Name: 1B Midterm Review - Week 3

1. **Forced Oscillators** *(YF 13th ed. 14.63)*. The amplitude of a forced oscillation is

$$A = \frac{F_{max}}{\sqrt{(k - m\omega_d^2)^2 + b^2\omega_d^2}} \tag{1}$$

same dimensions

A sinusoidally varying driving force is applied to a damped harmonic oscillator. (a) What are the units of the damping constant b? (b) Show that the quantity $\sqrt{km}$ has the same units as b. (c) In terms of F_{max} and k, what is the amplitude for $\omega_d = \sqrt{k/m}$ when (i) $b = 0.2\sqrt{km}$ and (ii) $b = 0.4\sqrt{km}$?

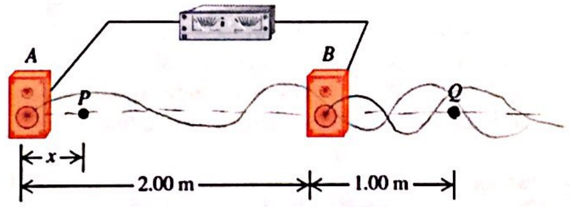
a) $[b^2\omega_d^2]^{1/2} = [Force]/[m] \Rightarrow b = [Force]/[velocity] = kg\,m\,s^{-2}/m\,s^{-1} = kg\,s^{-1}$

b) $\sqrt{km} = ?$; $[k^2] = [b^2\omega_d^2] \Rightarrow b = \frac{k}{\omega_d}$; $[\omega^2] = [k/m]$; $[b] = [\sqrt{km}]$

c)(i) $A = \frac{F_{max}\sqrt{m/k}}{\sqrt{0.04\,km}} = F_{max}/0.2k = 5F_{max}/k$

(ii) $A = \frac{F}{0.4k} = \frac{5}{2}\,F/k$

2. **Interference** *(YF 13th ed. 16.33)*. Two loudspeakers, A and B, are driven by the same amplifier and emit sinusoidal waves in phase. Speaker B is 2.00m to the right of speaker A. Consider point Q along the extension of the line connecting the speakers, 1.00m to the right of speaker B. Both speakers emit sound waves that travel directly from the speaker to point Q. (a) What is the lowest frequency for which constructive interference occurs at point Q? (b) What is the lowest frequency for which destructive interference occurs at point Q?



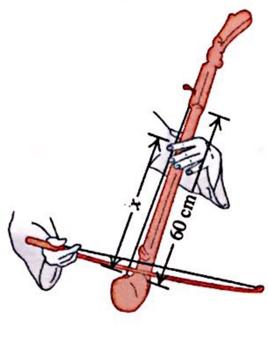
$A(x) = A_0 \sin(xk) + A_0 \sin((x-\Delta)k)$

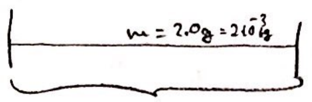
a) Constructive interference @ $\Delta x = n\lambda \Rightarrow$ need $\lambda = \frac{\Delta x}{n}$

$f_n = \frac{v}{\lambda} = \frac{nv}{\Delta x} = \frac{n\,344}{2} = n(172\,Hz) \Rightarrow$ lowest = 172 Hz

b) destructive @ $\Delta x = \frac{m\lambda}{2} \Rightarrow f_m = \frac{172}{2}\,Hz = 86\,Hz$

3. **Standing Waves** *(YF 13th ed. 15.47)*. The portion of the string of a certain musical instrument between the bridge and upper end of the finger board (that part of the string that is free to vibrate) is 60.0 cm long, and this length of the string has mass 2.00g. The string sounds an A_4 note (440Hz) when played.
(a) Where must the player put a finger (what distance x from the bridge) to play a D_5 note (587Hz)? For both the A_4 and D_5 notes, the string vibrates in its fundamental mode. (b) Without retuning, is it possible to play a G_4 note (392 Hz) on this string? Why or why not?

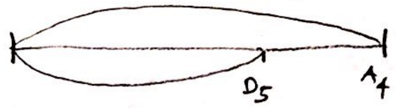




$f = 440\ Hz$

$L = 60cm = \lambda/2 \Rightarrow \lambda = 120\ cm = 1.2\ m$

a)



$v = \lambda f = 1.2 \times 440\ m/s = 528\ m/s$

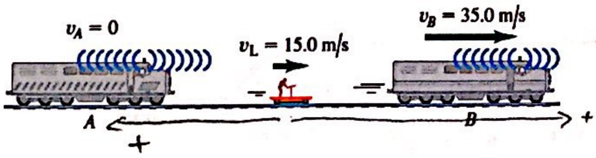
$v = $ const, since Tension and mass density $=$ const.

$v = \sqrt{\frac{T}{m/L}} = \lambda_2 f_2 \Rightarrow \lambda_2 = \frac{v}{f_2} = \frac{\lambda_1 f_1}{f_2} = \frac{1.2 \times 440}{587}\ m = 45\ cm$

b) $\lambda_3 = \frac{\lambda_1 f_1}{f_3} = \frac{1.2 \times 440}{392} = 1.35m$

↳ No. Need to retune to change $v = \sqrt{\frac{T}{m/L}}$.

4. **Doppler** *(YF 13th ed. 16.45)*. Two train whistles, A and B, each have a frequency of 392 Hz. A is stationary and B is moving toward the right (away from A) at a speed of 35.0m/s .A listener is between the two whistles and is moving toward the right with a speed of 15.0m/s. No wind is blowing. (a) What is the frequency from A as heard by the listener? (b) What is the frequency from B as heard by the listener? (c) What is the beat frequency detected by the listener?



$$f_L = \left(\frac{v + v_L}{v + v_S}\right) f_S$$

(+)ve from listener to source

$f_S = 392$

a) $V_S = 0$
$V_L = -15 m/s$

$$f_L = \left(\frac{v + v_L}{v + v_S}\right) f_S = \left(\frac{344 - 15}{344}\right)(392) = 375\ Hz$$

b)
$V_L = +15\ m/s$
$V_S = +35\ m/s$

$$f_L = \left(\frac{344 + 15}{344 + 35}\right)(392) = 371\ H$$

c) $f_{beat} = f_1 - f_2 = 4\ Hz$