8. Solve the equations of motion

After solving for each respective EOM, we can plot the solution and depict the behavior of the system for 10 seconds. The radial distance that the spring stretches, the spring’s angular deflection from the vertical, in addition to the angular deflection of the bar from the vertical make up the system’s behavior. The linear deflection caused by the spring stretching is plotted on its own figure, and the angular deflection of the spring and bar from the vertical are each plotted on one figure for each set of initial conditions.

Fig 3

Fig 4

Figures (4a) and (4b) depict the spring deflection as well as angular

deflection of the spring and bar, given the initial conditions shown. The angular deflections of the bar and spring in Figure (4b) are relatively similar (compared to that of Figure (5b) below).

It makes sense that the spring deflection plot depicts mostly consistent oscillatory

motion – since the amplitude in the oscillations of the pendulum are smaller, there is

less energy being "transferred," so-to-speak, from the kinetic energy of the bar (force

outward from the spring, dependent on its velocity and acceleration) to or from the

energy in the spring. This phenomena can also be seen in Figure (5a), where the

amplitudes of oscillation in the spring deflection are larger relative to that of this case, due to the fact that the initial conditions in the case of Figure (5a) are of a

greater angular deflection. Given that the initial release angle of the spring and bar are

small (less than 45o), the overall initial potential energy of the system is lower,

subsequently confirming the aforementioned idea that there is less overall energy in the

system, as represented by the generally smaller amplitude in oscillations.

Fig 5

Fig 6

In figure 6 the total energy of the system for each case is graphed. Running the ode45 function with a relative tolerance of 1 ∗ 10−6 and an absolute tolerance of 1 ∗ 10−9 we produce total energy plots that strays significantly less than the default ode45 implementation. The max percentage difference between the high and low tolerance integrations in Figure (6a) is -0.0245%. The max percentage difference in Figure (6b) is -0.0538%. The max percentage difference in Figure (6c) is -0.2116%. As expected, the increased tolerance plots stays constant through the entire runtime of each case. This is because there are no non-conservative forces and the total energy is thus conserved.