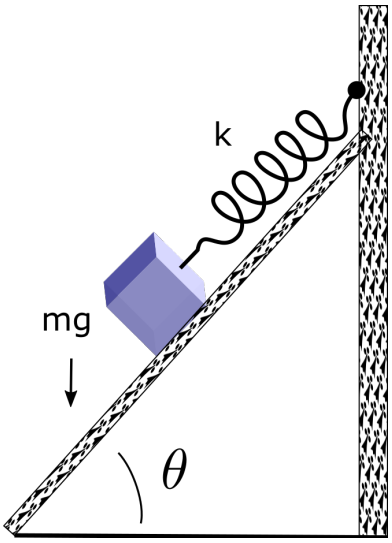
Homework set 03. Physics 141, Fall 2022

Due date: Friday Sept 23, 2022 at noon.
Total of 13 points. On force.

1. (2 points) A block of weight $W = mg = 23.5$ N, which can slide without friction on a 40° incline (shown as θ in the figure), is connected to the top of the incline by a massless spring of un-stretched length $x_0 = 0.4$ m and spring constant $k = 300$ N/m. Gravity pulls the block downward.

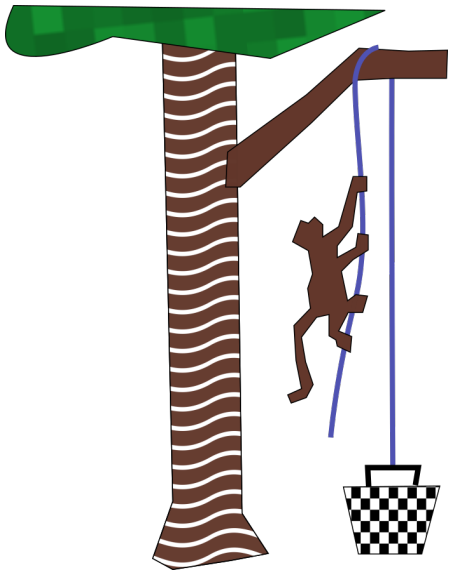


a) By how much will the spring be stretched when the system is in equilibrium?

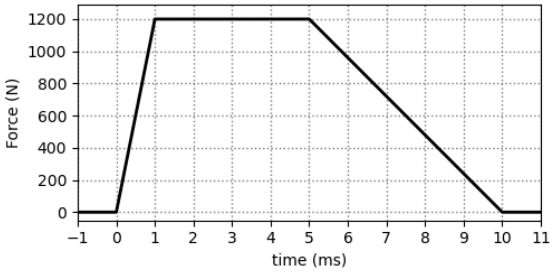
b) If the block is pulled slightly down the incline from its equilibrium position and released, what is the frequency f of the ensuing oscillations?

We are asking for the frequency, not the angular frequency $\omega = 2\pi f$.

2. (2 points) A 14-kg monkey climbs up a massless rope that runs over a frictionless tree limb and back down to a 30-kg package on the ground. What is the magnitude of the least acceleration the monkey must have if it is to lift the package off the ground?

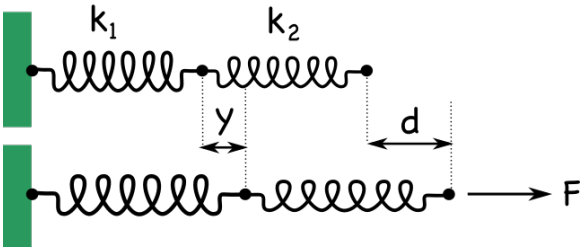


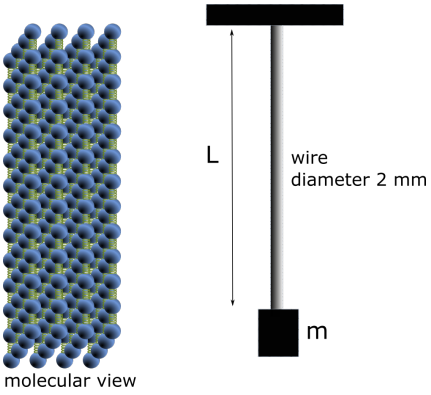
3. (2 points) The Figure shows an approximate representation of the contact force versus time during the collision of a 35-g tennis ball with a wall. The initial speed of the ball is 123.6 m/s perpendicular to the wall. What is the speed of the tennis ball after the collision? (The ball bounces and reverses direction).



4. (2 points) Two springs with spring constants $k_1 = 30.9$ N/m and $k_2 = 21.9$ N/m are connected as shown in the Figure.

   Find the displacement y of the connection point from its initial equilibrium position when the two springs are stretched a distance $d = 1.7$ m as a result of the application of force F.





5. (3 points) A hanging copper wire with a diameter of $d = 2$ mm has an initial length of $L = 3$ m and hangs vertically from the ceiling. When an $m = 5$ kg mass is attached to its end, the wire stretches by 0.425 mm; when a 10 kg mass is attached to its end, the wire stretches by 0.85 mm. The density of copper is $\rho = 9$ g/cm^3 and one mole has a mass of 63 g.

   Estimate the value of the effective spring stiffness of the inter-atomic force.

   Explain your analysis and any assumptions you may have made.

6. (2 points) There is no general analytical solution for the motion of a 3-body gravitational system. However, there exists an analytical solution for the very special case shown in the Figure below. In this Figure, three stars are shown, each of mass m, which move with the same speed in the plane of the page along a circle of radius r. The three stars move in a clock-wise direction. The center of mass remains fixed.

   Calculate how long it will take for this system to make one complete revolution.