3) We know that

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

$$\Rightarrow \frac{dp}{dt} = -Kx$$

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

$$\frac{dx}{dt} = \frac{p}{m}$$

now, we get the time evolution of P and X.

$$\frac{d^2x}{dt^2} = \frac{dp}{dt} \cdot \frac{1}{m}$$

Substituting $\frac{dp}{dt}$

$$\frac{d^2x}{dt^2} = \frac{-Kx}{m}$$

on solving this, we get

$$x = C_2 \sin\left(\sqrt{\frac{K}{m}}t\right) + C_1 \cos\left(\sqrt{\frac{K}{m}}t\right)$$

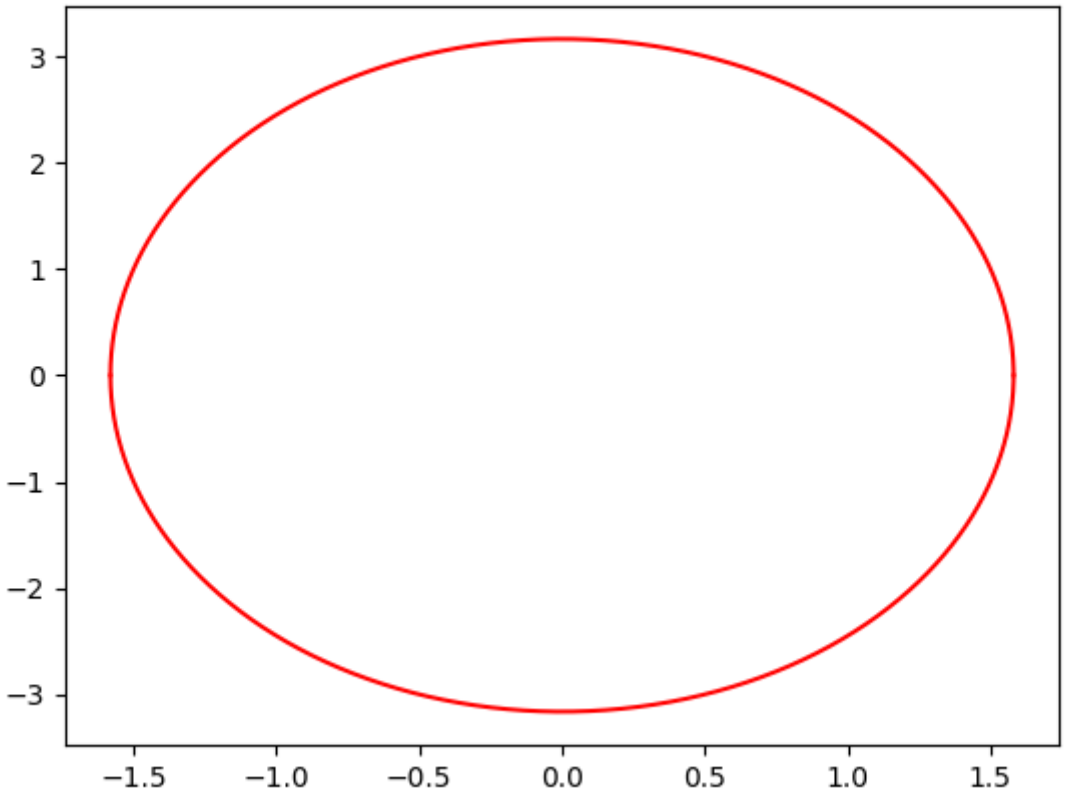
$$\frac{dx}{dt} \cdot m = p$$

$$p = m \cdot \frac{d}{dt}\left(C_2 \sin\sqrt{\frac{k}{m}}\,t + C_1 \cos\sqrt{\frac{k}{m}}\,t\right)$$

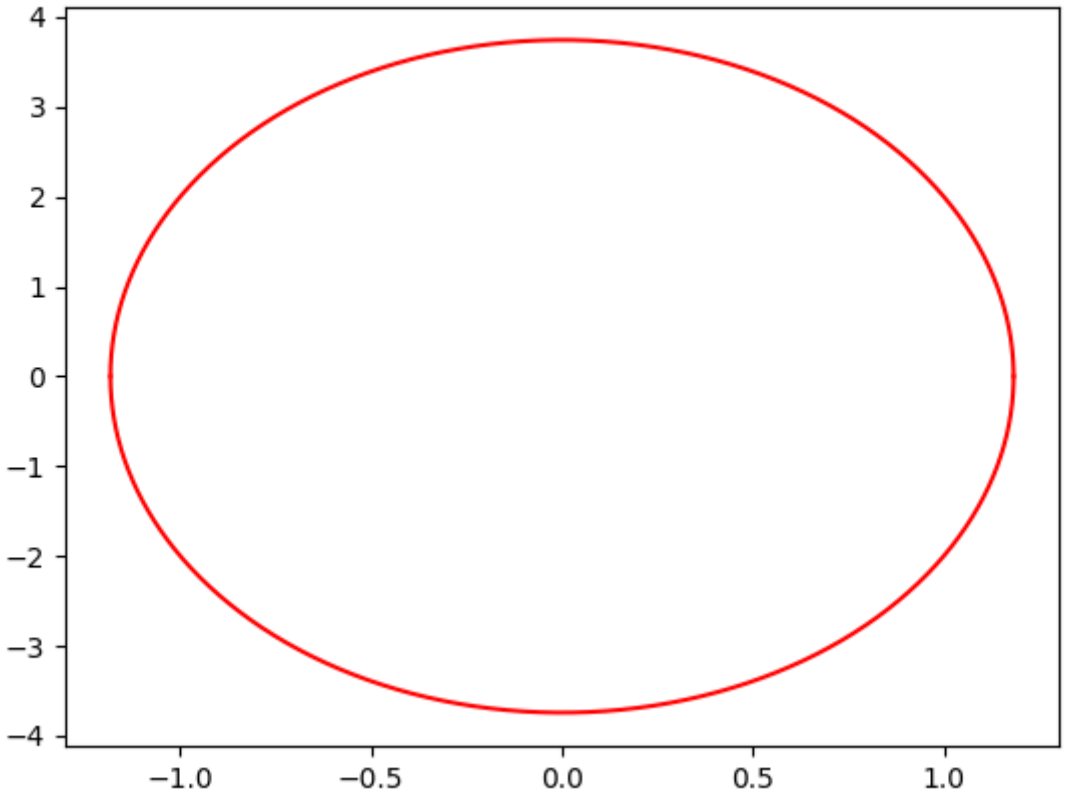
$$p = m \cdot \left(C_2\sqrt{\frac{k}{m}} \sin\left(\sqrt{\frac{k}{m}}\,t\right) - C_1\sqrt{\frac{k}{m}} \sin\left(\sqrt{\frac{k}{m}}\,t\right)\right)$$

time evolution P and X

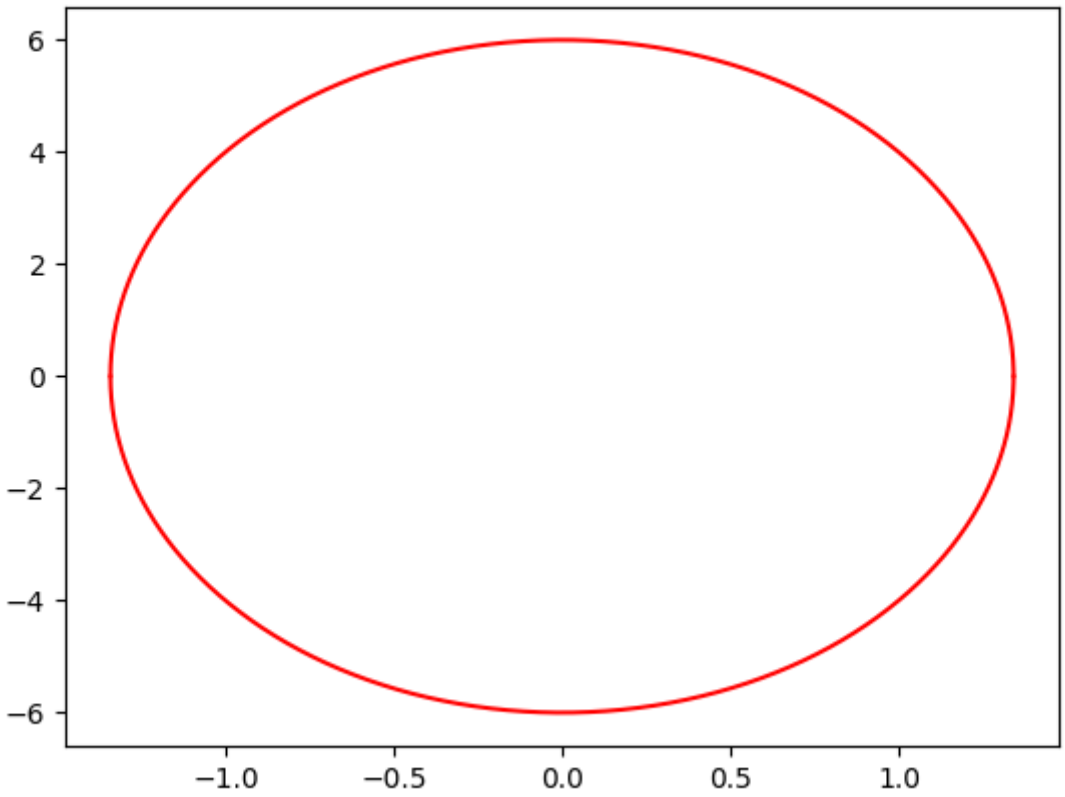
H = 5, K = 4, M = 1



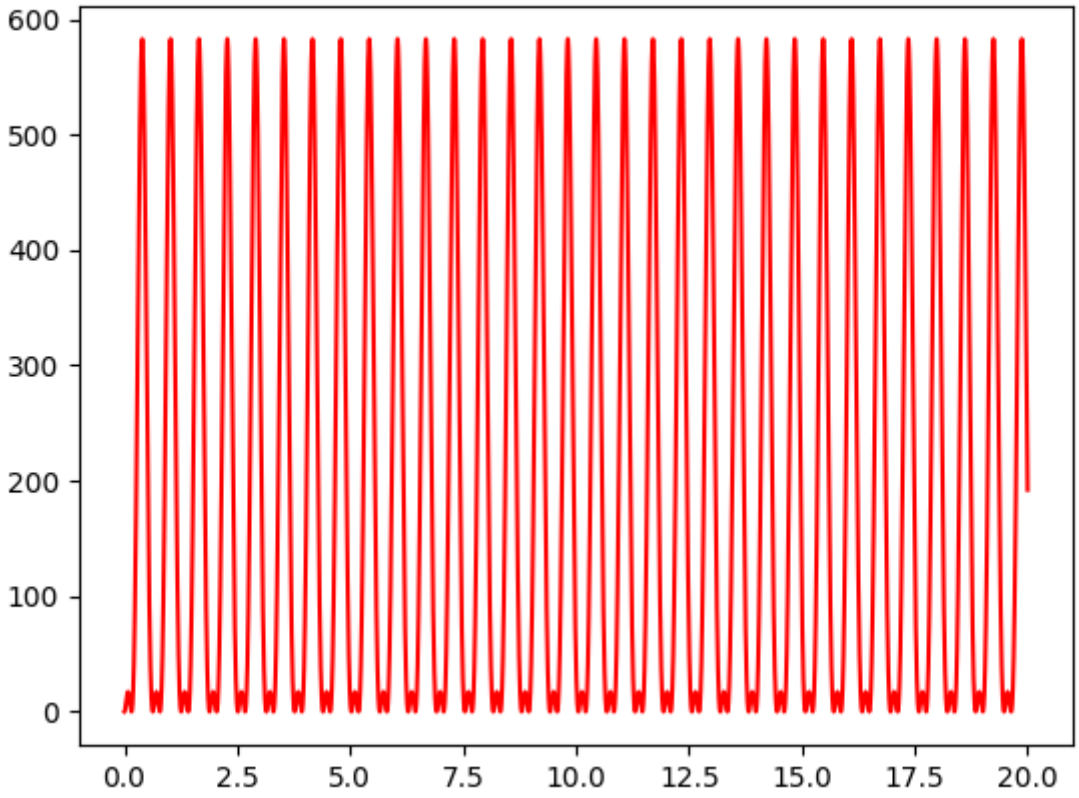
H = 7, K = 10, M = 1



H = 9, K = 10, M = 2



Mean square displacement


600
500
400
300
200
100
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0