Problem 1. Spring Block System

Suppose that a spring-block system is initially at rest at its equilibrium position at $t = 0$. Then a lump of clay, of mass m_c, initially traveling at velocity v_c strikes and stikes to the block. Describe the subsequent motions, assuming the block has a mass of m_b, and the spring has a spring constant k.

this is an inelastic collision, so momentum is conserved, but energy is **not**

$$p_i = p_f \qquad \Longrightarrow \qquad v = \frac{m_c v_c}{m_b + m_c}$$

$$v = A\omega, \qquad \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{m_b + m_c}}, \qquad \Longrightarrow \qquad A = \sqrt{\frac{m_c^2 v_c^2}{k(m_b + m_c)}}$$

sine wave with no phase $\phi = 0$

$$x(t) = \sqrt{\frac{m_c^2 v_c^2}{k(m_b + m_c)}} \sin\left(\sqrt{\frac{k}{m_b + m_c}} t\right)$$

Problem 2. Standing Waves

When you blow air into an open organ pipe, it produces a sound with a fundamental frequency of 440 [Hz]. If you close one end of this pipe, what is the new fundamental frequency?

220 [Hz]

Problem 3. Physical Pendulum

A sphere of mass m and radius r is hung from the ceiling from a sting of length $l = 4r$. When the sphere starts oscillation, what is its period? You may use $I_{\text{sphere}} = 2mr^2/5$.

don't forget to use the parallel axis theorem

$$T = 2\pi\sqrt{\frac{127r}{25g}}$$

Problem 4. Interference

Suppose that two speakers are separated by 5 [m] and play a uniform tone of 170 [Hz] in phase. Suppose you are standing 2 [m] from one and 3 [m] from the other. Describe what you hear at $t = 0$ if the waves are sines. What would you hear if you have heard were you instead at the center?

in the first case you are at an node, while in the second you are at an antinode, so you would hear nothing or louder, respectively

Problem 5. Diver

See the course website for 15.77.

Problem 6. Doppler

A police car's siren emits a sound wave with $f = 300$ [Hz]. The speed of sound is 340 [m/s] and the air is still. This police car is chasing a speeding car which is moving at 35 [m/s].

(a) Find out the wavelengths of the sound in front of and behind the siren if the police car is moving at 40 [m/s]. (10 points)

(b) What frequency does the police car hear reflected from the speeding car? (20 points)

$$\lambda_{\text{front}} = 1 \text{ [m]}, \qquad \lambda_{\text{back}} = 1.27 \text{ [m]}$$

for frequency, you have to account for two doppler shift, yielding

$$f = 309 \text{ [Hz]}$$

Problem 7. Shorter Questions

1. What is a transverse wave? What is a longitudinal wave?

   a transverse wave is like a snake, while a longitudinal wave is like a worm

2. Which wave travels left and which travels right? $A\cos(kx - \omega t)$, $A\cos(kx + \omega t)$.

   $A\cos(kx - \omega t)$ travels right, $A\cos(kx + \omega t)$ travels left

3. Which has the fastest, slowest and middle speed of sound among solids, liquids, and gasses?

   $v_{\text{gas}} < v_{\text{liquid}} < v_{\text{solid}}$

4. How many decibels is a 5 [mW] speaker at 2 [m]?

   80.0 [dB]

5. The wind is blowing in your face at 10 [m/s]. If the speed of sound is 343 [m/s]. how long does it take for a friend standing 20 [m] in front of you to hear you?

   0.060 [sec]