Chapter 14 - Simple Harmonic Motion

Physics 206

For any problems where you are given a variable/symbol and a value for that variable, make sure to solve the problem symbolically first. Your final answer should then only contain the variables that you are given values for in the problem, constants that appear on the equation sheet and numbers like 2 or π.

Group 1 Problems:

Problem 1: When a force F acts on a vertical spring it stretches by Δx.

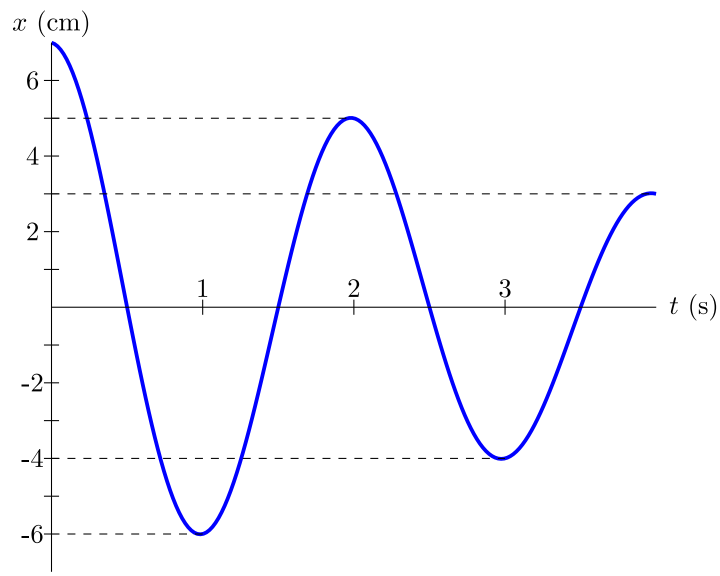
(a) What mass m must be suspended from the same spring so that the system will oscillate with a period of T? (The force F is no longer acting on the spring).

(b) If the amplitude of the motion is A and the period is that specified in part (a), where is the object and in what direction is it moving at $t = T/6$ after it has passed the equilibrium position, moving downward?

(c) What force (magnitude and direction) does the spring exert on the object when it is x below the equilibrium position, moving upward?

Problem 2: A particle moves in simple harmonic motion. The motion has an amplitude of 9 cm and it makes 12 full oscillations in 18 s. What are the speed and acceleration of the mass when it is 6 cm from equilibrium?

Problem 3: A mass is vibrating at the end of a spring of force constant 225 N/m. This graph shows the position as a function of time. Estimate how much energy this system lost between $t = 1.5$ and $t = 4$ seconds.

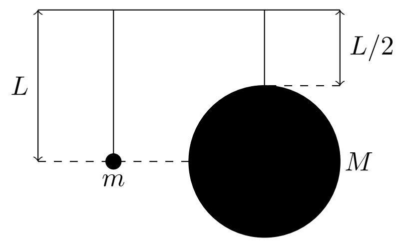


Group 2 Problems:

Problem 4: A simple harmonic oscillator has an angular frequency of 20 rad/s. At time $t = 0$ s it has a position $x = 0.015$ m and a velocity $v = 0.4$ m/s. Find the amplitude and phase angle.

Problem 5: An apple weighs 1.00 N. When you hang it from the end of a long spring of force constant 1.50 N/m and negligible mass, it bounces up and down in SHM. If you stop the bouncing and let the apple swing from side to side through a small angle, the frequency of this simple pendulum is half the bounce frequency. (Because the angle is small, the back-and-forth swings do not cause any appreciable change in the length of the Spring.) What is the unstretched length of the spring (with the apple removed)?

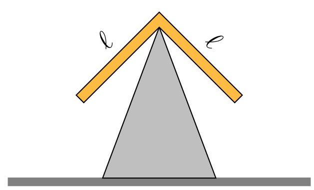
Problem 6: The two pendulums shown to the right each consist of a uniform solid ball of mass M supported by a rigid massless rod, but the ball for pendulum A is very tiny (effectively an ideal pendulum) while the ball for pendulum B is much larger. Find the period of each pendulum for small displacements.



Group 3 Problems:

Problem 7: A small box with mass $m = 0.450$ kg slides on a frictionless floor with a speed of $v = 2.16$ m/s. The box strikes and compresses a spring with a force constant of $k = 65.2$ N/m. How much time does it take for the spring to stop the mass?

Problem 8: Two identical thin rods, each with mass m and length ℓ, are joined at right angles to form an L-shaped object. This object is balanced on top of a sharp edge (see figure). If the L-shaped object is deflected slightly, it oscillates.
(a) Prove that the system will undergo Simple Harmonic motion.
(b) Find the frequency of oscillation.
(c) How will this frequency change on the Moon?



Problem 9: A physical pendulum in the shape of an equilateral triangle is composed of 3 thin rods with masses $4m$ each jointed with help of 3 connectors of negligible size with masses $3m$ each. One of the connectors (the top) has an axle enabling frictionless rotation. The pendulum is placed on horizontal frictionless surface and connected to the wall with spring as show on the figure. Pendulum is displaced from equilibrium on small angle θ and then released. The force constant of the spring is k. Length of each rod is ℓ. Below you will find a top view of the system.
(a) Find moment of inertia I of the pendulum in terms of m and ℓ (not all may be necessary)
(b) Prove that the pendulum would undergo simple harmonic motion.
(c) Find frequency of pendulum oscillations.
(d) Find maximum angular velocity of the pendulum.