Lecture 28 Announcements

1. Tutorial lab info: it *will* be open during reading days and finals, but the TAs have their own exams to study for and take so staffing may vary significantly from the regular schedule.
2. Final exam:
   a. Take in Testing Center anytime during finals week
      → See Testing Center website for their exact schedule
   b. Will have ~40 problems 42, [illegible]
   c. 10 problems on new stuff; rest is cumulative
   d. Average time should be 2-2.5 hours
      i. 4 hr time limit
   e. Last year's median = 75; this year's exam is a little harder, I'm shooting for 72-73.
      i. I'll curve it up to 70 if it ends up being below that
   f. No calculators, no notecards
   g. First page of exam has been posted to class website—that tells you which formulas will be given on exam.
   h. What to study (roughly in order of importance)
      i. Midterm exams
      ii. Homework (all of them, but especially the last three assignments)
      iii. Class notes
      iv. Warmup quizzes

Final will replace lowest midterm!

v. Last year's final

vi. Textbook

3. Two TA-led final exam reviews, room still TBA:
   a. Thurs 7 – 9 pm Will Benson
   b. Fri 1 – 3 pm C215 ESC
4. Deadlines:
   a. All extra credit must be turned in to your regular homework boxes by midnight tonight!
   b. Instructor/course ratings must be done by Sat Dec 13 http://studentratings.byu.edu
   c. All late computer homework must be done by midnight Fri Dec 19 (last day of finals)
   d. All late FBDs to HW boxes by Monday

$$\frac{3}{.2} = \frac{3}{1/5} = 3 \cdot 5 = 15$$

(a) $\sqrt{\frac{1000}{(9.8)(3)}}$

(b) $\sqrt{\frac{(1000)(3)}{9.8}}$

$$\frac{4}{.5} = 8$$

$g = 10$ most of time

$\log 100 = 2$ $\log(10^8) = 8$

Formulas Review: Chap 13-14

Definitions and Fundamental Laws

Final exam: you will be expected to know these on your own

$f = \frac{1}{T}$, $\overset{\text{rad}}{\omega} = 2\pi \overset{\text{rev}}{f}$, $T = \frac{2\pi}{\omega}$

Wave speed $v = f\lambda$

Intensity $I = P/A$

New stuff, but not quite as basic

Final exam: I will give you these (but maybe without the "tags")

spring $\omega = \sqrt{\frac{k}{m}}$, $T = 2\pi\sqrt{\frac{m}{k}}$ $\quad f = \frac{1}{2\pi}\sqrt{k/m}$

pendulum $\omega = \sqrt{\frac{g}{L}}$, $T = 2\pi\sqrt{\frac{L}{g}}$

wave speed $v = \sqrt{\frac{T}{\mu}}$, $\mu = m/L$ $\quad v = \sqrt{\frac{B}{\rho}}$ $\quad v = \sqrt{\frac{Y}{\rho}}$

$v_{air} = 343$ m/s, unless otherwise specified $\rightarrow 300$ m/s

$A_{sphere} = 4\pi r^2$

decibels $\beta = 10\log\left(\frac{I}{I_0}\right)$ $\quad I_0 = 10^{-12}$ W/m^2 $\quad \frac{\beta}{10} = \log I/I_0$

$10^{\beta/10} = I/I_0$

Doppler: $f' = f\frac{v \pm v_O}{v \pm v_S}$ $\quad v_S \rightarrow V_{source}$

V_{sound}

standing waves: $L = \frac{n}{2}\lambda \quad n = 1,2,3,\ldots$ $\qquad L = \frac{n}{4}\lambda \quad n = 1,3,5,\ldots$

open-open or string $\qquad$ open-closed

$L = \frac{n}{2}\left(\frac{v}{f}\right)$

Things which *you* might consider to be formulas

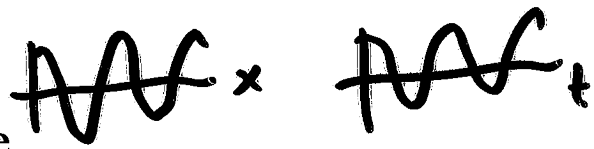
(but I don't really, so I won't give them to you on exam)

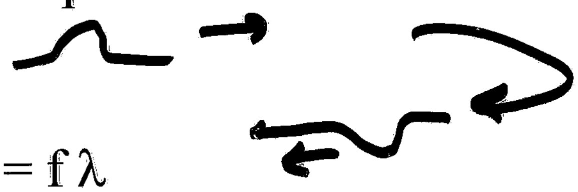
- What A and ω stand for in the equation for a sinusoidal wave, i.e. $x = A\cos(\omega t)$ 

  A $\omega = 2\pi/T$
- How to solve for I in the decibel formula
- How to choose +/- signs in Doppler formula
- How to use e.g. $L = \frac{n}{2}\lambda$ formula to figure out frequency of a harmonic
- (I'm sure there are more…)

Review of important concepts, Chap 13-14

1. Sinusoidal Oscillations   Asin(ωt)   or   Acos(ωt)
    a. Amplitude
    b. Period vs. frequency vs. angular frequency
        i. $f = \frac{1}{T}$, $\omega = 2\pi f$, $T = \frac{2\pi}{\omega}$
    c. "Simple harmonic motion"
        i. spring: $\omega = \sqrt{\frac{k}{m}}$
        ii. pendulum: $\omega = \sqrt{\frac{g}{L}}$
            1. When does this hold true? small angles

2. Waves: oscillations that transport energy


    a. Often sinusoidal in space and in time
    b. Longitudinal vs. transverse
    c. Reflections…when does an upward pulse reflect off downward?

    d. Superposition/interference
    e. Speed, wavelength, frequency: v = f λ
    f. Equations for wave speed in different materials
        i. sqrt(force-like quantity / mass-like quantity)

3. Sound waves
    a. Intensity of a wave $I = P/A$
        i. Spherical waves, A = $4\pi r^2$

b. Decibel scale (sound): $\beta = 10\log\left(\frac{I}{I_0}\right)$ $I_0 = 10^{-12}$ W/m^2

i. +10 to dB number = ×10 to the intensity

c. Doppler effect: $f' = f\,\frac{v \pm v_0}{v \pm v_S}$

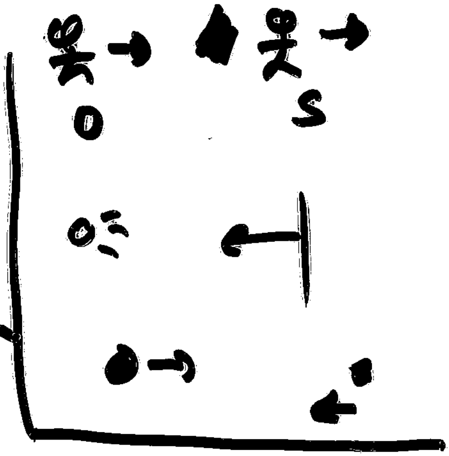
i. If lady (observer) is moving towards baker:

1. numerator + (because freq increases) $v + v_0$

ii. If baker (source) is moving towards lady:

1. denominator – (because freq increases) $v - v_s$

iii. If moving *away*, use opposite sign.



4. Interference/superposition of waves

a. Constructive/destructive interference

i. Waves off by λ vs. waves off by λ/2

$\Delta L = \lambda$ $\Delta L = \lambda/2$

b. Standing waves

i. Vocabulary: nodes vs. antinodes

small displ max

ii. Closed-closed or open-open

1. L = 1/2 λ, 2/2 λ, 3/2 λ, … from pictures

2. Summary: $L = \frac{n}{2}\lambda \quad n = 1, 2, 3, \ldots$

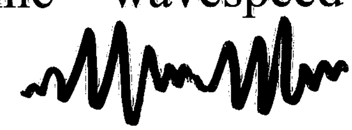
iii. Open-closed

1. L = 1/4 λ, 3/4 λ, 5/4 λ, … from pictures

2. Summary: $L = \frac{n}{4}\lambda \quad n = 1, 3, 5, \ldots$

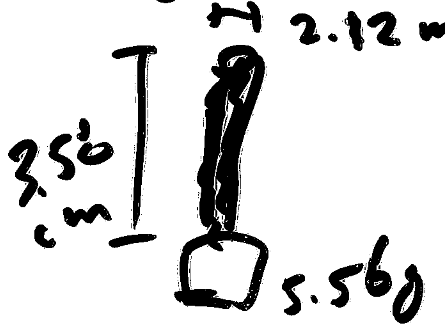
iv. Freq of nth harmonic = wavespeed ÷ λ of nth harmonic

c. Beats: $f_{beat} = |f_1 - f_2|$



Some HW problems (missed by many):

HW 20-1. A 5.56-g object is suspended from a cylindrical sample of collagen 3.58 cm long and 2.12 mm in diameter. If the object vibrates up and down with a frequency of 30.3 Hz, with is the Young's modulus of the collagen?



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

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$(2\pi f)^2 = \frac{k}{m}$$

$$k = m(2\pi f)^2$$

$$= \_\_\_\_\_\_$$

$$Y = \frac{\text{stress}}{\text{strain}}$$

$$Y = \frac{F/A}{\Delta L/L}$$ solve for F

$$F = \frac{YA}{L}\Delta L$$

$$= k$$

$F = k\Delta L$

defn of k

$$Y = \frac{kL}{A} = \frac{(\ )(.0358)}{\pi(.001\text{[illegible]})^2}$$

$$\boxed{Y = 2.04\text{E}6}$$

Answer: 2.04E06

Some clicker quizzes

Clicker quiz 1: You hear a 70 dB sound. After a while, the sound has its *intensity* increased by a factor of 100. The new decibel-level will be______________ dB.

A: 50 B: 60 C: 80 D: 90 E: 100

Clicker quiz 2: When people stand up and sit down in a stadium to perform the "wave", this is an example of what kind of wave?

A. Longitudinal
B. Circular
C. Simple Harmonic
D. Transverse

Clicker quiz 3: A mass on a spring oscillates with a certain frequency. The mass is removed, and a mass weighing 9 times as much is put on the same spring. What is the ratio of the new frequency to the old frequency? (f_{new}/f_{old} = _________)

a. 1/81
b. 1/9
c. 1/6
d. 1/3
e. 1

$\omega = \sqrt{k/m}$ $\quad f = \omega/2\pi$

$m \rightarrow 9\times$

$\omega \rightarrow \frac{1}{3}\times$

More worked problems (in exam format)

A 70 dB sound is coming out spherically from a speaker that puts out 0.5 Watts in sound power. How far away from the speaker are you? __________m

a. $\sqrt{\dfrac{0.5}{\left(10^{-5}\right)4\pi}}$

b. $\sqrt{\dfrac{0.5}{\left(10^{-7}\right)2\pi}}$

c. $\sqrt{\dfrac{0.5}{\left(10^{-7}\right)4\pi}}$

d. $\dfrac{0.5}{\left(10^{-5}\right)2\pi}$

e. $\dfrac{0.5}{\left(10^{-5}\right)4\pi}$

f. none of the above

$$dB = 10 \log I/10^{-12}$$

$$70 = 10 \log I/10^{-12}$$

$$7 = \log \frac{I}{10^{-12}}$$

$$10^{7} = \frac{I}{10^{-12}}$$

$$I = 10^{-5}\ W$$

$$I = \frac{P}{A}$$

$$10^{-5} = \frac{.5}{4\pi r^2}$$

$$r = \sqrt{\frac{.5}{(4\pi)(10^{-5})}}$$

Note: On the problem-type questions, I will only include "none of the above" as a fail-safe against my own solution being wrong. I won't intentionally make that be the answer. On the conceptual questions, however, that won't necessarily be the case.

Answer: A

A train whistle gives off a tone of 500 Hz when the train is still. What frequency will a person at the station hear as the train nears the station at a speed of 100 m/s? (Use 300 m/s as the speed of sound.)

a. 333 Hz
b. 375 Hz
c. 500 Hz
d. 667 Hz
e. 750 Hz
f. none of the above

$$f' = f\,\frac{v \pm v_o}{v \pm v_s}$$

$$= (500)\left(\frac{300}{300-100}\right)$$

$$= 500\left(\frac{300}{200}\right)$$

$$= 500\left(\frac{3}{2}\right)$$

$$= 750$$

Answer: E

Tarzan, standing on a tree branch, grabs a vine (length L) and swings on it. Approximately how long will it take him to go from his initial perch to the bottom of his swing where he is moving most quickly? (His initial angle is small.)

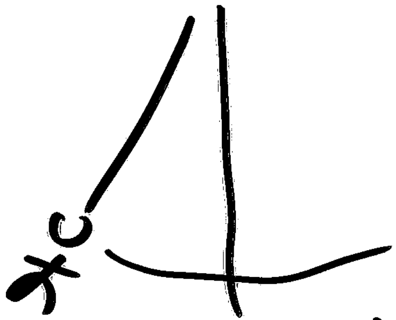
a. $\frac{\pi}{2}\sqrt{\frac{L}{g}}$

b. $\pi\sqrt{\frac{L}{g}}$

c. $2\pi\sqrt{\frac{L}{g}}$

d. $\sqrt{\frac{2L}{g}}$

e. $2\sqrt{\frac{L}{g}}$



$$t = \frac{1}{4}T$$

$$t = \frac{1}{4}\,2\pi\sqrt{\frac{L}{g}}$$

$$t = \frac{\pi}{2}\sqrt{\frac{L}{g}}$$

How would this answer change if Tarzan "pushes off" from his branch?

a. time would be longer

b. time would be shorter

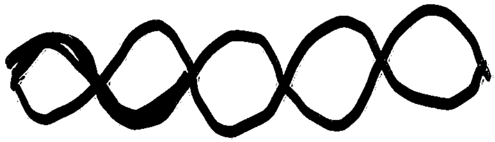
c. time would not change

Answers: A, B

A standing wave is set up in a 2.5 m length string fixed at both ends. The string vibrates in 5 distinct segments when driven at 100 Hz. (That is, the vibration has 5 anti-nodes.) What is the fundamental frequency of the string?

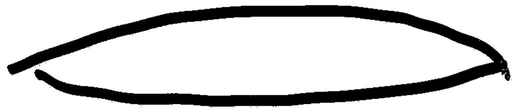
a. 20 Hz
b. 25 Hz
c. 50 Hz
d. 75 Hz
e. 100 Hz

$L = \frac{5}{2}\lambda$



100 Hz ⑤

$L = \frac{n}{2}\lambda$ $\quad L = \frac{1}{2}\lambda$



$f = ?$ ①

$\lambda_1 = 5 \times \lambda_5$

$v = f\lambda$

$f = \frac{v}{\lambda}$

$f_5 = 5 f_1$

What is the speed of the waves on the string?

a. 10 m/s
b. 20 m/s
c. 33 m/s
d. 100 m/s
e. 200 m/s

$$v = f\lambda$$
$$= (100)\left(\tfrac{2}{5} L\right)$$
$$= 100\left(\tfrac{2}{5} \cdot \tfrac{5}{2}\right)$$
$$= 100$$

Answers: A, D