

PHYSICS 102  
CLASSICAL MECHANICS LAB  
FALL 2013

**Assignment Four**

**Due Wednesday, November 6, 7:00 pm.**

- [1.] Type in the simplest “Euler” version of the simple harmonic oscillator molecular dynamics. Print it and hand it in.
- [2.] Run code for the initial conditions  $x_0 = 3.$ ,  $v_0 = 0.$ , and for spring constant and mass  $k = 2.$ ,  $m = 7.$  Use a range of time steps and time intervals: ( $N = 1000$ ,  $dt = 0.05$ ); ( $N = 5000$ ,  $dt = 0.01$ ). Plot  $x(t)$  and  $E(t)$  and hand in output.
- [3.] Discuss results. Some things you might want to comment on include: What is the analytic solution? Does the accuracy improve as  $dt$  decreases? Do you get the correct period? Is energy conserved?
- [4.] What does  $dt$  small *really* mean?
- [5.] Type in the “leapfrog” version of the simple harmonic oscillator molecular dynamics. Print it and hand it in.
- [6.] Run code for the initial conditions  $x_0 = 3.$ ,  $v_0 = 0.$ , and for spring constant and mass  $k = 2.$ ,  $m = 7.$  Use a range of time steps and time intervals: ( $N = 1000$ ,  $dt = 0.05$ ); ( $N = 5000$ ,  $dt = 0.01$ ). Plot  $x(t)$  and  $E(t)$  and hand in output.
- [7.] Discuss results. Some things you might want to comment on include: What is the analytic solution? Does the accuracy improve as  $dt$  decreases? Do you get the correct period? Is energy conserved?
- [8.] Add an anharmonic term ( $F = -kx - \frac{1}{3}bx^3$ ) to your program. This should be a *tiny* change! One of the really interesting things about the ‘usual’ ( $b = 0$ ) case is that the period  $T$  is independent of the amplitude. Is this true when  $b$  is non-zero? Provide numerical evidence one way or another.
- [9.] Extra credit: Analyze the errors in the energy the “leapfrog” version of molecular dynamics. What order in  $dt$  are they? Are they always positive?