Imports

In [12]:
```
import deap as dp
import time
import math
import nbody as nb
import numpy as np
import matplotlib
import matplotlib.pyplot as plt
matplotlib.use('nbagg')
%matplotlib notebook
```

Setting up the RK4 Butcher Tableau

In [2]:
```
bt = [[   0.,   0.,   0.,   0.,   0.],
      [ 1/2., 1/2.,   0.,   0.,   0.],
      [ 1/2.,   0., 1/2.,   0.,   0.],
      [   1.,   0.,   0.,   1.,   0.],
      [   0., 1/6., 1/3., 1/3., 1/6.]]
```

Implementation

Setting up bodies

In [3]:
```
sun = nb.Body(mass=1.988e30,
              position=[0, 0, 0],
              velocity=[0, 0, 0],
              name='sun',
             )

earth = nb.Body(mass=5.972e28,
              position=[149597870700, 0, 0],
              velocity=[0, 29.8e3, 0],
              name='earth',
             )
bodies = [sun, earth]
```

Setting up the system, the time interval of integration, and the integrators

In [17]:
```
the_system = nb.System(bodies)
t_init = 0.
t_fin = 365.25*24*3600
steps = 10000
t_interval = np.linspace(t_init, t_fin, steps)

the_system.setup_integrators(bt, t_init, t_fin, steps)
```

Run

In [18]:
```
start = time.process_time()

the_system.run()

end = time.process_time()
elapsed = end - start

print(elapsed)
```

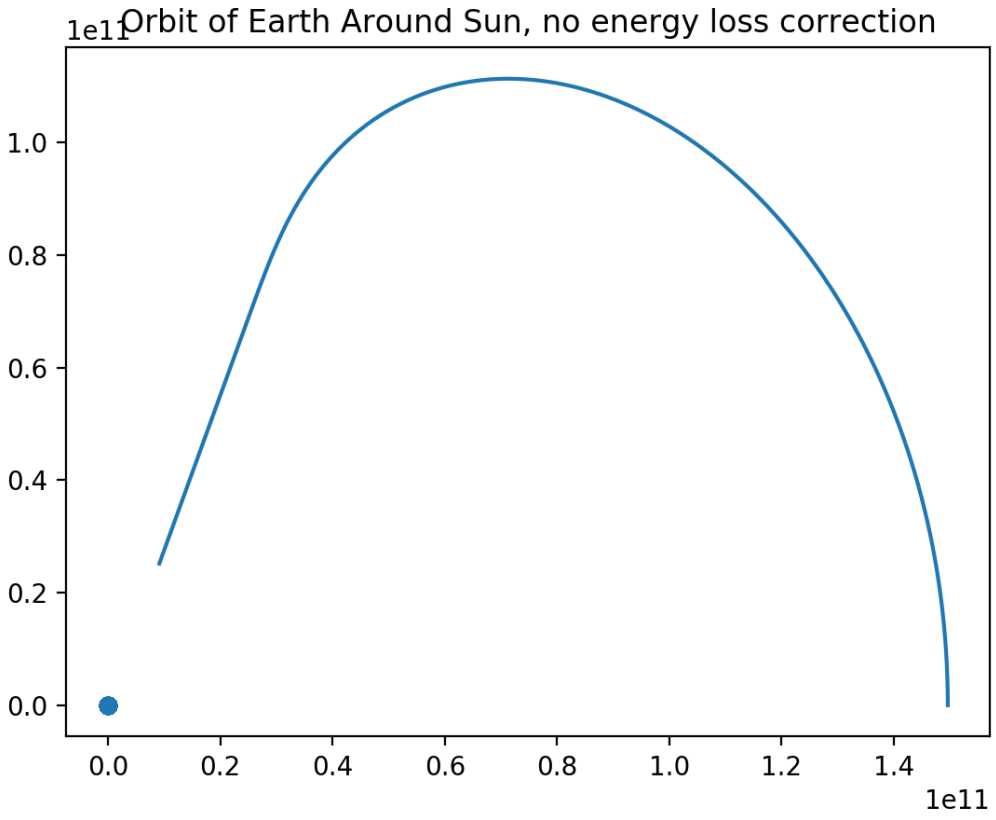
```
1.4328839999999978
```

In [8]:
```
#print(the_system.data['vx'][1][:5])
#print(the_system.data['vy'][1][:5])
#print(the_system.data['vz'][1][:5])
#print(the_system.data ['x'][1][:5])
#print(the_system.data ['y'][1][:5])
#print(the_system.data ['z'][1][:5])
#print(the_system.data['ac'][1][-5:])
```

Plotting

Orbits

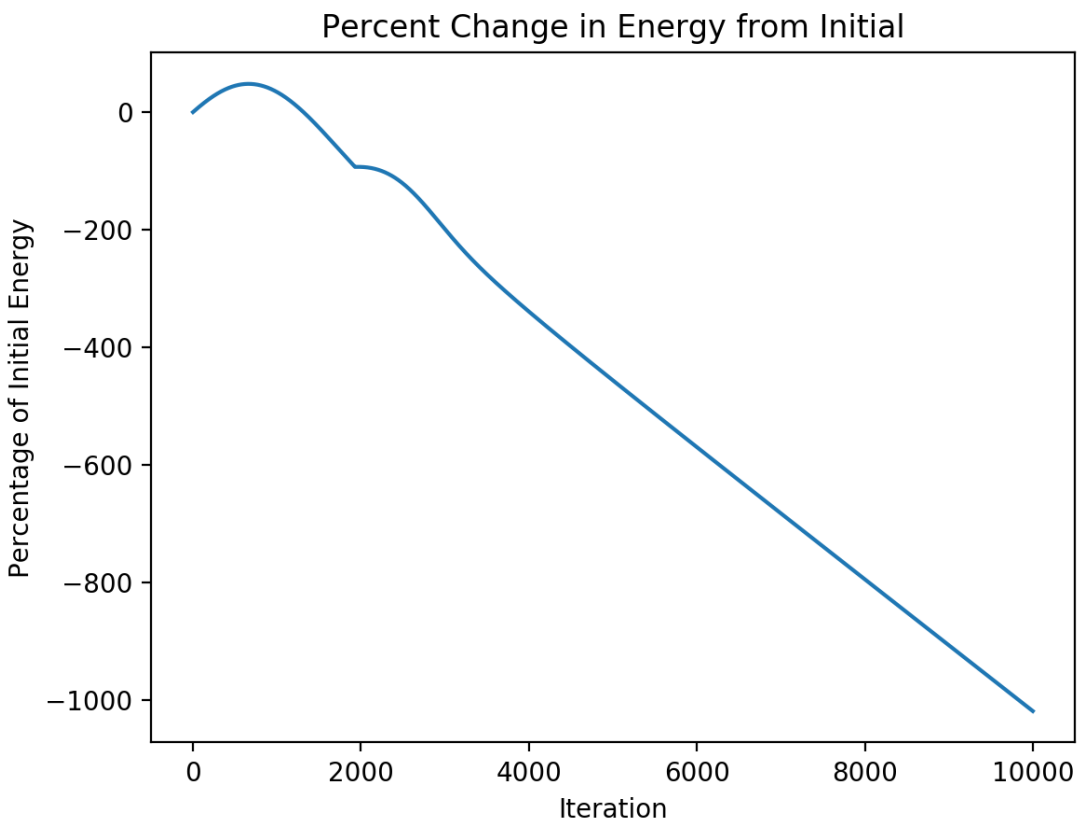
In [19]:
```
which = 1
fig = plt.figure()
ax1 = fig.add_subplot(111)
#print(len(bodies))
ax1.scatter(the_system.data['x'][0], the_system.data['y'][0])
for i in range(1, len(bodies)):
    ax1.plot(the_system.data['x'][i], the_system.data['y'][i])

plt.title('Orbit of Earth Around Sun, no energy loss correction')
plt.show()
```



Change in energy

In [10]:
```
E = the_system.energy
dE = [((e - E[0])/abs(E[0]))*100 for e in E]
```

In [13]:
```
fig = plt.figure()
ax1 = fig.add_subplot(111)
ax1.plot(dE)
plt.title('Percent Change in Energy from Initial')
plt.ylabel('Percentage of Initial Energy')
plt.xlabel('Iteration')
plt.show()
```



In [ ]: