1. We consider simple harmonic motion described by $x(t) = A\sin(2t + \theta)$, where $A \geq 0$ and $0 \leq \theta < 2\pi$.
   (a) Find the period of the motion.
   (b) Find the frequency of the motion.
   (c) Find A and θ, if the initial condition at $t = 0$ is $x(0) = 0.0$ m and $v(0) = -2.0$ m/s
   (d) Find the numerical values of A and θ if the position and velocity at $t = 2$ s are $x(2) = -1$ m and $v(2) = 1.0$ m/s. Use a hand calculator, a computer, or a mathematical table if necessary.
   (e) Provide a sketch of $x(t)$, $v(t)$, and $a(t)$ using the results from part (**??**)
   (f) Rewrite your solution in terms of the cosine function.
   (g) Calculate the average position, velocity, and acceleration of this system. Does this make sense? Why?

2. Consider a massless spring of spring constant k and of natural length l_0. One end of the spring is fixed at the origin of the xy coordinate system, where the positive y axis is taken in the vertical downward direction. An object of mass m, attached to the other end of the spring, undergoes a vertical periodic motion. The gravitational force acting on the object is mg, where g is the gravitational acceleration on the surface of the Earth.
   (a) Express the force that the spring exerts on the object at position y.
   (b) Find the equilibrium position.
   (c) Write down the equation of motion for the object in terms of m, k, and y.
   (d) Find the frequency, f and the period, T of the periodic motion.
   (e) Solve the equation of motion under the condition that the position and the velocity of the object at $t = 0$ are $y_0 = l_0$ and $v_0 = 0$, respectively. Express $y(t)$ in terms of m, k, and t.
   (f) Find the maximum value of y.
   (g) You bring the system to the surface of the moon, where the gravitational acceleration is αg with $\alpha < 1$. Find the equilibrium position on the surface of the Moon.
   (h) What is the frequency of the system on the surface of the Moon?
   (i) Sketch your solution for both Earth and the Moon.