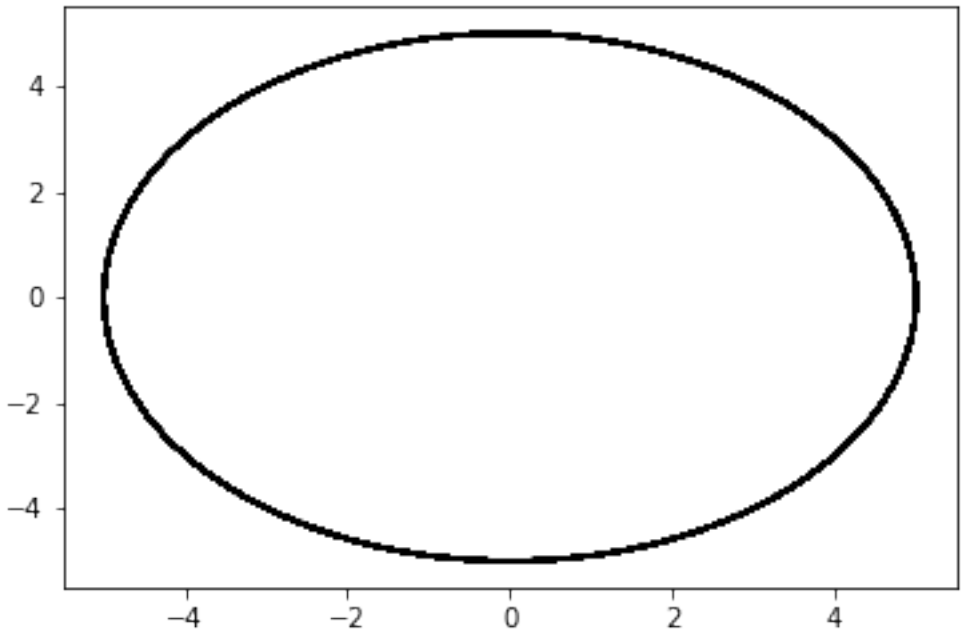
# rk4vsleapfrog

April 16, 2019

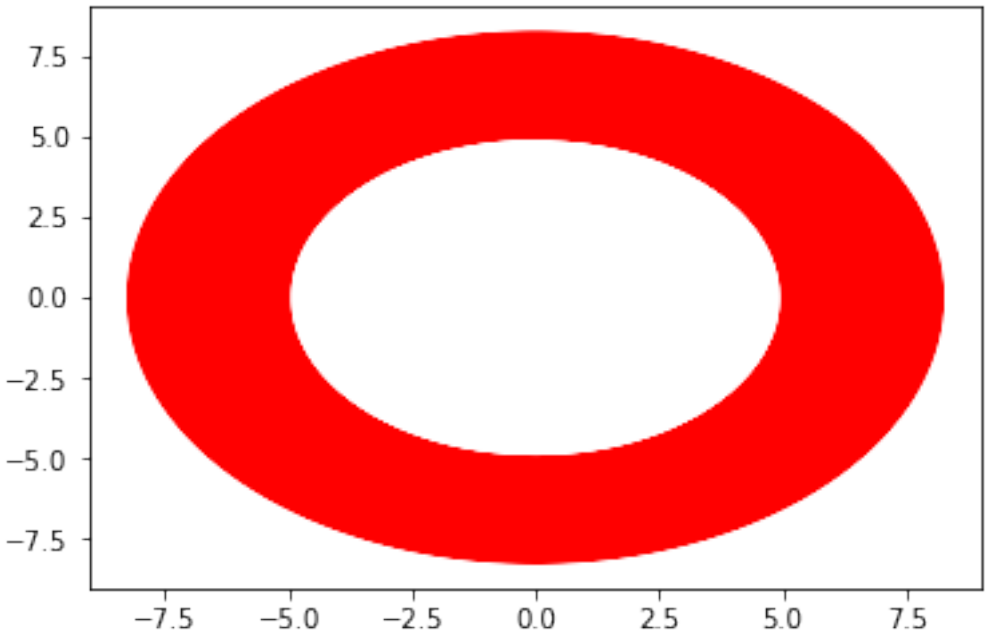
In [2]:
```
import numpy as np
import matplotlib.pyplot as plt
plt.ion()

Nsteps = 1000000  #the total number of time steps
h = 1e-3  #time stepping interval value

#creating arrays to store the values of p and q
q = np.zeros(Nsteps)
p = np.zeros(Nsteps)

#variables to store temporary values during calculations
q_temp = 0
p_temp = 0

#initial value of p
p[0] = 5.0

#shifting the p to half time steps by an initial forward euler.
p_temp = p[0] - 0.5*h*q[0]
p[0] = p_temp

for i in range(1,Nsteps):
    #computing the q's
    q_temp = q[i-1] + h*p[i-1]
    q[i] = q_temp

    #computing the p's
    p_temp = p[i-1] - h*q[i]
    p[i] = p_temp

plt.plot(q,p,'-k') #a line plot

q_lp = q
p_lp = p
```




### 0.1 RK4

```
In [3]: import numpy as np
        import matplotlib.pyplot as plt
        plt.ion()

        Nsteps = 1000000  #the total number of time steps
        h = 1e-3  #time stepping interval value

        #creating arrays to store the values of p and q
        q = np.zeros(Nsteps)
        p = np.zeros(Nsteps)

        #initial value of p
        p[0] = 5.0

        #variables to store the intermediate forces
        qk1 = 0
        qk2 = 0
        qk3 = 0
        qk4 = 0

        qp1 = 0
        qp2 = 0
        qp3 = 0
```

```
    qp4 = 0

    for i in range(1,Nsteps):
        qk1 = h*p[i-1]
        qk2 = h*(p[i-1] - 0.5*h*q[i-1])
        qk3 = qk2
        qk4 = h*(p[i-1] - h*q[i-1])

        pk1 = -h*q[i-1]
        pk2 = -h*(q[i-1] - 0.5*h*p[i-1])
        pk3 = pk2
        pk4 = -h*(q[i-1] - h*p[i-1])

        q[i] = q[i-1] + (1./6)*(qk1 + 2*qk2 + 2*qk3 + qk4)
        p[i] = p[i-1] + (1./6)*(pk1 + 2*pk2 + 2*pk3 + pk4)

    plt.plot(q,p,'-r')

    q_rk = q
    p_rk = p
```




In [4]:
```
    E_rk = 0.5*(p_rk**2 + q_rk**2)
    E_lp = 0.5*(p_lp**2 + q_lp**2)

    plt.plot(E_rk,'-r',label='RK4')
    plt.plot(E_lp,'-k',label='Leapfrog')
```

```
plt.title('Energy plot')
plt.ylabel('Hamiltonian')
plt.xlabel('Number of Timesteps')
plt.legend()
```

Out[4]: <matplotlib.legend.Legend at 0x7fea8b3f12e8>