PHYSICS 232 - Solution Key to Sample Test 1

1a. When you connect two springs of constants k_1 and k_2, respectively, you create a spring of constant k_{eff}, where

$$\frac{1}{k_{eff}} = \frac{1}{k_1} + \frac{1}{k_2}$$

If $k_1 = k_2 = k$, then $k_{eff} = k/2$. So each half has constant twice the constant of the original spring. The period is

$$T = 2\pi\sqrt{m/k}$$

so the period for each half is $1/\sqrt{2}$ times the period of the original. The period decreases.

1b. The two pulses must add up to the original one. Therefore, L = 5 cm and h = 2 cm.

1c. For P, the difference in paths is (AB) = 2 m. This is half the wavelength, so we have destructive interference at P.

Point Q is equidistant from A and B, so path difference is zero - constructive interference.

1d. The person is moving toward one end of the church, so he/she hears a higher frequency than the organ produces (Doppler effect). He/she hears a lower frequency from the other end because he/she is moving away from that source. The two waves interfere and form a beat.

2a. At time $t = 0$ s, the object is at the maximum position, so the equation that describes its motion is

$$x = A\cos(\omega t) \qquad \omega = \frac{2\pi}{T}$$

At time t = 1.5 s,

$$x = 0.5\cos(2\pi \times 1.5/5) = -0.15\ m$$

2b. The acceleration is

$$a = \frac{d^2x}{dt^2} = -A\omega^2\cos(\omega t) = -\omega^2 x$$

The force is

$$F = ma = -m\omega^2 x = -0.01 \times (2\pi/5)^2 \times (-0.15) = +0.0024\ N$$

in the positive direction.

3a. We have

$$90 = 10\log\frac{I}{I_{min}}$$

where I is the intensity and $I_{min} = 10^{-12}\ W/m^2$. Therefore,

$$I = 10^{90/10} \times I_{min} = 10^9 \times 10^{-12} = 10^{-3}\ W/m^2$$

The total power is

$$P = I \times 2\pi R^2 = 10^{-3} \times 2\pi \times 1^2 = 6.3 \times 10^{-3}\ W$$

3b. The power of the car engine is $P_{car} = 400 \times 746 = 3 \times 10^5$ W.
The fraction going into sound is

$$\frac{P}{P_{car}} = \frac{6.3 \times 10^{-3}}{3 \times 10^5} = 2.1 \times 10^{-8}$$