Physics 123 - February 18, 2013

Exam 1 for physics 123 takes place on Feb. 28 at 8 am in B&L 106.

That exam will cover the following material:

Problem sets 1-5

Workshops 1-4

Giancoli chapters 14, 15, 16 and 36 (except for sections 14-6, 15-10, 15-11)

Griffiths relativity chapter excerpt posted on Blackboard

Lectures 1 (Jan 16) thru some point on Lect. 9 (tomorrow) I think ... will make explicit when we reach that point.

- I'll schedule a Q+A session 1 to 2 days prior to the exam

Recent meteor in Russia → Waves in action!

http://www.pcmag.com/article2/0,2817,2415492,00.asp

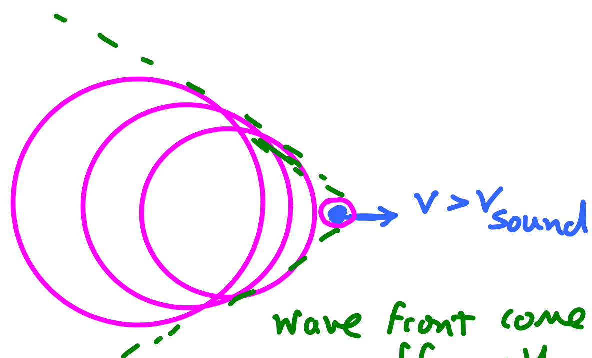
Videos ... Note the shock wave

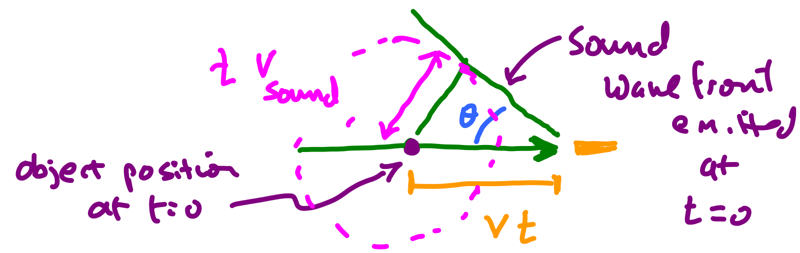
http://apod.nasa.gov/apod/astropix.html ← also see this video of coincidental near miss

Doppler Shift + Shock wave applet

http://lectureonline.cl.msu.edu/~mmp/applist/doppler/d.htm

Thanks W. Bauer
mich State U.





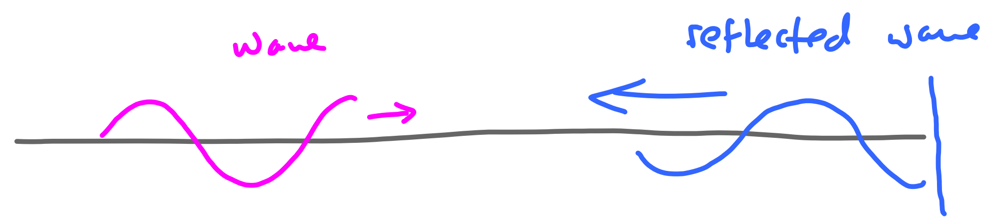
Wave front comes off with large Amplitude at characteristic Angle

$$\sin\theta = \frac{V_{sound}}{V_{object}}$$

$$\frac{t\,V_{sound}}{t\,V} = \sin\theta$$

$$\text{Mach \#} = \frac{V_{object}}{V_{sound}}$$

Last Time



Assume fixed end here

NOT necessary

$$y_1(x,t) = A\sin(kx-\omega t)$$

$$y_2(x,t) = A\sin(kx+\omega t+\phi)$$

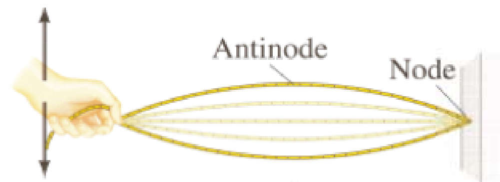
$$Y(x,t) = Y_1(x,t) + Y_2(x,t) = A\sin(kx-\omega t) - A\sin(kx+\omega t)$$

$$y(x,t) = \underbrace{\underbrace{(-2A)}_{\text{Amplitude}}\underbrace{\sin(\omega t)}_{0 \to 1 \text{ in Time}}}_{\text{Time varying amplitude}}\underbrace{\cos(kx)}_{\text{fixed form in Space, periodic in } \lambda}$$

$\boxed{\text{STANDING waves}}$

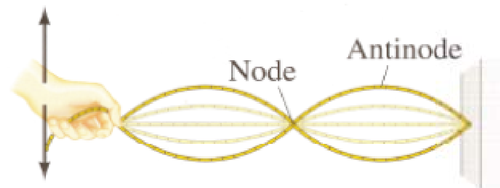
Standing waves on a string with 2 fixed ends

first harmonic $\lambda_1 = 2l, \quad f_1 = \frac{v}{2l}$



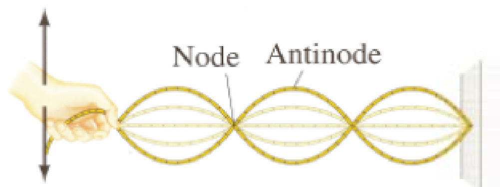
(a)

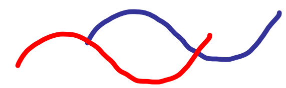
second harmonic $\lambda_2 = \frac{2l}{2}, \quad f_2 = 2\frac{v}{2l}$



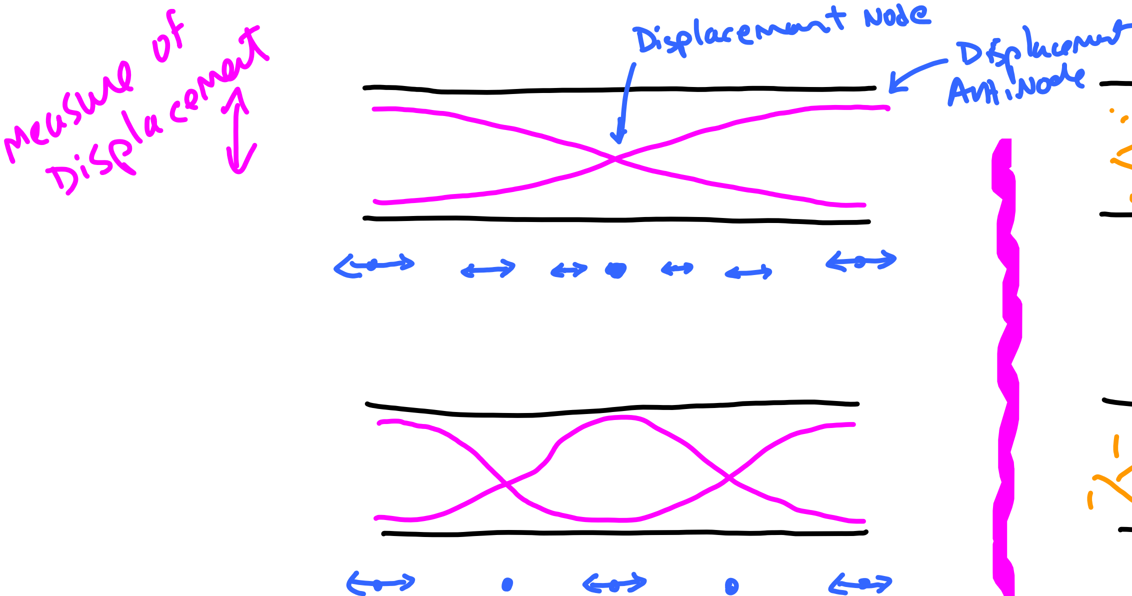
(b)

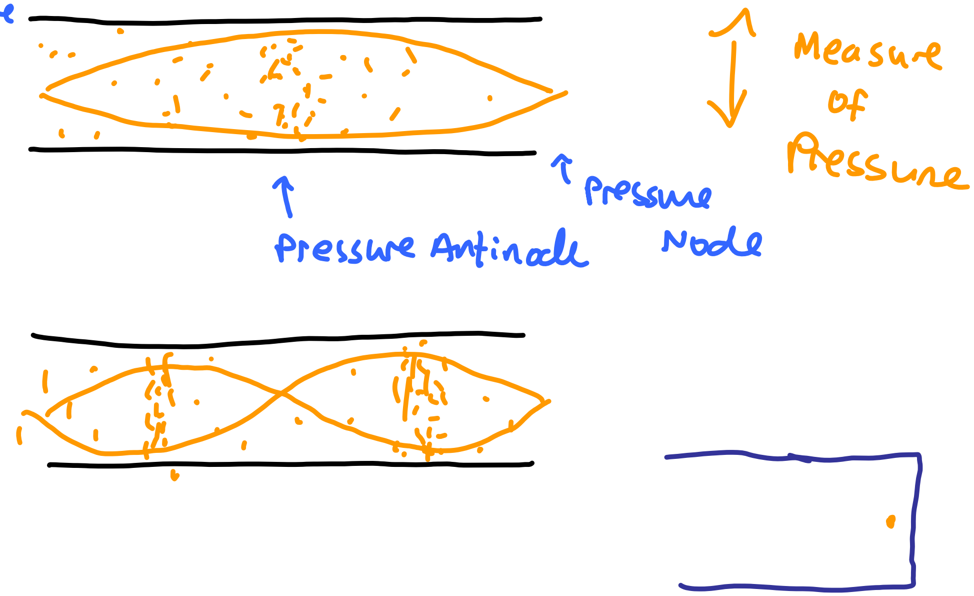
third harmonic $\lambda_3 = \frac{2l}{3}, \quad f_3 = 3\frac{v}{2l}$





Waves in Tubes or air columns (Wind instruments)





I like this way of thinking

Very similar to Transverse Displacement Diagrams for Transverse waves on String

This works, too.

But, be careful!

Sound Intensity

recall intensity = Energy/sec/m^2 = Power/m^2 = Watts/m^2

Giancoli p. 428

Human ear can detect huge range in intensity

intensity of sound in units of bel

dB , decibel

$$\beta \text{ (in dB)} = 10 \log \frac{I}{I_0} \qquad I_0 = 10^{-12}\ \text{W/m}^2$$

Convenient for the real world of human hearing.

	W/m^2	dB
Jet plane (30 m)	100	140
Pain Threshold	1	120
Busy Street Traffic	10^{-4}	80
Normal Talk (50 cm)	3×10^{-6}	65
whisper	10^{-9}	30
Threshold of hearing	10^{-12}	0

Seems a bit odd at 1st ...

Example

Shout of single fan in stadium → in center of field ~ 50 dB
What is the intensity level if 10,000 fans
shout at same level and same distance (in dB) ?

$$50\text{ dB} = 10 \log \frac{I}{I_0}$$

$$?\text{ dB} = \underbrace{10 \log \frac{10000\, I}{I_0}}_{\underbrace{10 \log \frac{I}{I_0}}_{50} + \underbrace{10 \underbrace{\log 10000}_{4}}_{40}} = \boxed{90\text{ dB}}$$

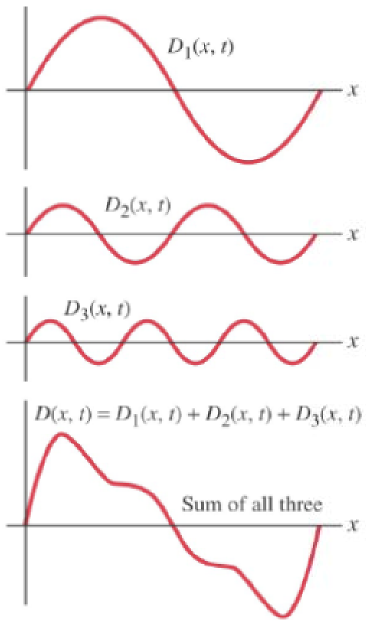
End of lecture Material for Exam !

Start of lecture Material for Exam 2

The Wave Equation is Linear
=> Superposition Principle

Fourier's theorem:

Any complex periodic wave can be written as the sum of sinusoidal waves of different amplitudes, frequencies, and phases.



in Giancoli

Conceptual Example 15-7:
Making a square wave.

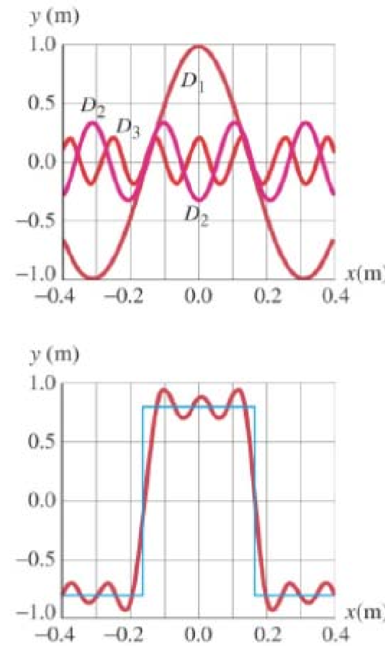
At $t = 0$, three waves are given by

$D_1 = A \cos kx$,

$D_2 = -\frac{1}{3} A \cos 3kx$,

$D_3 = \frac{1}{5} A \cos 5kx$.

(These three waves are the first three Fourier components of a "square wave.")



Fourier's Theorem (Take 2) — Any function $F(x)$ (or $f(x \mp vt)$) with a spatial period λ can be approximated to arbitrary precision by a sum of harmonic functions with wavelengths that are integral submultiples of λ, i.e, $\lambda, \frac{\lambda}{2}, \frac{\lambda}{3} \ldots$

$$f(x) = \frac{A_0}{2} + \sum_{m=1}^{\infty} A_m \cos(mkx) + \sum_{m=1}^{\infty} B_m \sin(mkx)$$

where $\frac{A_0}{2}$, A_m, B_M are constants

Finding the constants $\longrightarrow$ Fourier Analysis integrate both sides

$$\int_0^\lambda f(x)\,dx = \int_0^\lambda \frac{A_0}{2}\,dx + \int_0^\lambda \left[\sum A_m \cos mkx + \sum B_m \sin mkx\right] dx$$

$$\int_0^\lambda f(x)\,dx = \frac{A_0}{2}\lambda \longrightarrow A_0 = \frac{2}{\lambda}\int_0^\lambda f(x)\,dx$$

To find A_m and B_m $\longrightarrow$ use orthogonality of harmonic functions

$$\int_0^\lambda \sin(akx)\cos(bkx)\,dx = 0$$

$$\int_0^\lambda \begin{Bmatrix} \sin(akx)\sin(bkx) \\ \text{-or-} \\ \cos(abx)\cos(bkx) \end{Bmatrix} dx = \frac{\lambda}{2}\boxed{\delta_{ab}} = \begin{cases} \frac{\lambda}{2} & \text{when } a=b \\ 0 & \text{when } a \neq b \end{cases}$$

Kronecker Delta $\to$ 1 when $a = b$
0 when $a \neq b$

To get A_m's

mult both sides by $\cos lkx$, integrate from $0 \to \lambda$

$$\int_0^\lambda f(x)\cos(lkx)\,dx = \int_0^\lambda A_l \cos^2(lkx)\,dx$$

due to

all terms w/ $l \neq m \to 0$ on right

$$\int_0^\lambda f(x)\cos(lkx)\,dx = \frac{\lambda}{2} A_l$$

$$A_\ell = \frac{2}{\lambda} \int_0^\lambda f(x) \cos(\ell k x)\, dx$$

Similarly

$$B_\ell = \frac{2}{\lambda} \int_0^\lambda f(x) \sin(\ell k x)\, dx$$