Midterm 4 – 4/13/10

Name, sect. no.

MC1

An object is undergoing simple harmonic motion. Throughout a complete cycle it:

A. has constant speed
B. has varying amplitude
C. has varying period
D. has varying acceleration
E. has varying mass

ans: D

$a(t) = -\omega^2 x(t)$, "hallmark" of SHM

MC2

Sinusoidal waves travel on five different strings, all with the same tension. Four of the strings have the same linear mass density, but the fifth has a different linear mass density. Use the mathematical forms of the waves, given below, to identify the string with the different linear mass density. In the expressions x and y are in centimeters and t is in seconds.

A. $y(x,t) = (2\,\text{cm})\sin(2x - 4t)$
B. $y(x,t) = (2\,\text{cm})\sin(4x - 10t)$
C. $y(x,t) = (2\,\text{cm})\sin(6x - 12t)$
D. $y(x,t) = (2\,\text{cm})\sin(8x - 16t)$
E. $y(x,t) = (2\,\text{cm})\sin(10x - 20t)$

ans: B

$v = \omega/k$, all the waves accept for wave (b) have the same speed (2 m/s). V also equals $\sqrt{\tau/\mu}$ – if one wave has a different linear mass density its speed will be different.

MC3

The rise in pitch of an approaching siren is an apparent increase in its:

A. speed
B. amplitude
C. frequency
D. wavelength
E. number of harmonics

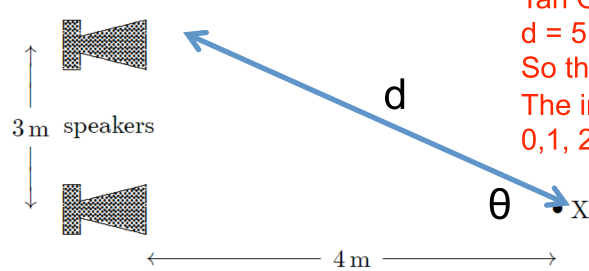
ans: C

MC4

Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at X, 4 m in front of one speaker as shown. The sound she hears will be most intense if the wavelength is:

A. 5 m
B. 4 m
C. 3 m
D. 2 m
E. 1 m

ans: E

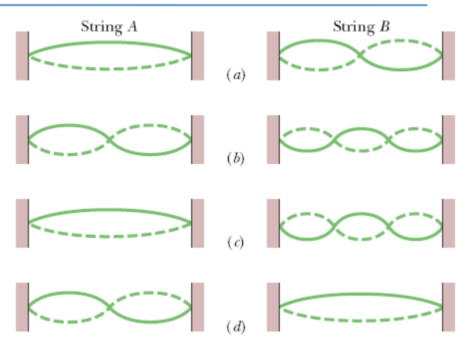


Consider the speakers to be point sources

Tan Θ = ¾ , θ = 36.8°, cos θ = 4/d,
d = 5 (the famous 3:4:5 triangle)
So the path length difference, ΔL is 1 m
The interference is constructive if $\Delta L/\lambda$ = 0,1, 2, etc.

MC5

Strings A and B have identical lengths and linear densities, but string B is under greater tension than string A. The figure shows four situations, (a) through (d), in which standing wave patterns exist on the two strings. In which situations is there the possibility that strings A and B are oscillating at the same resonant frequency?



$v = \sqrt{\tau/\mu}$, *B is has greater* ***T****, so v is greater in B. But v also* = λf, or $f = v/\lambda$. So to get the same f when v is greater, λ must be shorter. Only chance for this to be true is (d)

Problem 1: A wave travelling on a string is described by $y(x,t) = 3\sin(7x + 3t)$ in which the numerical constants are all in SI units. (please report units with all answers)

(a) What is the amplitude of the wave? 3m

(b) Which direction is the wave travelling? $kx + \omega t$ must be a constant, as t increases x must decrease- thus the wave is moving to the left (-x direction).

(c) What is the velocity of the wave? $v = \omega/k = 3/7 = 0.43$ m/s

(d) What is the displacement y of the element at x = 3 m at t = 3 s?
$y(3,3) = 3 \sin(21 + 9) = -2.96$ m

(e) What is the transverse velocity of this same element at t = 7 s?
$u = dy/dt$ at constant x, $= 3 * 3 \cos(7x+3t) = 9 \cos(21 + 21) = -3.6$ m/s

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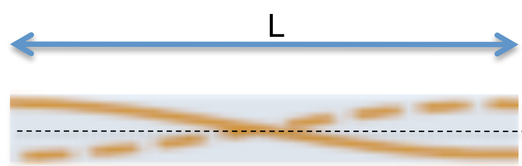
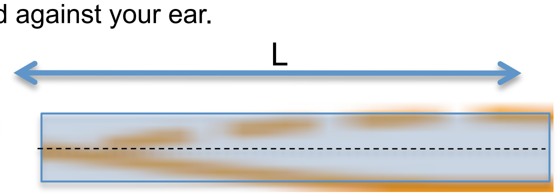
Problem 2: Weak background noises from a room set up the fundamental standing wave in a cardboard tube of length L = 67 cm with two open ends. Assume that the speed of sound in the air within the tube is 343 m/s.

(a) Sketch the first harmonic standing wave in the tube
(b) What frequency do you hear from the tube?
$f = 1 * 343$ m/s / $(2 * 0.67$m$) = 256$ Hz



(a) Sketch the lowest frequency harmonic if one end is jammed against your ear.
(b) What frequency is heard in this case?
$f = 1 * 343$ m/s / $(4 * 0.67$ m$) = 128$ Hz



Problem 3: A nylon guitar string has a linear density of 7.20 g/m and is under a tension of 150 N. The fixed supports are a distance of 90 cm apart. The string is oscillating in the standing wave pattern as shown. Calculate the (a) speed, (b) wavelength, and (c) frequency of the traveling waves gives this standing wave.

A) $v = \sqrt{(\tau/\mu)} = \sqrt{(150 \text{ N}/.0072 \text{ kg/m})} = 144$ m/s
B) $\lambda = (90/3)*2 = 60$ cm
C) $f = v/\lambda = 144$ m/s / 0.6 m = 2,40 Hz