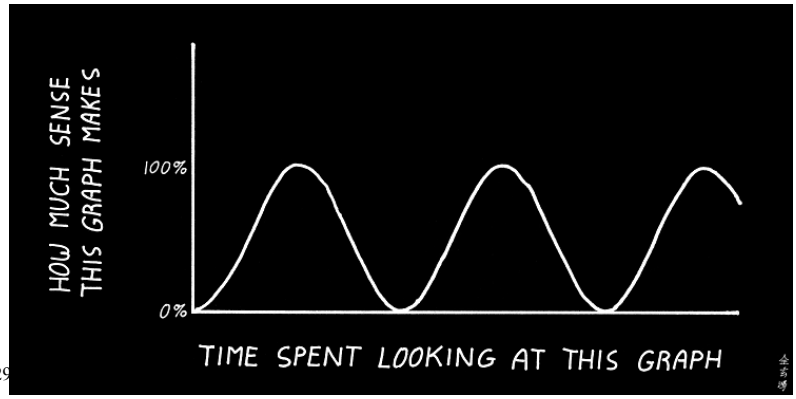
March 29, 2017 Physics 132 Prof. E. F. Redish

- **Theme Music:** **R.E.M.**
  What's the Frequency, Kenneth?
- **Cartoon:** ***Abstruse Goose***



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Outline

- Go over Quiz 7
- Discuss makeup exam
- Recap: The math of oscillations
- The hanging mass
- The pendulum
- Oscillations and circular motion

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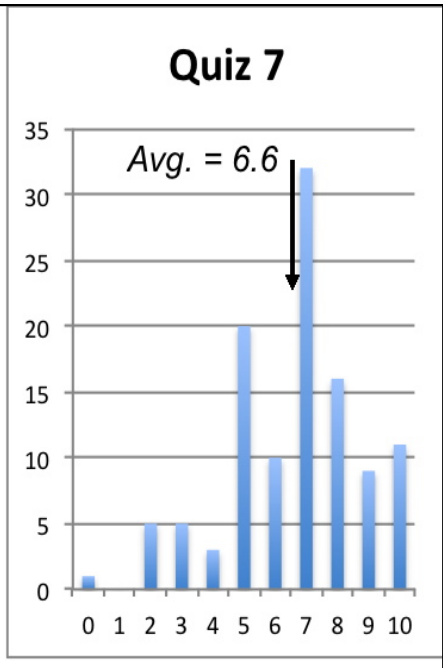
Quiz 7

	1		2		3
C	71%	A	4%	1	26%
A	4%	B	42%	2	34%
E	13%	C	5%	3	29%
F	52%	AB	0%	4	4%
B	0%	AC	8%	5	1%
D	27%	BC	39%		



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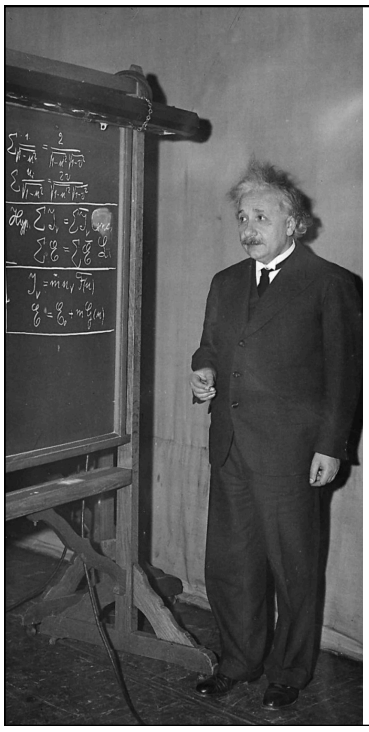

The Equation of the Day

The Harmonic Oscillator

$$\frac{d^2x}{dt^2} = -\omega_0^2 x$$

$$x(t) = A\cos(\omega_0 t + \phi)$$

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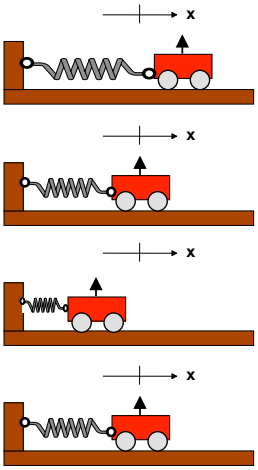
Tracking the motion



x	F^{net}	a	v

Mathematical structure

- Express $a = F^{net}/m$ in terms of derivatives.

$$\frac{d^2x}{dt^2} = -\omega_0^2 x$$

- Except for the constant, this is like having a functions that is its own second derivative.

$$\frac{d^2f}{dt^2} = -f$$

- In calculus, we learn that sin(t) and cos(t) work like this. How about: $x = \cos t$?

Interpreting the Result

- We can easily take the derivatives to show that our solution $x(t) = A\cos(\omega_0 t)$ satisfies the N2 equations
- What do the various terms mean?
  - A is the maximum displacement — the *amplitude*.
  - What is ω_0? If T is the *period* (how long it takes to go through a full oscillation) then

$$\omega_0 t : 0 \rightarrow 2\pi$$
$$t \quad : 0 \rightarrow T$$
$$\omega_0 T = 2\pi \quad \Rightarrow \quad \omega_0 = \frac{2\pi}{T}$$

  - $1/T$ is called the *frequency* and the unit 1/second = Hertz.

$$f = \frac{1}{T} \qquad \omega_0 = 2\pi f$$

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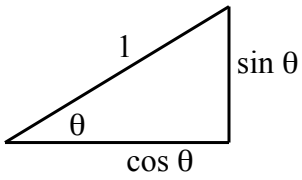
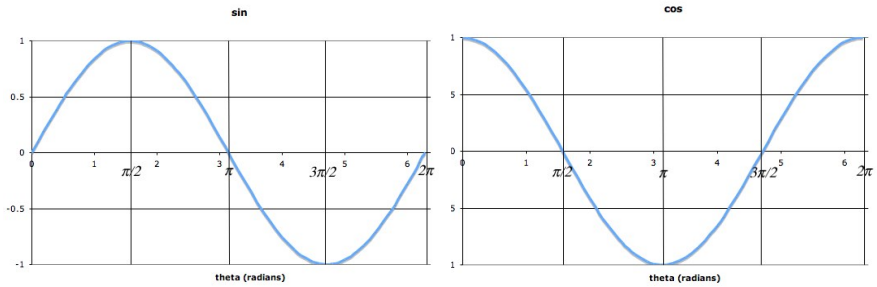
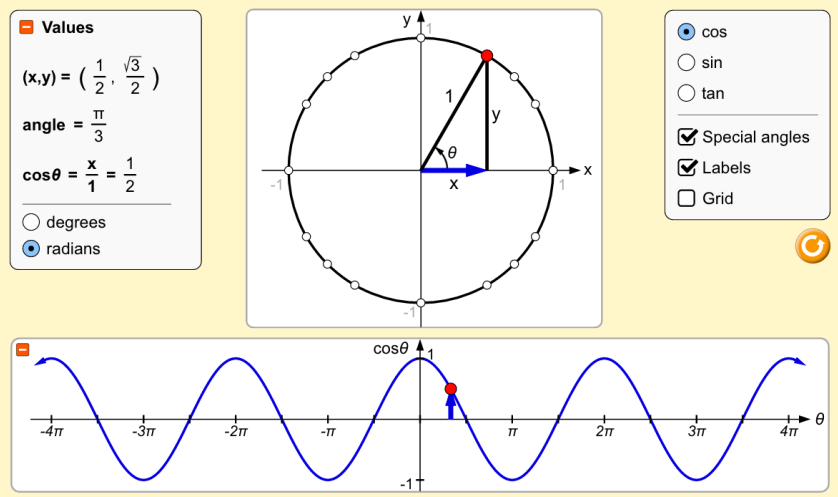
Graphs: sin(θ) vs cos(θ)

- Which is which? How can you tell?
- The two functions sin and cos are derivatives of each other (slopes), but one has a minus sign. Which one? How can you tell?





PhET sim: Trig Tour



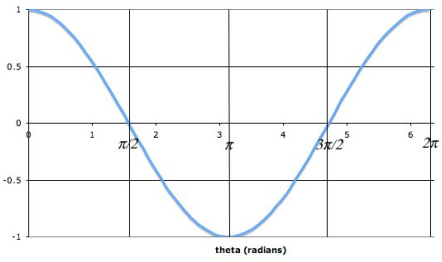
3/27/17 *https://phet.colorado.edu/en/simulation/trig-tour* **9**

Graphs: sin(θ) vs sin($\omega_0 t$)

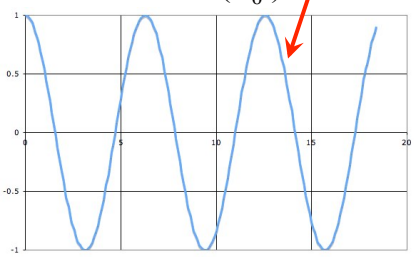
- For angles, θ = 0 and θ = 2π are the same so you only get one cycle.
- For time, *t* can go on forever so the cycles repeat.

What does changing ω_0 do to this graph?

cos(θ)

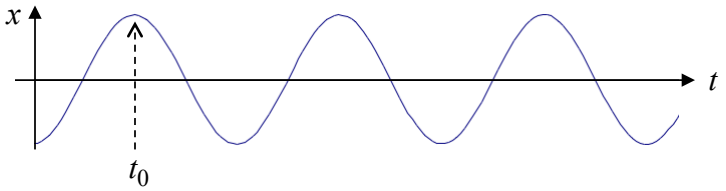


cos($\omega_0 t$)



Interpreting the Result

- What about the starting point?
  Using cos means you always start at a peak when $t = 0$. That might not always be true.



$$x(t) = A\cos(\omega_0(t - t_0))$$
$$= A\cos(\omega_0 t - \omega_0 t_0) = A\cos(\omega_0 t - \phi)$$

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