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"""
Registration : xxxx
Description  : Monte Carlo Integration and Estimation of Points under Curve
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"""

import numpy as np
from scipy.integrate import simps, quad
import matplotlib.pyplot as plt

def f(x):
    return np.exp(-x**2)*np.sin(x)      # 0,1
    #return np.sqrt(x)*np.exp(x)        # 0,1
    #return np.sqrt(1-x**2)*np.cos(x)   # 0,0.25

# Enter the integration limits
a, b = eval(input('Enter the lower and upper multiplier of pi: '))
a *= np.pi
b *= np.pi

# Number of points
N = 10000

# Create x and y limit for target area slightly larger
x = np.linspace(a, b, N)
ymin, ymax = np.min(f(x)), np.max(f(x))*1.1

# Calculate exact result using scipy
I_simps = simps(f(x),x)
I_quad = quad(f,a,b)[0]

# Create the target area
A = (b-a)*(ymax-ymin)

# Perform MC integration
x = np.random.uniform(a, b, N)
y = np.random.uniform(ymin, ymax, N)
n = np.sum([abs(y)<abs(f(x))])
I_mc = float(A*n)/N

print ('Integral_'+str(a)+'^'+str(b)+' exp(-x^2)*sin(x) dx (Quad Method) = ', I_quad)
print ('Integral_'+str(a)+'^'+str(b)+' exp(-x^2)*sin(x) dx (Simpson Method) = ', I_simps)
print ('Integral_'+str(a)+'^'+str(b)+' exp(-x^2)*sin(x) dx (MC Method) = ', I_mc)
print ('Points under curve = ',n, ', Total Points = ', N)

"""
Results:
Enter the lower and upper multiplier of pi: 0,1
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (Quad ) = 0.42443751077246467
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (Simpson) = 0.4244375107724644
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.5535535332628885,
Points under curve = 44, Total Points = 100
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4128146298168351,
Points under curve = 328, Total Points = 1000
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4222546752934122,
Points under curve = 3355, Total Points = 10000
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4231105165970531,
Points under curve = 33618, Total Points = 100000
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4232829425034934,
Points under curve = 336317, Total Points = 1000000
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4242599806817271,
Points under curve = 3370933, Total Points = 10000000
Integral_ 0.0 ^ 3.141592653589793 exp(-x^2)*sin(x) dx (MC) = 0.4244385107155959,
Points under curve = 33723515, Total Points = 100000000
"""

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