KC's Quantitative Problems
SHO

- *Wave-Oscillations.SHO*.**QP.KC.1:** You order some new springs for your low rider pickup truck and you wonder whether the oscillation formed from bouncing up and down are examples of simple harmonic motion. What experiment could you do to determine this using only a bunch of equal mass friends and a meter stick?

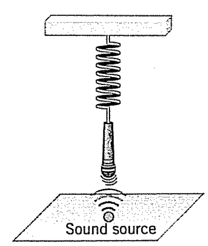
- *Wave-Oscillations.SHO*.**QP.KC.2:** In an engine, a piston oscillates with simple harmonic motion so that its position varies according to the expression $x(t) = 5.00\cos(2t)$ where x is in centimeters and t is in seconds. At $t = 1$ s, find (a) the position of the piston, (b) its velocity, and (c) its acceleration. Find (d) the period and (e) the amplitude of the motion. (f) Sketch a plot of the acceleration as a function of time and be sure to mark the value of the maximum acceleration and the period.

- *Wave-Oscillations.SHO*.**QP.KC.3:** The amplitude of a simple harmonic oscillator decreases to 60% its original value after 25 s of oscillating. What is the max amplitude 25 s after that?

- *Wave-Oscillations.SHO*.**QP.KC.4:** Atoms in a solid are in continuous vibrational motion due to thermal energy. At room temperature, the amplitude of these atomic vibrations is typically about 10^{-9} cm, and their frequency is on the order of 10^{12} Hz. (a) What is the approximate period of oscillation of a typical atom? What is it's maximum (b) speed and (c) acceleration.

- *Wave-Oscillations.SHO*.**QP.KC.5:** In an engine, a piston oscillates with simple harmonic motion so that its position varies according to the expression $x(t) = 15.0\cos(20.0t)$ where x is in centimeters and t is in seconds. At $t = 1$ s, find (a) the position of the piston, (b) its velocity, and (c) its acceleration. Find (d) the period and (e) the amplitude of the motion. (f) Sketch a plot of the acceleration as a function of time. Scale the plot properly.

- *Wave-Oscillations.SHO*.**QP.KC.6:** A microphone is undergoing simple harmonic motion (SHM) above a 440-Hz sound source as shown in the figure. The period of the microphone's SHM is 2.0 s and there is a difference of 2.1 Hz between the highest and lowest recorded frequencies. Ignoring any reflections of sound in the room and using the velocity of sound in air at room temperature, determine the amplitude of the simple harmonic motion.

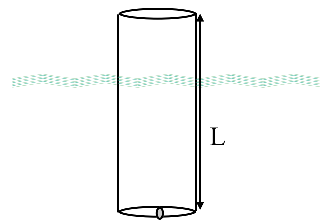


- *Wave-Oscillations.SHO*.**QP.KC.7:** A 50-g mass is vibrating vertically with simple harmonic motion. The amplitude of the vibration is 8 cm and the frequency is 0.398 cycles/s. Calculate the maximum speed of this vibrating mass.

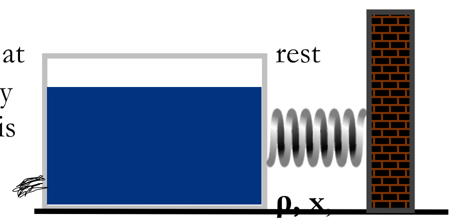
- *Wave-Oscillations.SHO*.**QP.KC.8:** The prong of a tuning fork moves back and forth when it is set into vibration. The distance the prong moves between its extreme positions is 2.2 mm. If the frequency of the tuning fork is 440 Hz, what are the magnitudes of (a) the maximum velocity and (b) the maximum acceleration of the prong? Assume simple harmonic motion.

- *Wave-Oscillations.SHO*.**QP.KC.9:** A 1.2-kg mass attached to a spring oscillates with an amplitude of 7.8 cm and a frequency of 2.6 Hz. What is the total mechanical energy of the motion?

- *Wave-Oscillations.SHO*.**QP.KC.10:** A long cylindrical tube of length **L**, and density $\boldsymbol{\rho_t}$, is very slightly weighted on one end so that it floats upright in a fluid having density $\boldsymbol{\rho_f}$. Assume the tube is constant density and the slight weighting on one end is very small (negligible), with the only purpose to stablize the cylinder vertically in the fluid. It is pushed down a distance ***x*** from its equilibrium position and released. (a) Show that it will execute simple harmonic motion if the resistive effects of the fluid are neglected, and (b) determine the period of the oscillation in terms of **L**, $\boldsymbol{\rho_t}$, and $\boldsymbol{\rho_f}$.



- *Wave-Oscillations.SHO*.**QP.KC.11:** A tank, full of liquid of depth **h**, is at rest on a frictionless table. The liquid (density = **ρ**) is pouring horizontally out of a hole of radius **r** located at the bottom of the tank. The tank is pressing against a spring of constant **k**, that is compressed a distance **x**, from equilibrium. Find the radius of the hole in terms of the **h, k,** **ρ, x,** and **g** the acceleration of gravity.



- *Wave-Oscillations.SHO*.**QP.KC.12:** Major results were just published that attempt to confirm the existence of gravitational waves. Two black holes (very massive celestial bodies) that orbited around each other collided. Their orbit decayed, meaning the distance between the two decreased. As they drew closer and closer to each other they sped up and the increased acceleration produced greater magnitude gravitational waves. A new wave interference device, now sensitive enough to detect the waves for the first time, is called a Laser Interferometer and two such devices exist so that they can confirm events like this. The time right before they collide is plotted below. (a) Why did the two black holes' speeds increase as they drew closer to each other? (b) Why did the two black holes' accelerations increase as they grew closer to each other? (c) Was the gravitational wave they created an example of a simple harmonic wave? Explain.