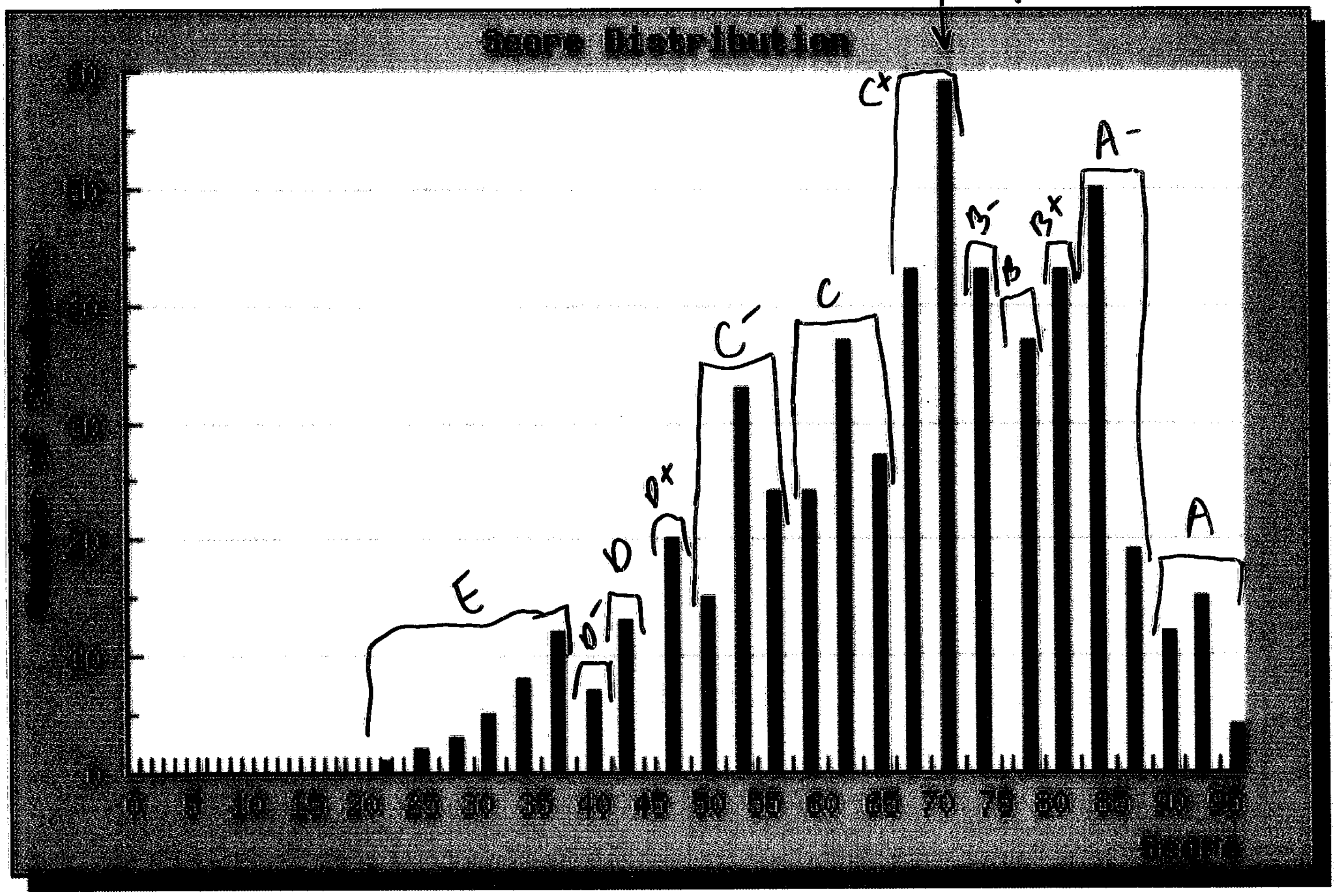
Lecture 25 Announcements

1. Exam 4 results…
   a. Exams can be picked up in the normal boxes
   b. Last page not yet graded (TA got them yesterday)
2. Final exam info
   a. Take in Testing Center any time during Finals week
   b. Four hour time limit (-1/2 point after 4:05)
   c. No calculator, no note card
   d. The first page of final with list of equations will be posted to the class website soon
   e. I plan approx 40 questions
      i. approx 10 on new stuff (Chap 13 & 14)
      ii. approx 30 on Chapters 1-12
   f. Last year's exam posted to website
      i. 71% average, 76% median, 2 hour ave time
3. **Clicker quiz:** Class survey, vote for an option
   a. Final will count 20% of grade, as in syllabus
   b. Final will count 20% of grade, plus it will replace your lowest midterm exam score (if higher), 11% of grade
      i. …but will be a little more difficult than last year's exam… ~73% median (I'll curve it up if below 70%)
4. Instructor/course evaluations due before Dec 13
   http://studentratings.byu.edu
   Please take both the ratings and the comments seriously

Physics ~~104~~ 105 – Fall 2008 – Exam 4 Results

(multiple choice only, out of 96)

Median = $\frac{71}{96}$ = 74%



A	89-96	C	58-68
A-	84-89	C-	50-58
B+	81-84	D+	46-50
B	76-81	D	42-46
B-	72-76	D-	38-42
C+	68-72	E	less than 38

Ralph is confused about pendulums. He read in the textbook that the period T of a pendulum depends on its length L and on the acceleration of gravity g,but does not depend on its mass. Ralph thinks that heavier pendulums should swing with a longer period. After all, if he puts a heavier weight on the end of the spring, it oscillates more slowly. Can you help Ralph understand this?

The masses cancel out in the mathematic equation.

Just as a feather and lead shot fall at the same acceleration in a vacuum, so do different masses on a pendulum fall at the same acceleration.

They acceleration of all objects on earth going down is the same, because the acceleration caused by gravity is 9.8 meters/s^2 for all objects, and that is what affects the oscillating of the pendulum.

$F_{gravity} \sim m$

$a = \frac{F_{net}}{m}$

m cancels

$F_{spring} = kx$

$a = \frac{F_{net}}{m}$

doesn't cancel

Which part of today's assignment was particularly hard or confusing?

What does it mean that with small amplitudes, sin(theta) almost equals theta and so "we are justified in saying that a pendulum undergoes simple harmonic motion only when it swing back and forth at very small amplitudes"?

Sin(theta) (on my calculator at least) is always less than 1. This is okay so long as the angle is less than 1 but the book is saying that this works up to about 15 degrees. I am very confused. How does this make sense?

$\sin\theta \simeq \theta$ if $\theta \lesssim 15^\circ$

in radians!

$\omega = \frac{rad}{s}$ $t = sec$

$\sin(\omega t)$

$\cos(\omega t)$

radians!

Any other comments:

Up at my Aunt's house on Thanksgiving I saw a whipped cream dispenser—they poured cream and sugar into it, closed the lid and stuck a small CO2 cartridge on it. It fluffed up the cream and was very nifty. Anyways, the reason I bring it up is that I felt the jar right after the gas went out of the cartridge and into the jar, and sure enough it was cold. Sigh, I like physics well enough but on Thanksgiving I was kind of hoping to not think about expanding gasses or energy and other physicsy things but I can't help it............

I like how the class web page lets us know what scores we have to get on the final in order to end up with an A or whatever. Will it change when I submit my extra credit?

Oh yeah, for writing an extra paper on "physics in the world around us" do we have to include statistical information and calculations, or can I just write more or a conceptual paper explaining the principles behind why something is the way it is...I am having trouble finding equations and calculations to go along with my "observation."

What kind of a write up do you need to do if you went to the planetarium? Thanks. Just to double check, is the extra credit due the last day of class?

"Simple harmonic motion"

→*Sinusoidal vibrations*

Demo: weight on spring

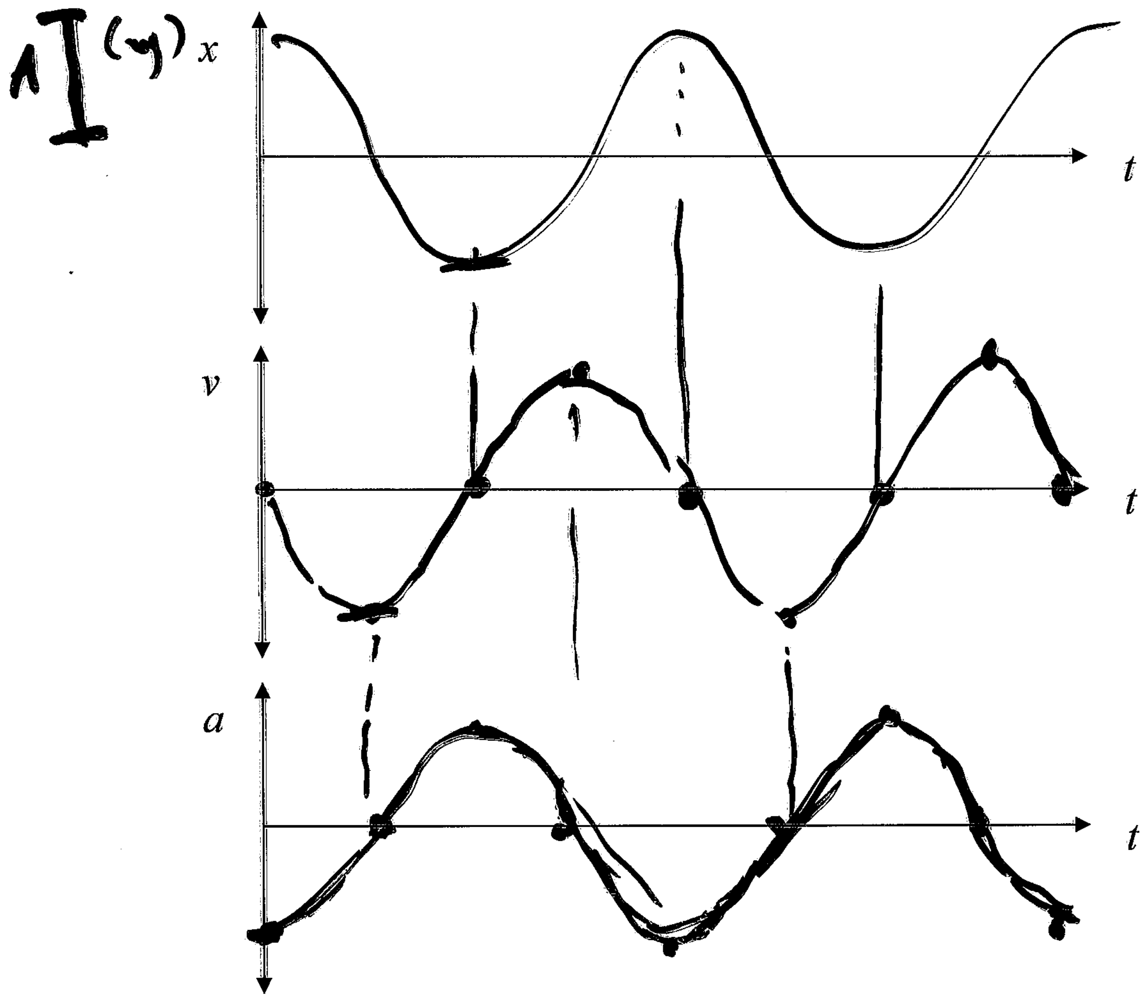
Occurs when an object has a **spring-like** restoring force:

F ~ displacement

Result: $\boxed{x=A\cos(\omega t)}$

→ or $x=A\sin(\omega t)$ or $x=A\cos(\omega t+\phi)$ ...what's the difference?

A = "amplitude", how far from origin it travels



Quick proof, using simple calculus (sorry):

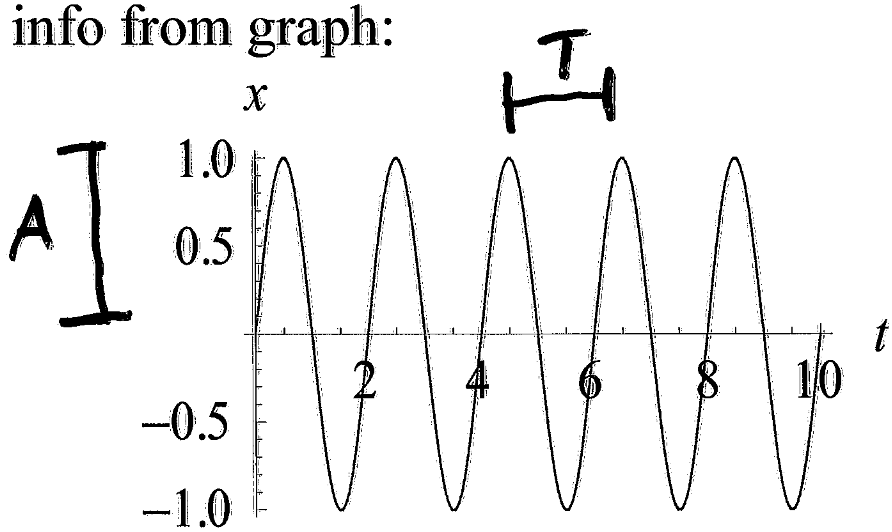
Start with F ~ -x

$x = A\cos \omega t$

$v = \frac{dx}{dt} = -A\omega \sin \omega t$

$a = \frac{dv}{dt} = -A\omega^2 \cos \omega t$

Reading info from graph:



Amplitude A= 1

Period T = 2 sec/oscillation

Frequency f = $1/T$ = .5 cycles/sec (Hz)

Angular frequency ω = $2\pi f$ rad/sec

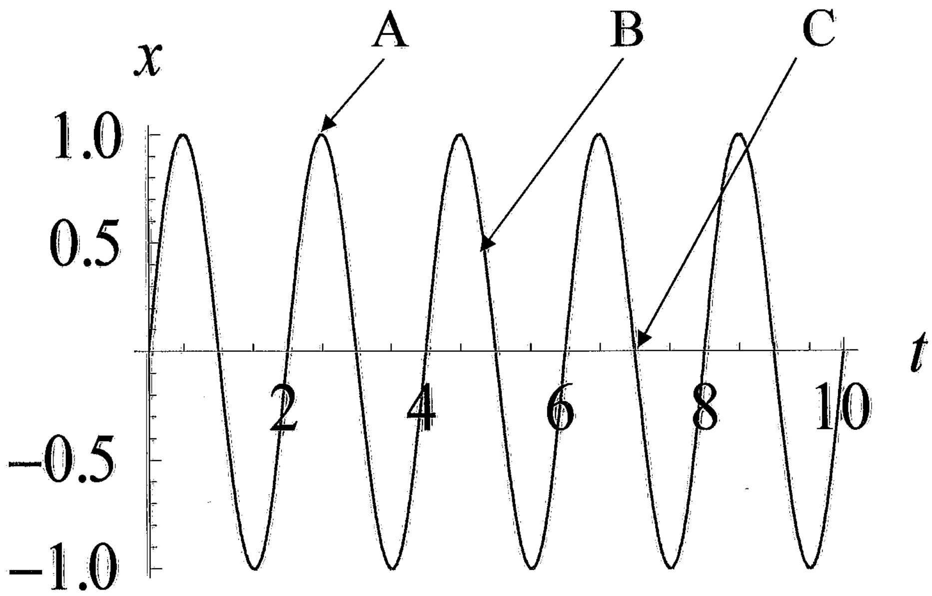
$= 2\pi(.5)$ rad/s

$$\boxed{f = \frac{\omega}{2\pi}}$$

$\omega = 2\pi f$

Angular frequency?? Where's the angle?

Demo: SHM/Circular motion analogy



Clicker quiz 1: Where does it have the most kinetic energy?

a. position A
b. position B
c. position C

speed is greatest (biggest slope)

Clicker quiz 2: Where does it have the most potential energy?

a. position A
b. position B
c. position C

$PE_{spring} = \frac{1}{2}kx^2$

Clicker quiz 3: Where does it have the largest acceleration?

a. position A
b. position B
c. position C

$a = \frac{F_{net}}{m}$

$F_{spring} = kx$

Springs

Demo: spring with mass

Frequency, period:

$$\omega = \sqrt{\frac{k}{m}}$$

$$f = \frac{1}{T}$$

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

$$f = \omega/2\pi$$

Pendulums

Demo: pendulum

Frequency, period:

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

$$\omega = \sqrt{g/L}$$

$$T = 2\pi\sqrt{\frac{1\,m}{9.8\,m/s^2}} \approx 2\,s$$

Clicker quiz: Does period depend on amplitude?

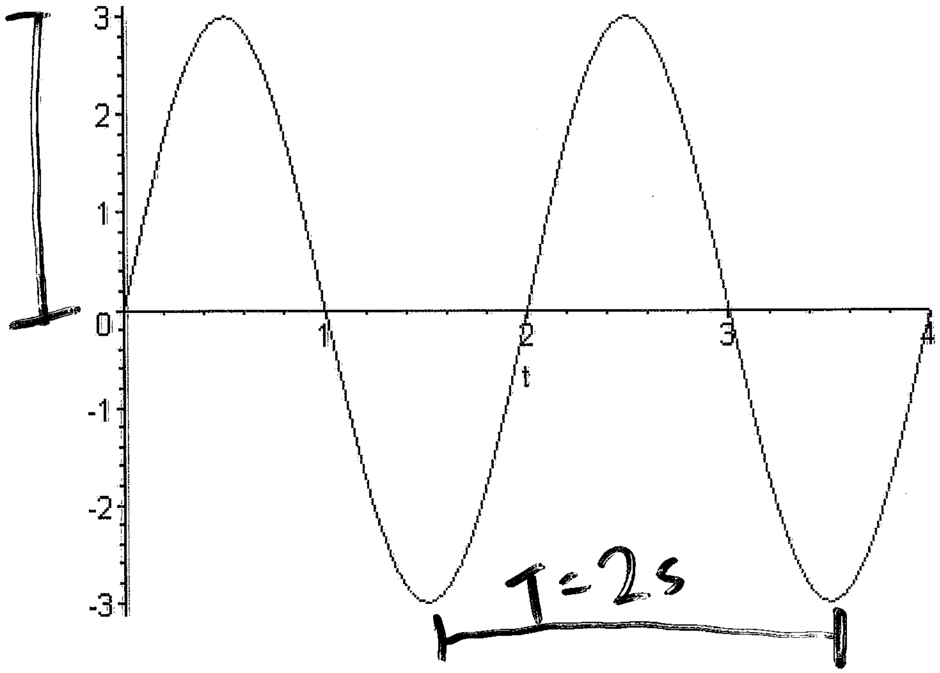
a. yes

b. no

c. it depends

if $\theta \lesssim 15°$ then No

Clicker quiz: Given the oscillation picture below,



what's the correct equation to describe the position vs. time?

~~a. $x(t) = 6 \cos(t)$~~

b. $x(t) = 3 \sin(2t)$

~~c. $x(t) = 6 \sin(2t)$~~

d. $x(t) = 3 \sin(\pi t)$

~~e. $x(t) = 3 \cos(\pi t)$~~

$A \sin \omega t$

$f = \frac{1}{T} = .5\,\text{Hz}$

$\omega = 2\pi f = 2\pi(.5) = \pi \frac{\text{rad}}{\text{s}}$

Worked Problem: A 70 kg trapeze artist swings on a long trapeze and takes 5 seconds to return to his starting spot.

How long will it take a woman of mass 50kg to make the same swing? ___5___ sec

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

How long will it take for the 70 kg man to swing from his starting place to when he first reaches the bottom?
___$\frac{1}{4}(5)$___ sec

1.25 s

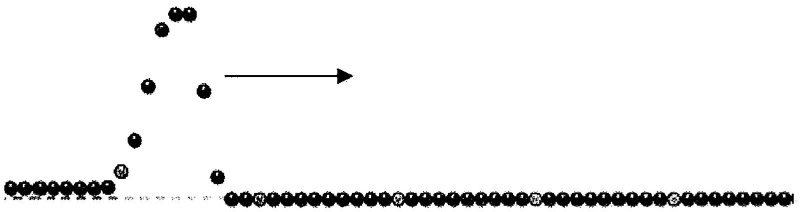
How long is the rope? ______________ m

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

$$\left(\frac{T}{2\pi}\right)^2 = \frac{L}{g}$$

$$L = g\frac{T^2}{4\pi^2} = \frac{(9.8)(5^2)}{4\pi^2} = \underline{6.2\ m}$$

Reflections



Clicker quiz: What happens when an upward pulse hits the end and turns around?

a. the wave reflects back, upward
b. the wave reflects back, downward
c. it depends

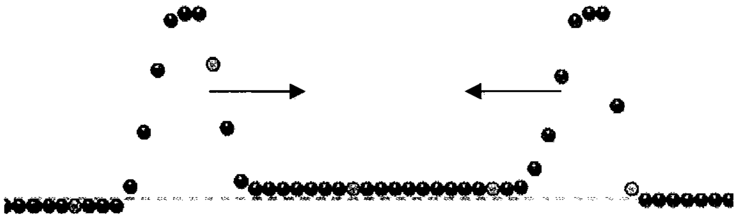
Web Demo:
http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

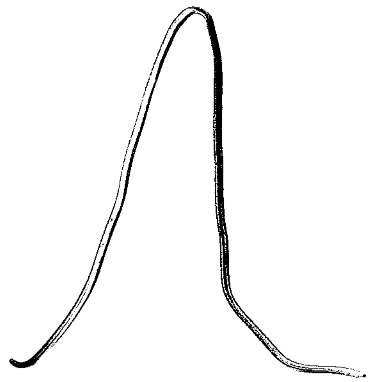
Boundaries

Rope: Light rope meets heavy rope or fixed end
~~Sound: Thin air meets dense air~~
Light: Air meets glass

In all those cases: transverse wave flips upside down

Superposition/Interference

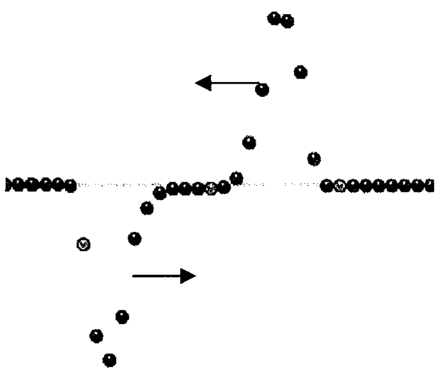




Clicker quiz: What happens if two pulses, one from each end, meet in the middle? Do they pass through or reflect back when they meet?

a) pass through
b. reflect off of each other

What about this case?



for a brief instant

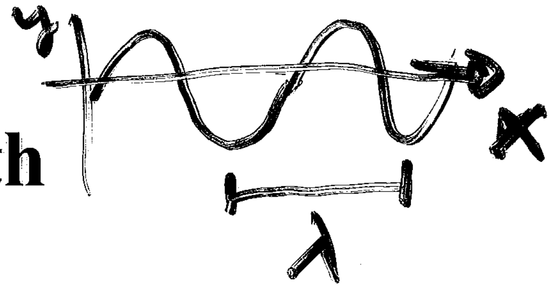
Review:

What gets transported by the wave? energy

What does the transporting? medium

λ

Speed, frequency, wavelength



m/s   ~~wave~~/s $\times$ m/~~wave~~

m/s

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

Worked Problem: AM 1320 broadcasts the Utah Jazz games ☺ at a frequency of 1320 kHz. Radio waves travel at the speed of light, 3×10^8 m/s. (a) What is the wavelength of the AM1320 radio waves? (b) What is the period?

$f = 1320$ kHz

$v = 3 \cdot 10^8$ m/s

$$\lambda = \frac{v}{f} = \frac{3 \cdot 10^8 \text{ m/s}}{1320 \cdot 10^3 \ 1/\text{s}} = \underline{227.3} \text{ m}$$

$$T = \frac{1}{f} = \frac{1}{1320 \cdot 10^3 \ \frac{1}{\text{s}}} = 7.6 \cdot 10^{-7} \text{ s}$$

What will changing the **tension** do?

(Web demo, continued)

$$v = \sqrt{\frac{T}{\mu}}$$ For waves on a rope/string/etc

tension

"linear mass density" = $\frac{\text{mass}}{\text{meter}}$

(book uses symbol *F* for tension)

What happens when you increase the wave speed while keeping the wavelength constant?

f increases

Demo: violin

$v = f\lambda$

Review problems

Clicker quiz: Two guitar strings of the same length have the same tension, but one has four times the mass of the other. The speed of a wave on the heavier guitar string is ___________ that of the lighter string.

a. ¼
b. ½
c. the same as
d. 2×
e. 4×

$v = \sqrt{T/\mu}$

$\mu \rightarrow 4x$

$v \rightarrow \frac{1}{2}$

Clicker quiz: A boy shakes a rope, moving his hand up and down. He sends a wave crest out every 0.5 seconds. He sees the wave crests move away with a distance between them of 25 cm. How fast is the wave moving?

a. 0-10 cm/s
b. 10-20 cm/s
c. 20-30 cm/s
d. 30-40 cm/s
e. more than 40 cm/s

$T = .5s$

$f = \frac{1}{T} = 2Hz$

$\lambda = .25m$

$v = f\lambda$

$= (2)(.25) = .5\ m$