Assignment 4
Due Thurs Mar 11

1. Numerically solve the harmonic oscillator problem:

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

in Fortran, C, or C++. For this example, let's set $k = m = \omega = 1$

(a) (75 points) Solve this as a system of ordinary differential equations using ODEINT in your chosen language. Follow at least five cycles and plot the position as a function of time and the energy as a function of time.

(b) (75 points) Use the Leapfrog method described in class and make the same plots as in Part (a). Recall in leapfrog method we had

$$\begin{aligned} x_{i+1} &= x_i + v_i \Delta t + \tfrac{1}{2} a_i (\Delta t)^2 \\ a_{i+1} &= a(x_{i+1}) \\ v_{i+1} &= v_i + \tfrac{1}{2}(a_i + a_{i+1}) \end{aligned}$$

(c) (75 points) Use the 2nd order sympletic (velocity verlet) method described in class and make the same plots as in Part (a). Recall in 2nd order sympletic method we had

$$\begin{aligned} q_{i+1} &= q_i + \tfrac{(\Delta t)}{m} p_i + \tfrac{(\Delta t)^2}{2m} F(q_i) \\ p_{i+1} &= p_i + \tfrac{(\Delta t)}{2} [F(q_i) + F(q_{i+1})] \end{aligned}$$

(d) (50 points) Compare and contrast your results in Part (a)–Part (c).