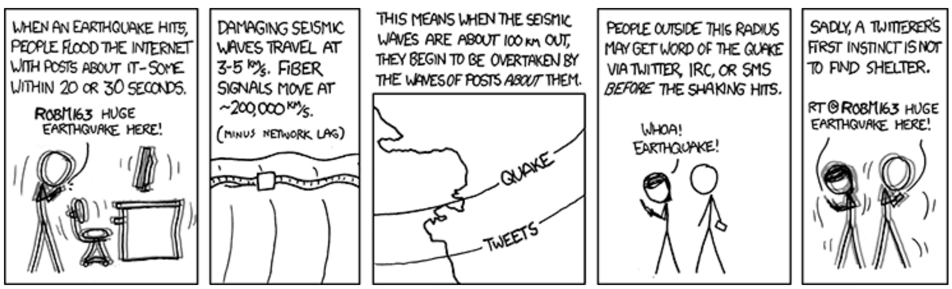
April 12, 2017 Physics 132 Prof. E. F. Redish

- **Theme Music:** **Frank Sinatra**
  Wave
- **Cartoon:** **Randall Munroe,**
  xkcd



Outline

- Go over Quiz 9
- Beats
- Standing Waves

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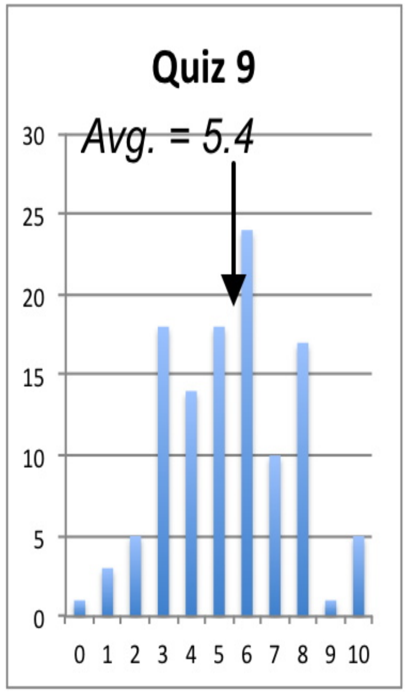
Quiz 9

	1.1	1.2	2	3.a	3.b	3.c
A	39%	2%	22%			
B	37%	1%	3%			
C	10%	45%	36%			
D	7%	51%	13%			
N	6%	2%	0%			
P				45%	3%	61%
0				1%	88%	1%
N				54%	9%	38%



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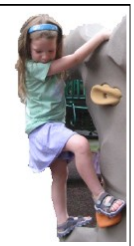
Foothold principles: Mechanical waves 2



- *Superposition*: when one or more disturbances overlap, the result is that each point displaces by the sum of the displacements it would have from the individual pulses. (signs matter)
- *Beats*: When sinusoidal waves of <u>different frequencies</u> travel <u>in the same direction</u>, you get variations in amplitude (when you fix either space or time) that happen at a rate that depends on the difference of the frequencies.
- *Standing waves*: When sinusoidal waves of the <u>same frequency</u> travel in <u>opposite directions</u>, you get a stationary oscillating pattern with fixed nodes.

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Beats

- Adding two sinusoidal oscillations with nearby frequencies leads to alternate enhancement and cancellation producing *pulses*.
  (When we do this with a space oscillations with nearby wavelengths we call the result *wave packets*.)
- This comes from the trig identity

$$\sin(a+b) = \sin a \cos b + \cos a \sin b$$

which gives

$$A\sin(\omega_1 t) + A\sin(\omega_2 t) = 2A\sin(\bar{\omega} t)\cos\left(\frac{\Delta\omega}{2}t\right)$$

$$\bar{\omega} = \frac{\omega_1 + \omega_2}{2} \qquad \Delta\omega = \omega_1 - \omega_2$$

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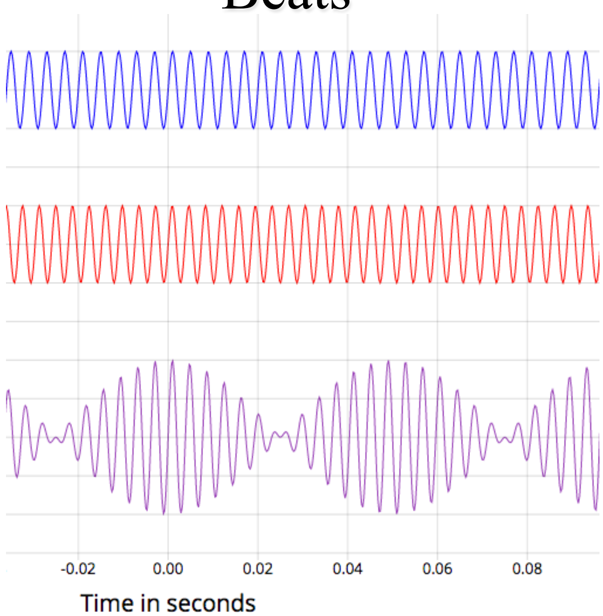
Beats



4/10/17 ***https://academo.org/demos/wave-interference-beat-frequency/***

Adding Sinusoidal Waves going in opposite directions

- Interesting things happen when we add two sinusoidal waves.

$$y = A\sin(kx - \omega t) + A\sin(kx + \omega t)$$

Using trig identities (sc+cs…) we can show

$$y = 2A\sin(kx)\cos(\omega t)$$

- For each point on the string labeled "x" it oscillates with an amplitude that depends on where it is — but all parts of the string go up and down together.

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Standing Waves

- Some points in this pattern (values of x for which $kx = n\pi$) are always 0. (NODES)
- We can tie the string down at these points and still let it wiggle in this shape. (Why???)
- To wiggle like this (all parts oscillating together) we need to have (Why???)

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

- We still have $v_0 = \omega/k$ that is $v_0 = \lambda f$

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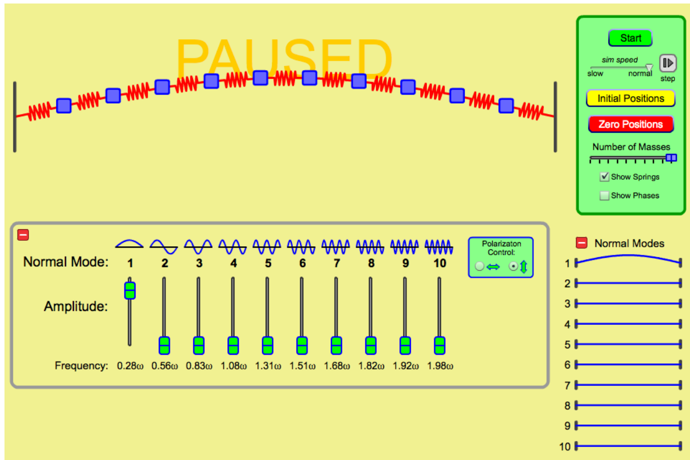
Explore with a simulation



http://phet.colorado.edu/en/simulation/normal-modes

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