Computational Physics 06 Lab

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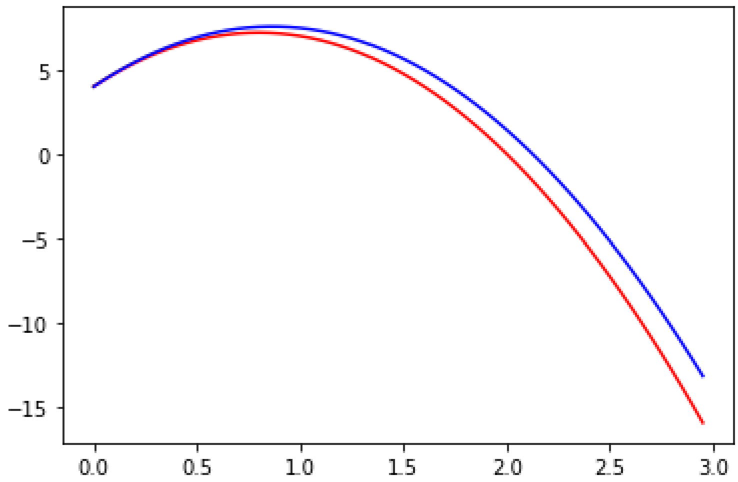
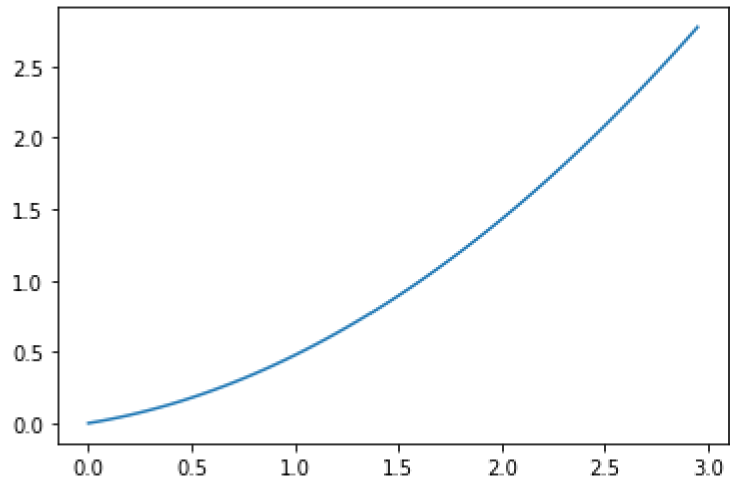
20PH20028

ODE 1

Y vs x



E vs X



Coupled ODE 1

While solving a set of M coupled ODEs the function 'Eul' may be extended to return an array $Y = Eul(F(x, y), x_0, y_0, h, N, M)$, where Y is the M-dimensional array of solutions and F is a M-dimensional array of RHS functions for coupled ODEs. Using this modified function find the phase space trajectory of a particle of unit mass in a potential $V(x)$. You need to solve the Hamilton's equations of the system, given by:

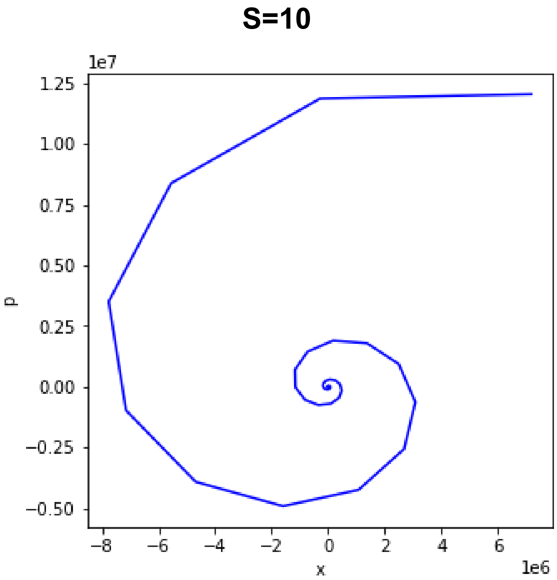
$$\frac{dp}{dt} = -\frac{\partial H}{\partial x}$$

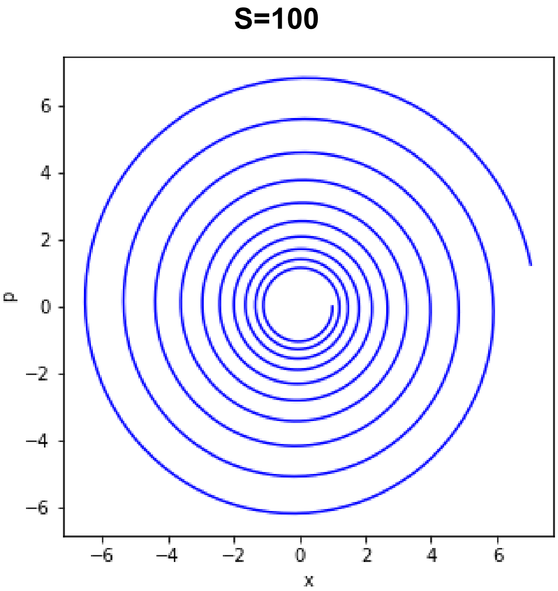
$$\frac{dx}{dt} = \frac{\partial H}{\partial p}$$

a)

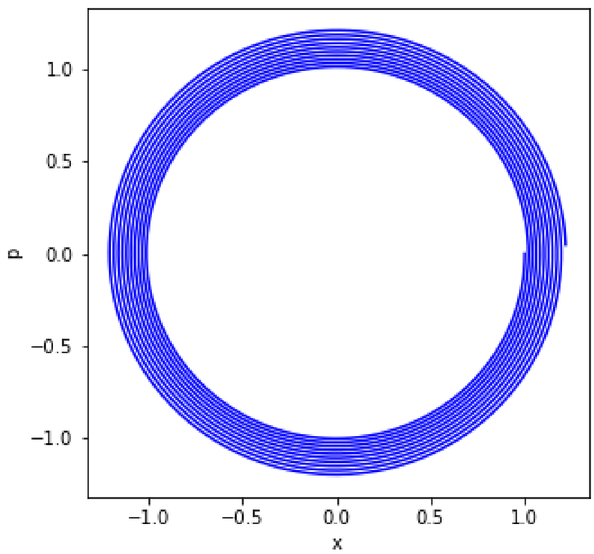
Start by taking simple harmonic oscillator potential $V(x) = \frac{1}{2}kx^2$, $k = 1\frac{N}{m}$ What is the period T of this oscillator? Use h=T/S with S=10, 100 and 1000 for the step size and follow the trajectory over a time 10 T considering the initial condition $(x, px) = (1.0, 0.0)$. For all the cases, compare the following The time period $T = 2\pi$

i) Show the trajectory i.e. x and p as functions of time and also the phase space . Compare these with the analytical solutions.

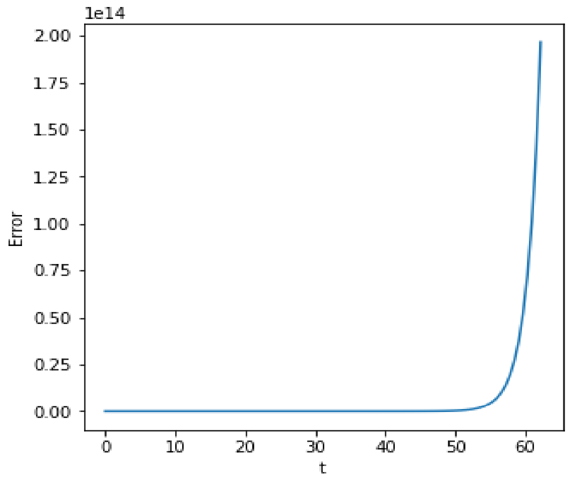




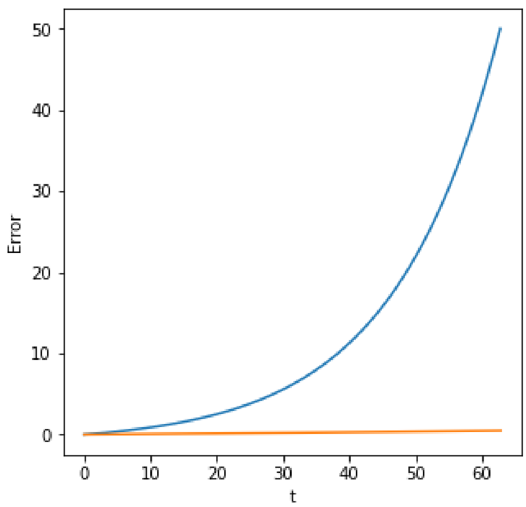
S=1000



Error vs t for S=10

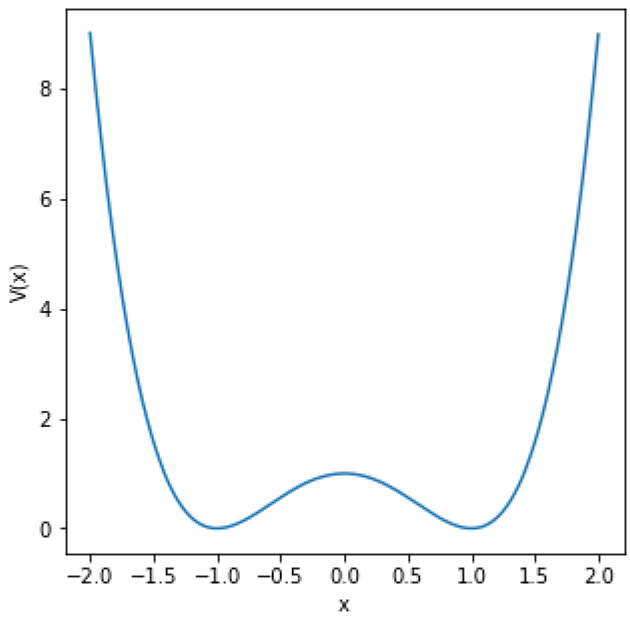


Error vs t for S=100, 1000

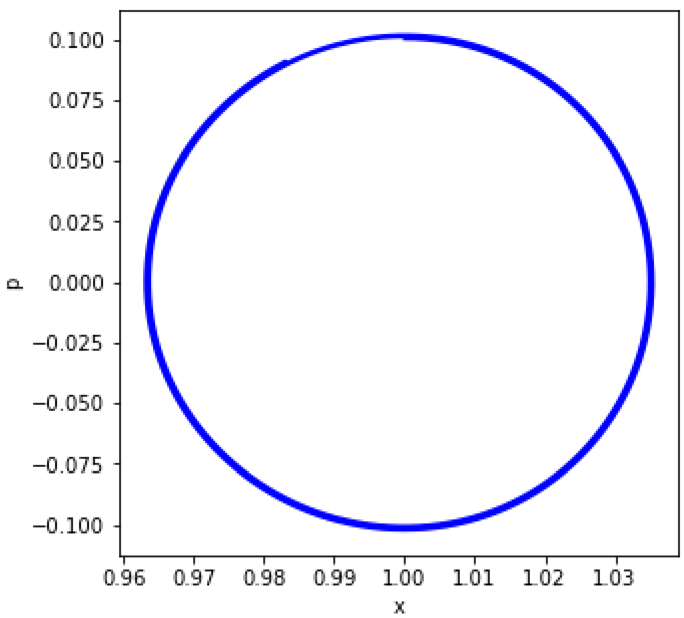


b)

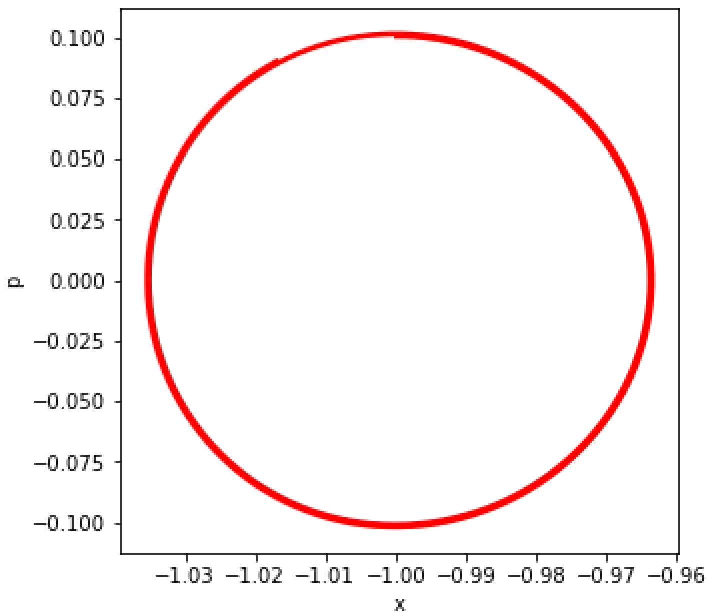
V(x) vs x



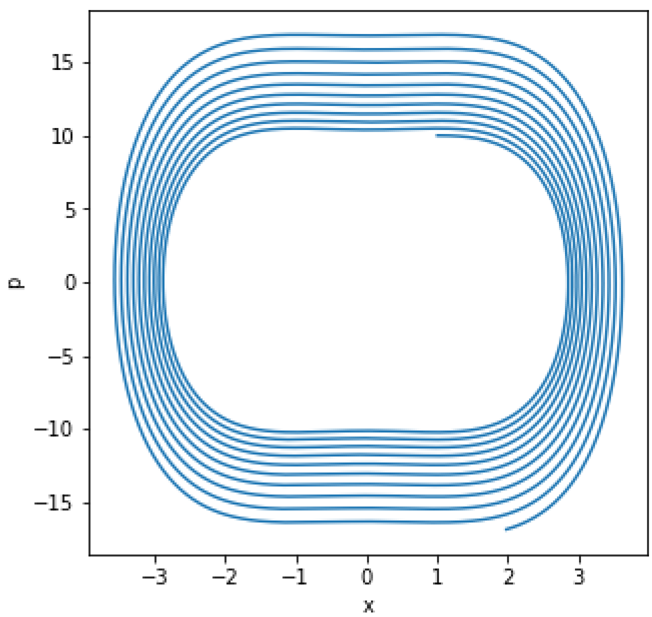
Phase space for (x0,p0)=(1,0.1)



Phase space for(x0,p0)=(-1,0.1)

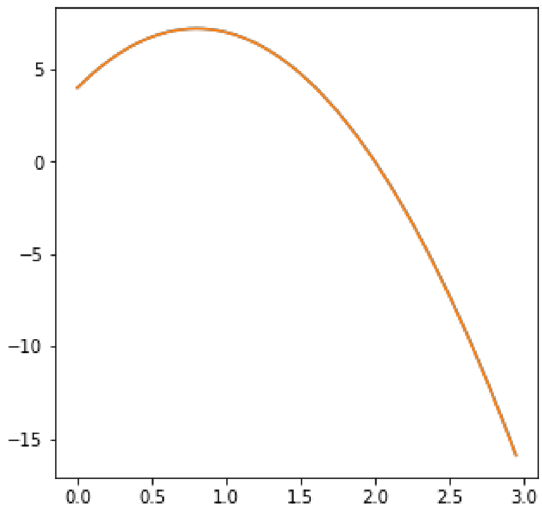


Phase space for (x0,p0)=(1,10)

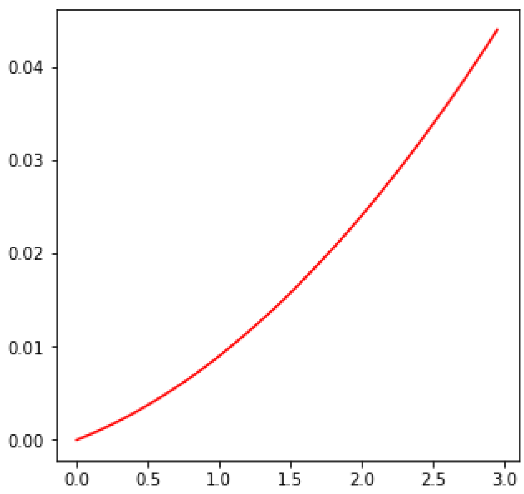


RK 2nd order

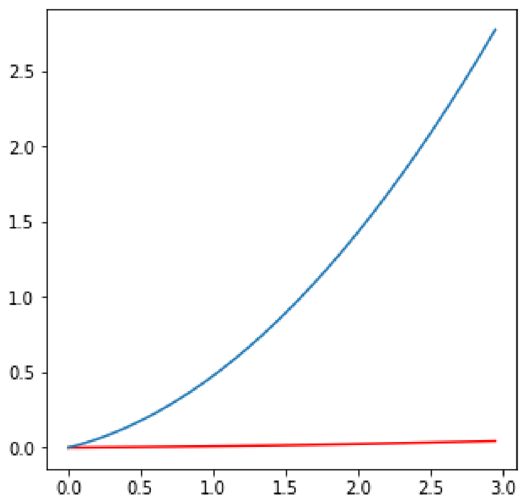
Y vs x



Error vs x

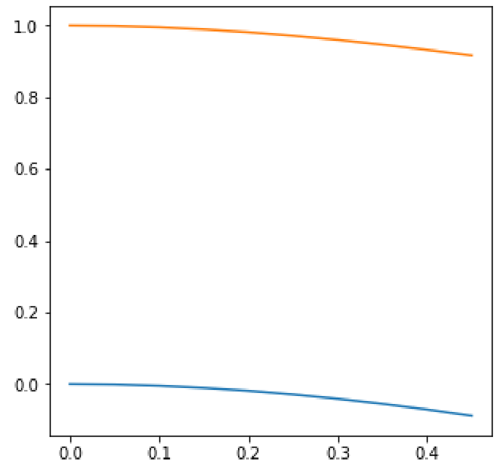


Error vs x (comparision RK2 and Euiler)



Coupled ODE II

Y vs x and z vs x



Coupled ODE 4

Coupled equation 4

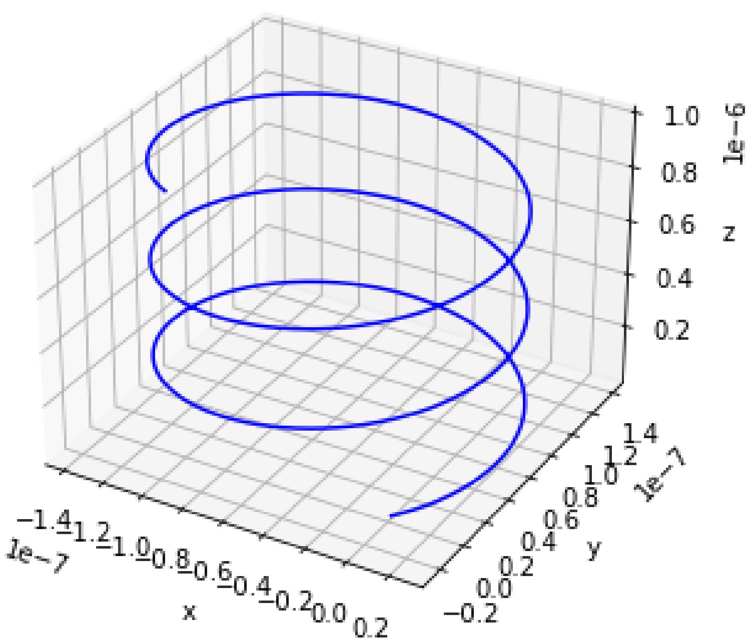
Write a program to follow the motion of an electron (e) in an electric field $E(x,t)$ and a magnetic field $B(x,t)$. Numerically determine the trajectory of an electron for 1 micro second with 1 nano second of time resolution by solving Lorentz force equation:

$$m\frac{d\vec{v}}{dt} = q(\vec{E} + \vec{v}\vec{B})$$

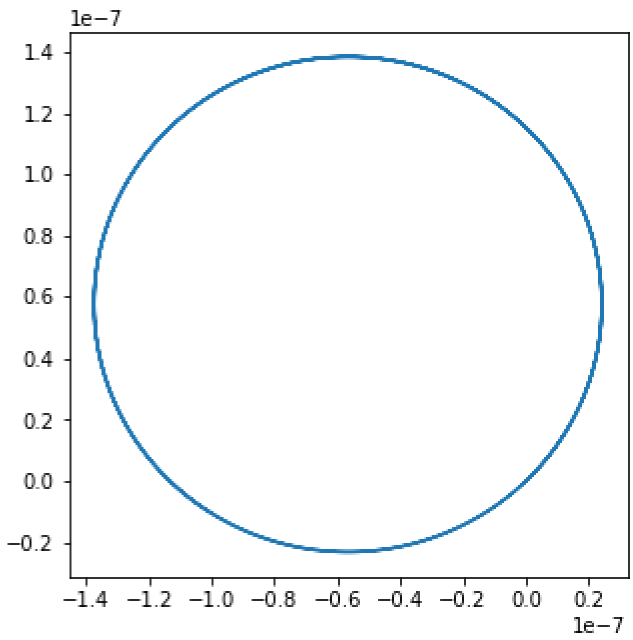
Assume that the particle starts at the origin with velocity $v = (1.0, 1.0, 1.0) m/sec$ for the following field configurations:

I) Uniform magnetic field 10^{-4} Tesla along the z-axis.

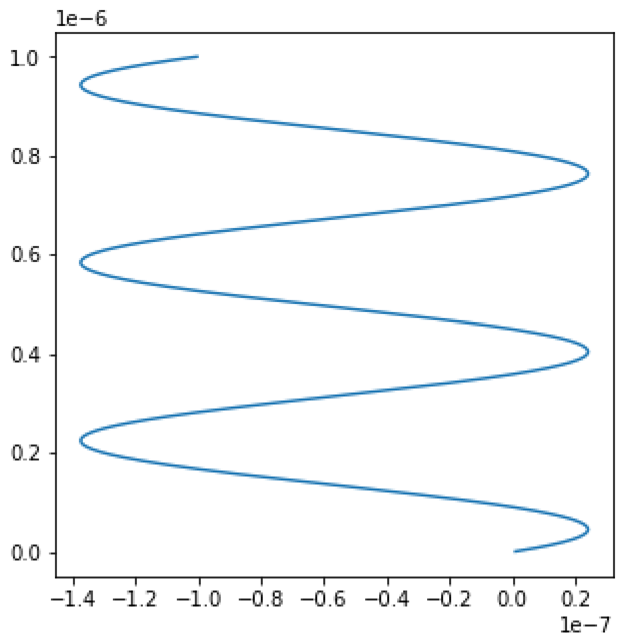
The trajectory is a helix



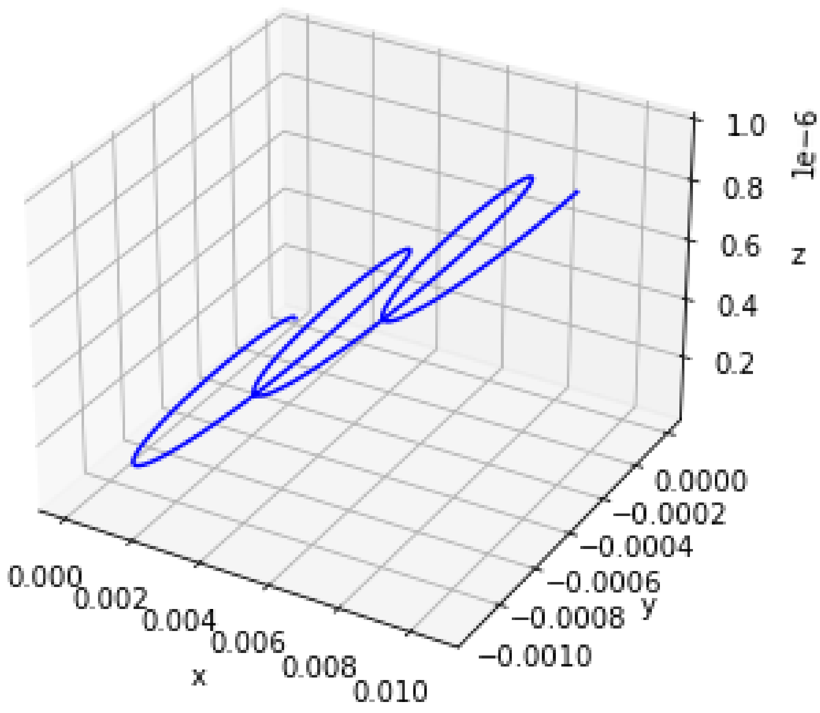
Trajectory in x-y plane



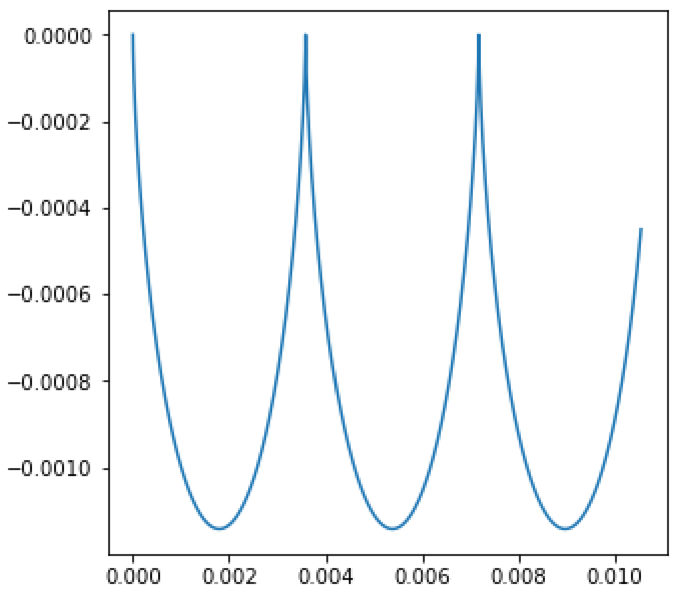
Trajectory in x-z plane

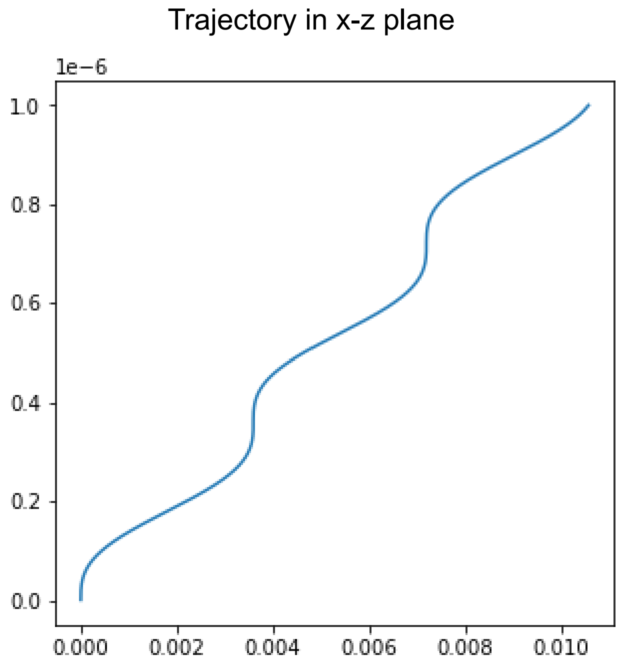


II)Uniform magnetic field $10^{(-4)}\ Tesla$ along the z-axis and a uniform electric field 1V/m along the y-axis



Trajectory in x-y plane




Trajectory in x-z plane
1e−6
1.0
0.8
0.6
0.4
0.2
0.0
0.000
0.002
0.004
0.006
0.008
0.010