Diagram, engineering drawing

Description automatically generated

**Python Code**

#Program to create Figure 4.8 from Giordano

import pandas as pd

from matplotlib import pyplot as plt

from math import cos,sin,exp,sqrt,pi,radians

import sys

#Lists of x and y positions

xlist=[]

ylist=[]

xmaxlist=[]

ymaxlist=[]

#Variables

x = 0.475 #x position in AU

y = 0 #y position in AU

vx = 0 #x velocity

vy = 8.2 #y velocity

dt = 0.0001 #time step in years

alpha = 0.01

GMs = 4\*(pi\*\*2)

Mm = 2.4 \* 10\*\*23

xlist.append(x)

ylist.append(y)

#Euler-Cromer method to calculate x and y positions and velocities

for i in range(10450):

r = sqrt(x\*\*2 + y\*\*2)

F = (GMs\*Mm)/(r\*\*2) \* (1+ alpha/(r\*\*2))

vx -= (4\*(pi\*\*2)\*x\*dt)/(r\*\*3) + (4\*(pi\*\*2)\*alpha\*x\*dt)/(r\*\*5)

x += vx\*dt

vy -= (4\*(pi\*\*2)\*y\*dt)/(r\*\*3) + (4\*(pi\*\*2)\*alpha\*y\*dt)/(r\*\*5)

y += vy\*dt

xlist.append(x)

ylist.append(y)

if r >= 0.475: #Checks for maximum distance of Mercury to generate the precession lines

xmaxlist.append(x)

ymaxlist.append(y)

point1 = [0.414, 0.233]

point2 = [0.244, 0.4075]

point3 = [0.01, 0.475]

point4 = [-0.2265, 0.4175]

#Creates a plot with both sets of data

%matplotlib

plt.plot(xlist, ylist, 'k-', lw=1.2)

plt.plot([0, point1[0]], [0, point1[1]], 'k-', lw=1.2)

plt.plot([0, point2[0]], [0, point2[1]], 'k-', lw=1.2)

plt.plot([0, point3[0]], [0, point3[1]], 'k-', lw=1.2)

plt.plot([0, point4[0]], [0, point4[1]], 'k-', lw=1.2)

plt.yticks([-0.58,-0.5,0,0.5,0.58], ['','-0.5','0','0.5',''])

plt.xticks([-0.58,-0.5,0,0.5,0.58], ['','-0.5','0','0.5',''])

plt.title("Simulation of the precession of Mercury")

plt.xlabel("x (AU)")

plt.ylabel("y (AU)")

plt.text(-0.1, 0.49, "\u03B1 = 0.01", fontsize=11, horizontalalignment='left', verticalalignment='bottom')

plt.tick\_params(direction = 'in', bottom=True, top=True, left=True, right=True)

plt.tick\_params(labelbottom=True, labeltop=False, labelleft=True, labelright=False)

ax = plt.gca()

ax.set\_aspect(1)

plt.show()