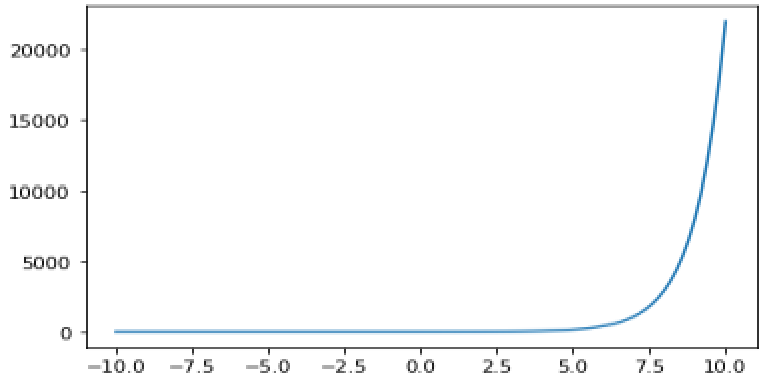
OUTPUT :



#2. Plot the graph of f(x) =ex in [-10,10].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-10,10,100)
f=np.exp(x)
plot(x,f)
show()
```

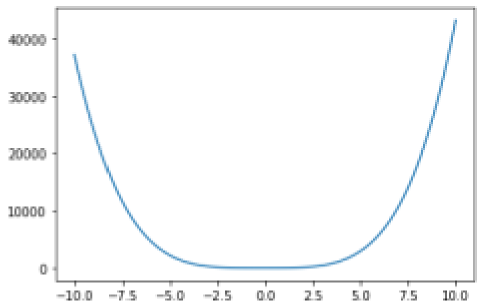
OUTPUT :



#3. Plot the graph of f(x)= 1+x+2x2+3x3+4x4 in [-10,10].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-10,10,100)
f=-1+x+2*x**2+3*x**3+4*x**4
plot(x,f)
show()
```

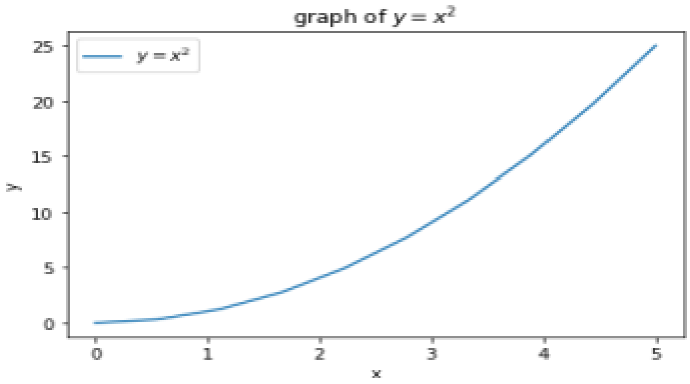
OUTPUT :



#4. Plot the graph of f(x) = x2 in [0,5].

```
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(0,5,10)
y=x**2
plot(x,y,label="$y=x^2$")
xlabel('x')
ylabel('y')
title('graph of $y=x^2$')
legend()
show()
```

OUTPUT:



PRACTICAL 3: Application to Computational Geometry-I

#1. find the distance between points x and y,y and w,x and z,if x=[1,-1],y=[-2,4],z=[-1,-1] and w=[3,5]

```
import sympy as sp
x=sp.Point(1,-1)
y=sp.Point(-2,4)
z=sp.Point(-1,-1)
w=sp.Point(3,5)
print(x.distance(y))
print(y.distance(w))
print(x.distance(z))
```

OUTPUT:

```
sqrt(34)
sqrt(26)
2
```

#2.Reflect the given points through respective lines.

#(a) (−3, 6) , x + 2y = 0

#(b) (2, −6) , 2x + 3y = −1

#(c) (5, −2) , x − y = 5

#(d) (6.3, 3.6) , x − 4y = 1

#(e) (−5, 8) , 4x + 3y = 11

```
import sympy as sp
x,y=sp.symbols('x y')
P=sp.Point(-3,6)
print("a.",P.reflect(sp.Line(x+2*y)))
P=sp.Point(2,-6)
print("b.",P.reflect(sp.Line(2*x+3*y+1)))
P=sp.Point(5,-2)
print("c.",P.reflect(sp.Line(x-y-5)))
```

```
P=sp.Point(6.3,3.6)
print("d.",P.reflect(sp.Line(x-4*y-1)))
P=sp.Point(-5,8)
print("e.",P.reflect(sp.Line(4*x+3*y-11)))
```

OUTPUT:

```
a. Point2D(-33/5, -6/5)
b. Point2D(6, 0)
c. Point2D(3, 0)
d. Point2D(1253/170, -58/85)
e. Point2D(-69/25, 242/25)
```

#3. Reflect the point P(-3,6) through the line 3x/sqrt2 − 2y +4/3 = 0.

```
import sympy as sp
x,y=sp.symbols('x y')
P=sp.Point(-3,6)
print(P.reflect(sp.Line(3*x/sp.sqrt(2)-2*y+4/3)))
```

OUTPUT:

```
Point2D(3/17 + 64*sqrt(2)/17, 50/51 - 36*sqrt(2)/17)
```

Practical 4: Application to Computational Geometry-II

#1. Apply each of the following transformations on the point P = [2, −5].
#(a) Reflection through X-axis.
#(b) Scaling in X-coordinate by factor 4.
#(c) Scaling in Y-coordinate by factor 5.
#(d) Reflection through the line y = −2x.
#(e) Shearing in Y direction by 2 units.
#(f) Scaling in X and Y direction by 4/5 and 7 units respectively.
#(g) Shearing in both X and Y direction by −3 and 1 units respectively.
#(h) Rotation about origin by an angle 45 degrees.

```
import sympy as sp
P=sp.Point(2,-5)
x,y=sp.symbols('x y')
print("a.",P.transform(sp.Matrix([[1,0,0],[0,-1,0],[0,0,1]])))
print("b.",P.transform(sp.Matrix([[4,0,0],[0,1,0],[0,0,1]])))
print("c.",P.transform(sp.Matrix([[1,0,0],[0,5,0],[0,0,1]])))
print("d.",P.reflect(sp.Line(y+2*x)))
print("e.",P.transform(sp.Matrix([[1,2,0],[0,1,0],[0,0,1]])))
print("f.",P.transform(sp.Matrix([[4/5,0,0],[0,7,0],[0,0,1]])))
print("g.",P.transform(sp.Matrix([[1,1,0],[-3,1,0],[0,0,1]])))
print("h.",P.rotate(sp.pi/4))
```

```
OUTPUT:
a. Point2D(2, 5)
b. Point2D(8, -5)
c. Point2D(2, -25)
d. Point2D(14/5, -23/5)
e. Point2D(2, -1)
f. Point2D(8/5, -35)
g. Point2D(17, -3)
h. Point2D(7*sqrt(2)/2, -3*sqrt(2)/2)
```

#2. Apply each of the following transformations on the point P = [−2, 4].
#(a) Scaling in X and Y direction by 7/2 and 4 units respectively.
#(b) Shearing in both X and Y direction by 4 and 7 units respectively.
#(c) Reflection through the line y = 2x + 3.
#(d) Shearing in Y direction by 7 units.
#(e) Rotation about origin by an angle 48 degrees.
#(f) Reflection through line 3x + 4y = 5.
#(g) Scaling in X-coordinate by factor 6.
#(h) Scaling in Y-coordinate by factor 4.

```
import sympy as sp
import math as mt
P=sp.Point(-2,4)
x,y=sp.symbols('x y')
print("a.",P.transform(sp.Matrix([[7/2,0,0],[0,4,0],[0,0,1]])))
print("b.",P.transform(sp.Matrix([[1,7,0],[4,1,0],[0,0,1]])))
print("c.",P.reflect(sp.Line(-2*x+y-3)))
print("d.",P.transform(sp.Matrix([[1,7,0],[0,1,0],[0,0,1]])))
print("e.",P.rotate(angle))
print("f.",P.reflect(sp.Line(3*x+4*y-5)))
print("g.",P.transform(sp.Matrix([[6,0,0],[0,1,0],[0,0,1]])))
print("h.",P.transform(sp.Matrix([[1,0,0],[0,4,0],[0,0,1]])))
angle=mt.radians(48)
```

OUTPUT:

```
a. Point2D(-7, 16)
b. Point2D(14, -10)
c. Point2D(2, 2)
d. Point2D(-2, -10)
e. Point2D(-431084051462729/100000000000000, 929869355063/781250000000)
f. Point2D(-16/5, 12/5)
g. Point2D(-12, 4)
h. Point2D(-2, 16)
```

#3. Apply each of the following transformations on the point P = [−4, 1]
#(a) Scaling in X-coordinate by factor 3.
#(b) Scaling in Y-coordinate by factor 4.
#(c) Reflection through the line y = 2x − 3.
#(d) Shearing in Y direction by 7 units.
#(e) Scaling in X and Y direction by 5/2 and 4 units respectively.
#(f) Rotation about origin by an angle 35 degrees.
#(g) Reflection through line x + 4y = 0.

```
import sympy as sp
import math as mt
P=sp.Point(-4,1)
x,y=sp.symbols('x y')
print("a.",P.transform(sp.Matrix([[3,0,0],[0,1,0],[0,0,1]])))
print("b.",P.transform(sp.Matrix([[1,0,0],[0,4,0],[0,0,1]])))
print("c.",P.reflect(sp.Line(-2*x+y+3)))
print("d.",P.transform(sp.Matrix([[1,7,0],[0,1,0],[0,0,1]])))
print("g.",P.reflect(sp.Line(x+4*y)))
print("e.",P.transform(sp.Matrix([[5/2,0,0],[0,4,0],[0,0,1]])))
angle=mt.radians(35)
print("f.",P.rotate(angle))
```

OUTPUT:
```
a. Point2D(-12, 1)
b. Point2D(-4, 4)
c. Point2D(28/5, -19/5)
d. Point2D(-4, -27)
e. Point2D(-10, 4)
f. Point2D(-385018461350701/100000000000000, -
147515370111519/100000000000000)
g. Point2D(-4, 1)
```

Practical 5: Application to Computational Geometry-III

#1.Rotate the line passing through points A[5 1] and B[2 5] about origin through an angle 270 degrees

```
import sympy as sp
l=sp.Line((5,1),(2,5))
print(l.rotate(3*sp.pi/4))
```

OUTPUT:

Line2D(Point2D(-3*sqrt(2), 2*sqrt(2)), Point2D(-7*sqrt(2)/2, -3*sqrt(2)/2))

#2. Rotate the line passing through points A[0 −1] and B[2 −5] about origin through an angle 80 degrees

```
import sympy as sp
import math as mt
l=sp.Line((0,-1),(2,-5))
angle=mt.radians(80)
print(l.rotate(angle))
```

OUTPUT:

Line2D(Point2D(61550484563263/62500000000000, -17364817766693/100000000000000),
Point2D(52713351203949/10000000000000, 6883591360561/6250000000000))

#3. If the line segment joining the points A[−2 5], B[−4 3] is transformed to the line segment A∗B∗ by the transformation matrix, [T] =
#[2 −2],[3 −6] then find the midpoint and length of A∗B∗

```
import sympy as sp
import math as mt
A=sp.Point(-2,5)
B=sp.Point(-4,3)
A1=A.transform(sp.Matrix([[2,-2,0],[3,-6,0],[0,0,1]]))
B1=B.transform(sp.Matrix([[2,-2,0],[3,-6,0],[0,0,1]]))
L=sp.Segment(A1,B1)
print(L)
print(L.midpoint)
```

OUTPUT:

$Point2D$(6,−18)

```
#4. Reflect the line segment joining the points A[5, 2] and B[−3, 4]
#through the line y = 2x − 1.
import sympy as sp
A=sp.Point(5,2)
B=sp.Point(-3,4)
S=sp.Segment(A,B)
x,y=sp.symbols('x,y')
L=sp.Line(-2*x+y+1)
S.reflect(L)
```

OUTPUT:
$Segment2D(Point2D(-3/5,24/5),Point2D(29/5,-2/5))$

```
#5. Rotate the line by 75 degrees having two points (0, 0) and (0, 1). Also
#find its equation after applying rotation.
import sympy as sp
import math as mt
l=sp.Line((0,0),(0,1))
angle=mt.radians(75)
print(l.rotate(angle))
l1=l.rotate(angle)
print(l1.equation())
```

OUTPUT:

```
Line2D(Point2D(0, 0), Point2D(-241481456572267/250000000000000,
258819045102521/1000000000000000))
-258819045102521*x/1000000000000000 -
241481456572267*y/250000000000000
```

```
#6. Rotate the segment by 180 degrees having end points (1, 0) and (2, −1)
import sympy as sp
l=sp.Line((1,0),(2,-1))
print(l.rotate(sp.pi))
```

OUTPUT:

```
Line2D(Point2D(-1, 0), Point2D(-2, 1))
```

```
#7. Rotate the ray by 90 degrees having starting point (0, 0) in the direction of (4, 4).
import sympy as sp
import math as mt
R=sp.Ray(sp.Point(0,0),sp.Point(4,4))
print(R.rotate(mt.pi/2))
```

OUTPUT:

```
Ray2D(Point2D(0, 0), Point2D(-4, 4))
```

Practical 6: Study of Graphical aspects of Two-dimensional transformation matrix using matplotlib

```
#1. Reflect the line 4x + 3y = 5 through line x + y = 0 and find the
#equation of reflected line.
import sympy as sp
l=sp.Line(4*x+3*y-5)
l1=sp.Line(x+y)
reflected_line=l.reflect(l1)
eqn=reflected_line.equation()
print(eqn)
```

OUTPUT:
x+4*y/3+5/3

```
#2. Reflect the segment having two endpoints (2, 3),(4, 6) through line
#7x + 6y = 3.
import sympy as sp
A=sp.Point(2,3)
B=sp.Point(4,6)
S=sp.Segment(A,B)
x,y=sp.symbols('x,y')
L=sp.Line(7*x+6*y-3)
print(S.reflect(L))
```

OUTPUT:
Segment2D(Point2D(-236/85, -93/85), Point2D(-514/85, -222/85))

```
#3. Reflect the line segment having starting point (0, 0) in the direction of
#(2, 4) through line x − 2y = 3.
import numpy as np
A=sp.Point(0,0)
B=sp.Point(2,4)
S=sp.Ray(A,B)
x,y=sp.symbols('x,y')
L=sp.Line(x-2*y-3)
print(S.reflect(L))
```

OUTPUT:
$Ray2D(Point2D$(6/5,−12/5),$Point2D$(28/5,−16/5))

Practical 7: Study of Graphical aspects of Three-dimensional transformation matrix using matplotlib

#1. If the line with points A[2 1], B[4 −1] is transformed by the transformation matrix, [T] = [1 2],[2 1] then find the equation of transformed line.

```
import sympy as sp
import math as mt
A=sp.Point(2,1)
B=sp.Point(4,-1)
print(A.transform(sp.Matrix([[1,2,0],[2,1,0],[0,0,1]])))
print(B.transform(sp.Matrix([[1,2,0],[2,1,0],[0,0,1]])))
```

OUTPUT:
Point2D(4, 5)
Point2D(2, 7)

#2. Rotate the line passing through points A[1 1] and B[5 5] about origin through an angle 90 degrees.

```
import sympy as sp
import math as mt
l=sp.Line((1,1),(5,5))
print(l.rotate(mt.pi/2))
```

OUTPUT:
Line2D(Point2D(-1, 1), Point2D(-5, 5))

#3. If the line segment joining the points A[2 5], B[4 3] is transformed to the line segment A∗B∗ by the transformation matrix, [T] =[2 −3],[4 1] then find the midpoint of A∗B∗.

```
import sympy as sp
l=sp.Segment((2,5),(4,3))
l1=l.midpoint
print(l1.transform(sp.Matrix([[2,-3,0],[4,1,0],[0,0,1]])))
```

OUTPUT:
Point2D(22, -5)

#4. Reflect the line segment joining the points A[5 −3] and B[1 4] through the line y = 2x + 3.

```
x,y=sp.symbols('x,y')
l=sp.Line((5,-3),(1,4))
print(l.reflect(sp.Line(-2*x+y-3)))
```

OUTPUT:
Line2D(Point2D(-39/5, 17/5), Point2D(1/5, 22/5))

#5. Suppose that the line segment between the points A[1 4] and B[3 6] is transformed to the line segment A∗B∗ using the transformation matrix [T] = [2 −1],[1 −3] Find slope of the transformed line segment A∗B∗

```
import sympy as sp
import math as mt
A=sp.Point(1,4)
B=sp.Point(3,6)
L=sp.Line((A.transform(sp.Matrix([[2,-1,0],[1,-
3,0],[0,0,1]]))),(B.transform(sp.Matrix([[2,-1,0],[3,6,0],[0,0,1]]))))
print(L.slope)
```

OUTPUT:
23/9

#6. If the two lines 2x − y = 5 and x + 3y = −1 are transformed using the transformation matrix [T] = [−2 3],[1 1] then find the point of intersection of the transformed lines.

```
import sympy as sp
sp.symbols('x,y')
l1=sp.Line(2*x-y-5)
l2=sp.Line(x+3*y+1)
P=l1.intersection(l2)
p=P[0]
print(p.transform(sp.Matrix([[-2,3,0],[1,1,0],[0,0,1]])))
```

OUTPUT:
Point2D(-5, 5)

#7. If we apply shearing on the line 2x + y = 3 in x and y directions by 2 and -3 units respectively, then find the equation of the resulting line.

```
import sympy as sp
sp.symbols('x,y')
l=sp.Line(2*x+y-3)
p=l.points[0]
q=l.points[1]
l1=sp.Line((p.transform(sp.Matrix([[1,-
3,0],[2,1,0],[0,0,1]]))),(q.transform(sp.Matrix([[1,-3,0],[2,1,0],[0,0,1]]))))
print(l1.equation())
```

OUTPUT:
5*x - 3*y - 21

Practical 8:Study of Graphical aspects of Three-dimensional transformation matrix using matplotlib

#1. Write a python programme to draw a polygon with vertices (0, 1),(1, 0),(−2, 2),(1, −4) and find its area and perimeter

```
import sympy as sp
p=sp.Polygon((0,0),(1,0),(-2,2),(1,-4))
print(p.area)
print(p.perimeter)
```

OUTPUT:
4
1 + sqrt(13) + sqrt(17) + 3*sqrt(5)

#2. Write a python programme to draw a regular polygon with 8 sides and radius 6 centered at origin and find its area and perimeter

```
import sympy as sp
p=sp.Polygon((0,0),6,n=8)
print(p.area)
print(p.perimeter)
```

OUTPUT:
(576 - 288*sqrt(2))/(-4 + 4*sqrt(2))
48*sqrt(2 - sqrt(2))

#3. Write a python programme to draw a regular polygon with 6 sides andradius 1 centered at (1, 2) and find its area and perimeter

```
import sympy as sp
p=sp.Polygon((1,2),1,n=6)
print(p.area)
print(p.perimeter)
```

OUTPUT:
3*sqrt(3)/2
6

#4. Write a python programme to draw a regular polygon with 7 sides and radius 1.5 centered at (2, 2) and reflect it through line x − y = 5

```
import sympy as sp
x,y=sp.symbols('x,y')
p=sp.Polygon((2,2),1.5,n=7)
l=sp.Line(x-y-5)
p.reflect(l)
```

OUTPUT:

```
RegularPolygon(Point2D(7, -3), -1.50000000000000, 7, 3*pi/14)
```

#5. Write a python programme to draw a polygon with vertices (0, 0),(2, 0),(2, 3),(1, 6) and rotate by 180 degrees and find internal angle at

```
# each vertex.
import sympy as sp
import math as mt
A=sp.Point(0,0)
B=sp.Point(2,0)
C=sp.Point(2,3)
D=sp.Point(1,6)
P=sp.Polygon(A,B,C,D)
print(P.rotate(mt.pi/2))
print(P.angles[A])
print(P.angles[B])
print(P.angles[C])
print(P.angles[D])
```

OUTPUT:

```
Polygon(Point2D(0, 0),
Point2D(24492935982947/200000000000000000000000000000, 2), Point2D(-3, 2),
Point2D(-6, 1))
acos(sqrt(37)/37)
pi/2
acos(-3*sqrt(10)/10)
acos(17*sqrt(370)/370)
```

#6. Write a python programme to draw a polygon with vertices (0, 0),(1, 0),(2, 2),(1, 4) and find its area and perimeter.

```
import sympy as sp
p=sp.Polygon((0,0),(1,0),(2,2),(1,4))
print(p.area)
print(p.perimeter)
```

OUTPUT:

```
4
1 + sqrt(17) + 2*sqrt(5)
```

#7. Write a python programme to draw a regular polygon with 4 sides and radius 6 centered at origin and find its area and perimeter.

```
import sympy as sp
p=sp.Polygon((0,0),6,n=4)
print(p.area)
print(p.perimeter)
```

OUTPUT:

```
72
24*sqrt(2)
```

#8. Write a python programme to draw a regular polygon with 8 sides and radius 2 centered at (−1, 2) and find its area and perimeter

```
import sympy as sp
p=sp.Polygon((-1,2),2,n=8)
print(p.area)
print(p.perimeter)
```

OUTPUT:

```
(64 - 32*sqrt(2))/(-4 + 4*sqrt(2))
16*sqrt(2 - sqrt(2))
```

#9. Write a python programme to draw a regular polygon with 7 sides and radius 6 centered at (−2, 2) and reflect it through line x − 2y = 5

```
import sympy as sp
x,y=sp.symbols('x,y')
p=sp.Polygon((-2,2),6,n=7)
l=sp.Line(x-2*y-5)
p.reflect(l)
```

OUTPUT:

$RegularPolygon(Point2D(12/5,-34/5),-6,7,-2\pi/7+\text{atan}(4/3))$

#10. Write a python programme to draw a polygon with vertices (0, 0),(−2, 0),(5, 5),(1, −6) and rotate by 180 degrees and find internal angle

```
#at each vertex.
import sympy as sp
import math as mt
A=sp.Point(0,0)
B=sp.Point(-2,0)
C=sp.Point(5,5)
D=sp.Point(1,-6)
P=sp.Polygon(A,B,C,D)
print(P.rotate(mt.pi))
print(P.angles[A])
print(P.angles[B])
print(P.angles[C])
print(P.angles[D])
```

OUTPUT:

```
Polygon(Point2D(0, 0), Point2D(2, -
244929359829471/1000000000000000000000000000000), Point2D(-5, -5),
Point2D(-1, 6))
acos(-sqrt(37)/37)
-acos(7*sqrt(74)/74) + 2*pi
-acos(83*sqrt(10138)/10138) + 2*pi
-acos(62*sqrt(5069)/5069) + 2*pi
```

Practical 9:Study of effect of concatenation of Two dimensional and Three dimensional transformations

#1. Reflect the pol ABC through the line y = 3, where A[1 0], B[2 − 1],C[−1 3].

```
import sympy  as sp
x,y=sp.symbols('x,y')
P=sp.Polygon((1,0),(2,-1),(-1,3))
P1=sp.Point(0,3)
Q1=sp.Point(1,3)
l=sp.Line(P1,Q1)
print(P.reflect(l))
```

OUTPUT:

```
Triangle(Point2D(1, 6), Point2D(2, 7), Point2D(-1, 3))
```

#2. Rotate the triangle ABC by 90 degree, where A[1 2], B[2 −2], C[−1 2].

```
import sympy  as sp
import math as mt
P=sp.Polygon((1,2),(2,-2),(-1,2))
print(P.rotate(mt.pi/2))
```

OUTPUT:

```
Triangle(Point2D(-2, 1), Point2D(2, 2), Point2D(-2, -1))
```

#3. Find the area and perimeter of the triangle ABC, where A[0 0], B[5 0],C[3 3].

```
import sympy  as sp
P=sp.Polygon((0,0),(5,0),(3,3))
print(P.area)
print(P.perimeter)
```

OUTPUT:

```
15/2
sqrt(13) + 3*sqrt(2) + 5
```

#4. Find the angle at each vertices of the triangle ABC, where A[0 0],B[2 2], C[0 2].

```
import sympy  as sp
A=sp.Point(0,0)
B=sp.Point(2,2)
C=sp.Point(0,2)
T=sp.Triangle(A,B,C)
print(T.angles[A])
print(T.angles[B])
print(T.angles[C])
```

OUTPUT:
pi/4
pi/4
pi/2

#5. Find the angle at each vertices of the triangle PQR, where P[1 0],Q[2 3], R[0 − 2].import sympy as sp

```
P=sp.Point(1,0)
Q=sp.Point(2,3)
R=sp.Point(0,-2)
T=sp.Triangle(P,Q,R)
print(T.angles[P])
print(T.angles[Q])
print(T.angles[R])
```

OUTPUT:
acos(-7*sqrt(2)/10)
acos(17*sqrt(290)/290)
acos(12*sqrt(145)/145)

#6. Reflect the triangle ABC through the line y = −3, where A[1 1],B[2 − 3], C[−1 5].

```
import sympy as sp
x,y=sp.symbols('x,y')
P=sp.Polygon((1,1),(2,-3),(-1,5))
P1=sp.Point(0,-3)
Q1=sp.Point(1,-3)
l=sp.Line(P1,Q1)
print(P.reflect(l))
```

OUTPUT:
Triangle(Point2D(1, -7), Point2D(2, -3), Point2D(-1, -11))

#7. Rotate the triangle ABC by 90 degree, where A[1 − 2], B[4 − 6],C[−1 4].

```
import sympy as sp
import math as mt
P=sp.Polygon((1,-2),(4,-6),(-1,4))
print(P.rotate(mt.pi/2))
```

OUTPUT:
Triangle(Point2D(2, 1), Point2D(6, 4), Point2D(-4, -1))

#8. Find the area and perimeter of the triangle ABC, where A[0 1], B[−5 0],C[3 − 3].

```
import sympy  as sp
P=sp.Polygon((0,0),(-5,0),(3,-3))
print(P.area)
print(P.perimeter)
```

OUTPUT:

```
15/2
3*sqrt(2) + 5 + sqrt(73)
```

#9. Find the angle at each vertices of the triangle ABC, where A[1 1],B[1 2], C[0 1].

```
import sympy  as sp
A=sp.Point(1,1)
B=sp.Point(1,2)
C=sp.Point(0,1)
T=sp.Triangle(A,B,C)
print(T.angles[A])
print(T.angles[B])
print(T.angles[C])
```

OUTPUT:

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

#10. Reflect the triangle ABC through the line y = x + 3, where A[−1 0],B[2 − 1], C[1 3].

```
import sympy  as sp
x,y=sp.symbols('x,y')
P=sp.Polygon((-1,0),(2,-1),(1,3))
P1=sp.Point(0,3)
Q1=sp.Point(1,4)
l=sp.Line(P1,Q1)
print(P.reflect(l))
```

OUTPUT:

```
Triangle(Point2D(-3, 2), Point2D(-4, 5), Point2D(0, 4))
```

#11. Rotate the triangle ABC by 270 degree, where A[−1 2], B[2 − 5],C[−1 7].

```
import sympy  as sp
import math as mt
P=sp.Polygon((-1,2),(2,-5),(-1,7))
print(P.rotate(3*mt.pi/2))
```

OUTPUT:

```
Triangle(Point2D(2, 1), Point2D(-5, -2), Point2D(7, 1))
```

#12. Find the area and perimeter of the triangle ABC, where A[0 1], B[−5 0],C[−3 3].

```
import sympy  as sp
P=sp.Polygon((0,1),(-5,0),(-3,3))
print(P.area)
print(P.perimeter)
```

OUTPUT:

```
-13/2
sqrt(26) + 2*sqrt(13)
```

Practical 10:Generation of Bezier curve using given control points

```
#1. If a 2×2 transformation matrix [T] =[1 7][−2 5] is used to transform a line L,
#then the equation of transformed line is y∗ = x∗ + 3.
#Find the equation of original line.
import sympy as sp
sp.symbols('x,y')
l=sp.Line(x-y+3)
p=l.points[0]
q=l.points[1]
m=sp.Matrix([[1,7,0],[-2,5,0],[0,0,1]])
n=m.inv()
p1=p.transform(n)
q1=q.transform(n)
l1=sp.Line(p1,q1)
print(l1.equation())
```

OUTPUT:

6*x/19 + 7*y/19 - 3/19

```
#2. Find the combined transformation of the line segment between the points A[−4
1]  and B[3 0] for the following sequence of transformations:
#  first rotation about origin through an angle π degrees; followed by scaling in x
coordinate by 2 units; followed by reflection through the
#line y =-x
import sympy as sp
import math as mt
a=sp.Point(-4,1)
b=sp.Point(3,0)
s=sp.Segment(a,b)
s=s.rotate(mt.pi)
s=s.scale(2,0)
p=s.points[0]
q=s.points[1]
p1=p.transform(sp.Matrix([[0,-1,0],[-1,0,0],[0,0,1]]))
q1=q.transform(sp.Matrix([[0,-1,0],[-1,0,0],[0,0,1]]))
print(sp.Segment(p1,q1))
```

OUTPUT:

Segment2D(Point2D(0, -8), Point2D(6/19, 3/19))

#3. Suppose that the line segment between the points A[1 −4] and B[5 −6] is transformed to the line segment A∗B∗ using the
transformation matrix [T] = [3 −1],[−5 3]. Find slope of the transformed linesegment A∗B∗.

```
import sympy as sp
import math as mt
A=sp.Point(1,-4)
B=sp.Point(5,-6)
L=sp.Line((A.transform(sp.Matrix([[-3,-1,0],[-
1,5,3],[0,0,1]]))),(B.transform(sp.Matrix([[3,-1,0],[-5,3,0],[0,0,1]]))))
print(L.slope)
```

OUTPUT:
-1/22

#4. If the two lines 2x + y = 0 and x − 3y = 1 are transformed using
#the transformation matrix [T] = [2 −3],[−1 −1] then find the point of
#intersection of the transformed lines.

```
import sympy as sp
x,y=sp.symbols('x,y')
l1=sp.Line(2*x+y)
l2=sp.Line(x-3*y-1)
P=l1.intersection(l2)
p=P[0]
print(p.transform(sp.Matrix([[2,-3,0],[-1,1,0],[0,0,1]])))
```

OUTPUT:
Point2D(4/7, -5/7)

#5. If we apply shearing on the line 2x − y = 8 in x and y directions by 4 and 6 units respectively, then find the equation of the resulting line.

```
import sympy as sp
sp.symbols('x,y')
l=sp.Line(2*x-y-8)
p=l.points[0]
q=l.points[1]
l1=sp.Line((p.transform(sp.Matrix([[1,6,0],[4,1,0],[0,0,1]]))),(q.transform(sp.Matrix([
[1,6,0],[4,1,0],[0,0,1]]))))
print(l1.equation())
```

OUTPUT:
-8*x + 9*y - 184

#6. If a −3 × 2 transformation matrix [T] = [1 3],[2 2] is used to transform a line L, then the equation of transformed line is y∗ = x∗− 3.

```
# Find the equation of original line.
import sympy as sp
x,y=sp.symbols('x,y')
l=sp.Line(x-y-3)
p=l.points[0]
q=l.points[1]
m=sp.Matrix([[1,3,0],[2,2,0],[0,0,1]])
n=m.inv()
p1=p.transform(n)
q1=q.transform(n)
l1=sp.Line(p1,q1)
print(l1.equation())
```

OUTPUT:

x + 3/2

#7. Find the combined transformation of the line segment between the points A[4 1] and B[−3 0] for the following sequence of transformations:

```
# first rotation about origin through an angle π degrees; followed by scaling in x coordinate by 3 units; followed by reflection through the
#line y=3*x+9
import sympy as sp
import math as mt
a=sp.Point(4,1)
b=sp.Point(-3,0)
s=sp.Segment(a,b)
s=s.rotate(mt.pi)
s=s.scale(3,0)
s=s.reflect(sp.Line(3*x-y+9))
print(s)
```

OUTPUT:

Segment2D(Point2D(21/5, -27/5), Point2D(-63/5, 36/5))

Practical 11:Study of Operational Research in Python (Unit 5-5.1)

```
#1. Solve the following LLP:
#Max Z = 150x + 75y
#subject to,
#4x + 6y ≤ 24
#5x + 3y ≤ 15
#x ≥ 0, y ≥ 0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMaximize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
model +=(4*x+6*y<=24)
model +=(5*x+3*y<=15)
model += 150*x+75*y
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
```

OUTPUT:

```
NoName:
MAXIMIZE
150*x + 75*y + 0
SUBJECT TO
_C1: 4 x + 6 y <= 24

_C2: 5 x + 3 y <= 15

VARIABLES
x Continuous
y Continuous

1
450.0
3.0
0.0
```

```
#2. Solve the following LLP:
#Min. Z = 3.5x + 2y
#subject to,
#x + y ≥ 5
#x ≥ 4
#y ≤ 2
#x ≥ 0, y ≥0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMinimize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
model +=(x+y>=5)
model +=(x>=4)
model +=(y<=2)
model += 3.5*x+2*y
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
```

OUTPUT:

```
NoName:
MINIMIZE
3.5*x + 2*y + 0.0
SUBJECT TO
_C1: x + y >= 5

_C2: x >= 4

_C3: y <= 2

VARIABLES
x Continuous
y Continuous

1
16.0
4.0
1.0
```

```
#3. Solve the following LLP:
#Max. Z = 3x + 5y + 4z
#subject to,
#2x + 3y ≤ 8
#2y + 5z ≤ 10
#3x + 2y + 4z ≤ 15
#x ≥ 0, y ≥ 0 z ≥ 0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMaximize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
z=pl.LpVariable(name='z',lowBound=0)
model +=(2*x+3*y<=8)
model +=(2*x+5*z<=10)
model +=(3*x+2*y+4*z<=15)
model += 3*x+5*y+4*z
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
print(z.value())
```

OUTPUT:

```
NoName:
MAXIMIZE
3*x + 5*y + 4*z + 0
SUBJECT TO
_C1: 2 x + 3 y <= 8

_C2: 2 x + 5 z <= 10

_C3: 3 x + 2 y + 4 z <= 15

VARIABLES
x Continuous
y Continuous
z Continuous

1
21.33335
0.0
2.66667
2.0
```

```
#4. Solve the following LLP:
#Min. Z = x + 2y + z
#subject to,
#x +1/2y +1/2z ≤ 1
#3/2x + 2y + z ≥ 8
#x ≥ 0, y ≥ 0, z ≥ 0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMinimize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
z=pl.LpVariable(name='z',lowBound=0)
model +=(x+1/2*y+1/2*z<=1)
model +=(3*x/2+2*y>=8)
model += x+2*y+z
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
print(z.value())
```

OUTPUT:

```
NoName:
MINIMIZE
1*x + 2*y + 1*z + 0
SUBJECT TO
_C1: x + 0.5 y + 0.5 z <= 1

_C2: 1.5 x + 2 y >= 8

VARIABLES
x Continuous
y Continuous
z Continuous

-3
0.0
0.0
0.0
0.0
```

```
#5. Solve the following LLP:
#Min. Z = x + y
#subject to,
#x ≥ 6
#y ≥ 6
#x + y ≤ 11
#x ≥ 0, y ≥ 0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMinimize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
model +=(x>=6)
model +=(y>=6)
model +=(x+y<=11)
model += x+y
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
```

OUTPUT:

```
NoName:
MINIMIZE
1*x + 1*y + 0
SUBJECT TO
_C1: x >= 6

_C2: y >= 6

_C3: x + y <= 11

VARIABLES
x Continuous
y Continuous

-3
0.0
0.0
0.0
```

```
#6. Solve the following LLP:
#Max. Z = x + y
#subject to,
#x − y ≥ 1
#x + y ≥ 2
import pulp as pl
model=pl.LpProblem(sense=pl.LpMaximize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
model +=(x-y>=1)
model +=(x+y>=2)
model += x+y
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
```

OUTPUT:

```
NoName:
MAXIMIZE
1*x + 1*y + 0
SUBJECT TO
_C1: x - y >= 1

_C2: x + y >= 2

VARIABLES
x Continuous
y Continuous

-3
0.0
0.0
0.0
```

```
#7. Solve the following LLP:
#Max. Z = 4x + y + 3z + 5w
#subject to,
#4x + 6y − 5z − 4x ≥ −20
#−3x − 2y + 4z + w ≤ 10
#−8x − 3y + 3z + 2w ≤ 20
#x ≥ 0, y ≥ 0, z ≥ 0, w ≥ 0
import pulp as pl
model=pl.LpProblem(sense=pl.LpMaximize)
x=pl.LpVariable(name='x',lowBound=0)
y=pl.LpVariable(name='y',lowBound=0)
z=pl.LpVariable(name='z',lowBound=0)
w=pl.LpVariable(name='w',lowBound=0)
model +=(4*x+6*y-5*z>=-20)
model +=(-3*x-2*y+4*z+w<=10)
model +=(-8*x-3*y+3*z+2*w<=20)
model += 4*x+y+3*z+5*w
print(model)
print(model.solve())
print(model.objective.value())
print(x.value())
print(y.value())
```

OUTPUT:

```
NoName:
MAXIMIZE
5*w + 4*x + 1*y + 3*z + 0
SUBJECT TO
_C1: 4 x + 6 y - 5 z >= -20

_C2: w - 3 x - 2 y + 4 z <= 10

_C3: 2 w - 8 x - 3 y + 3 z <= 20

VARIABLES
w Continuous
x Continuous
y Continuous
z Continuous

-3
0.0
0.0
0.0
```

Practical 12:

```
#1. A beer company has two warehouses from which it distributes beer to four carefully chosen shops. At the start of every week, each barsends
#  an order to the brewery’s head office for so many crates of beer,which is then dispatched from the appropriate warehouse to the bar.The
#  brewery would like to have an interactive computer program whichthey can run week by week to tell them which warehouse should supply which
#  bar so as to minimize the costs of the whole operation. For example, suppose that at the start of a given week the brewery has 2000 cases
#  at warehouse A, and 4500 cases at warehouse B, and that the bars require 600, 1000, 1600, 150 and 800 cases respectively. Transportation costs
#  (dollars per crate) is given in the following table.
# From Warehouse to Bar A B
#            1 3 2
#            2 4 3
#            3 6 3
#            4 2 1
#Which warehouse should supply which bar?
import pulp as pl
warehouses=["a","b"]
supply={"a":2000,"b":4500}
bars=["1","2","3","4"]
demand={"1":600,"2":1000,"3":1600,"4":800}
costs={"a":{"1":3,"2":4,"3":6,"4":2},"b":{"1":2,"2":3,"3":3,"4":1}}
prob=pl.LpProblem("beer distribution problem",pl.LpMinimize)
routes=[(w,b) for  w in warehouses for b in bars]
vars=pl.LpVariable.dicts("Route",(warehouses,bars),0,None,pl.LpInteger)
prob +=pl.lpSum([vars[w][b]*costs[w][b] for (w,b) in routes])
for w in warehouses:
   prob +=pl.lpSum([vars[w][b] for b in bars])<=supply[w]
for b in bars:
   prob +=pl.lpSum([vars[w][b] for w in warehouses])>=demand[b]
print(prob.writeLp())
print(prob.objective.value())
```

```
OUTPUT:
MINIMIZE
2*Route_a_1 + 4*Route_a_2 + 5*Route_a_3 + 2*Route_a_4 + 1*Route_a_5 +
3*Route_b_1 + 1*Route_b_2 + 3*Route_b_3 + 2*Route_b_4 + 3*Route_b_5 + 0
SUBJECT TO
_C1: Route_a_1 + Route_a_2 + Route_a_3 + Route_a_4 + Route_a_5 <= 1000

_C2: Route_b_1 + Route_b_2 + Route_b_3 + Route_b_4 + Route_b_5 <= 4000

_C3: Route_a_1 + Route_b_1 >= 500

VARIABLES
0 <= Route_a_1 Integer
0 <= Route_a_2 Integer
0 <= Route_a_3 Integer
0 <= Route_a_4 Integer
0 <= Route_a_5 Integer
0 <= Route_b_1 Integer
0 <= Route_b_2 Integer
0 <= Route_b_3 Integer
0 <= Route_b_4 Integer
0 <= Route_b_5 Integer
beer_distribution_problem:
MINIMIZE
2*Route_a_1 + 4*Route_a_2 + 5*Route_a_3 + 2*Route_a_4 + 1*Route_a_5 +
3*Route_b_1 + 1*Route_b_2 + 3*Route_b_3 + 2*Route_b_4 + 3*Route_b_5 + 0
...
0 <= Route_b_3 Integer
0 <= Route_b_4 Integer
0 <= Route_b_5 Integer
9600
```