March 28, 2013 Physics 132 Prof. W. Losert

Outline

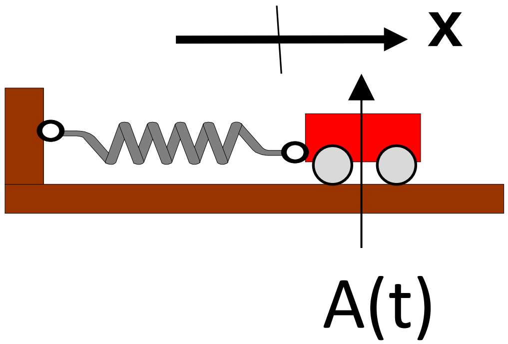
Oscillations and Waves

Office hours Thursday 4/3: 3-4.30

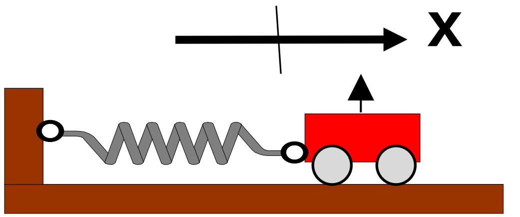
Learning about Oscillations and waves

- Why to learn it
  - How the ear senses sound
  - Sound itself
  - Brain waves
  - Heart contraction waves
  - Molecule oscillations
- What to learn
  - How to describe oscillations mathematically (sin, cos)
  - How to think about waves
  - Resonances

- Position of the cart depends on time t
- Lets call the x position of the cart: A(t)



Doing the Math: The Equation of Motion



- Newton's equation for the cart is

$$a = {F_{net}}/{m} = {-kA(t)}/{m} = -\left(\frac{k}{m}\right)A(t)$$

- What kind of a quantity is k/m? (i.e. what is its "Dimension"

$$\left[\frac{k}{m}\right] =$$

Mathematical structure

- Express *a* as a derivative of A(t).

$$\frac{d^2 A(t)}{dt^2} = -\omega_0^2 A(t)$$

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

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

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

- How do we define A=0 ?
  1. The origin (where A=0) is chosen at the initial state of the spring
  2. The origin is chosen at the unstretched state of the spring
  3. The origin can be chosen arbitrarily

- How do we define t
    1. t=0 is chosen at the initial state of the spring
    2. t=0 is chosen when the string is not stretched.
    3. t=0 can be chosen arbitrarily

Interpreting the Result

- We'll leave it to our friends in math to show that these results actually satisfy the N2 equations.
- What do the various terms mean?
  - A_{max} is the maximum displacement — the *amplitude* of the oscillation.
  - What is ω_0? If T is the *period* (how long it takes to go through a full oscillation) then

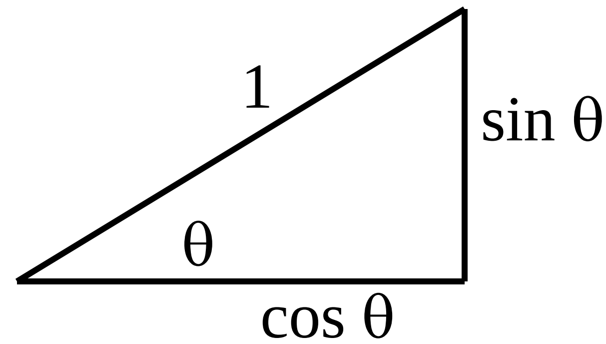
$$\omega_0 t : 0 \to 2\pi$$

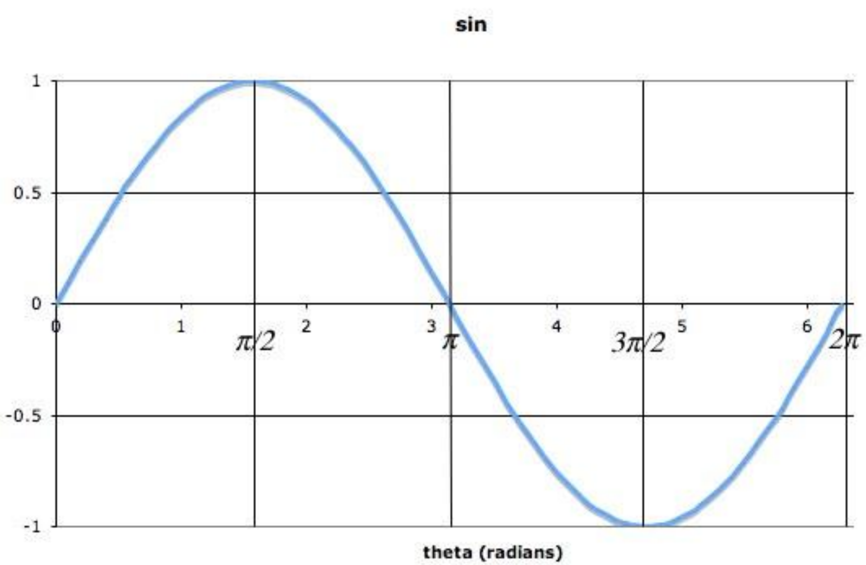
$$t \quad : 0 \to T$$

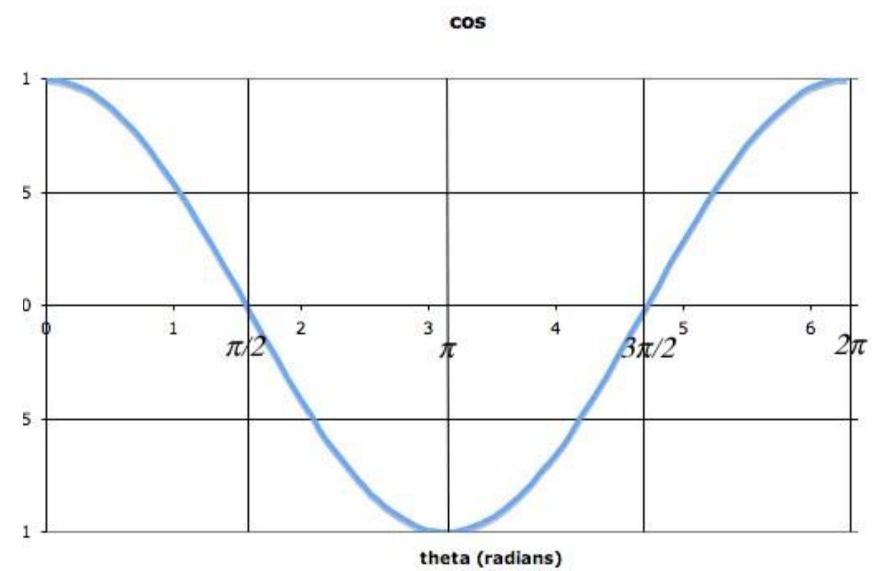
$$\omega_0 T = 2\pi \quad \Rightarrow \quad \omega_0 = \frac{2\pi}{T}$$

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?





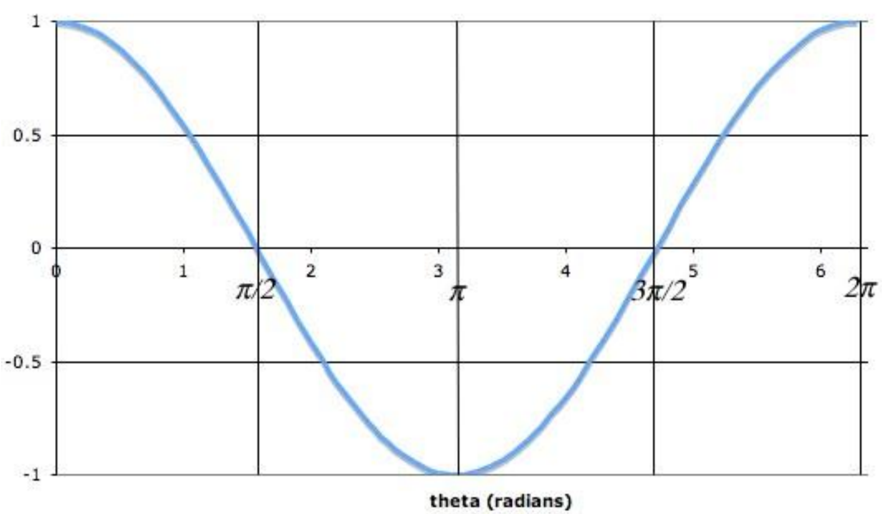


Graphs: sin(θ) vs sin(ω_0t)

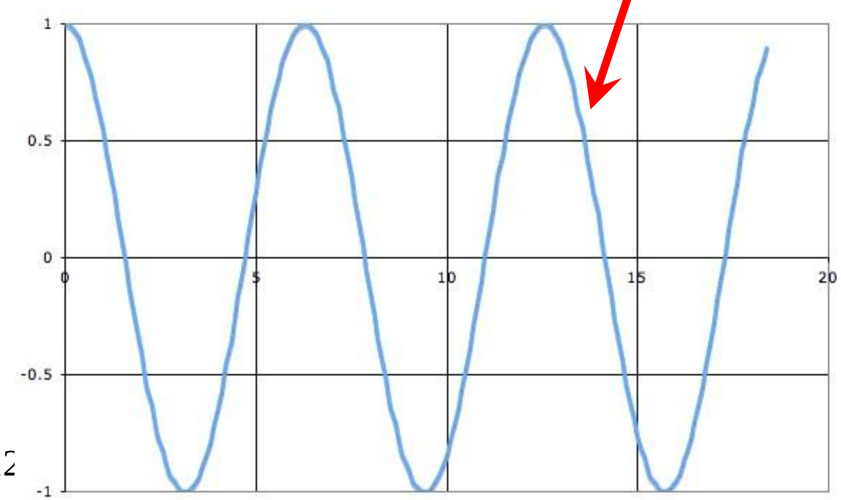
- For angles, θ = 0 and θ = 2π are the same so you only get one cycle.
- For time, *t* can go on forever so the cycles repeat.

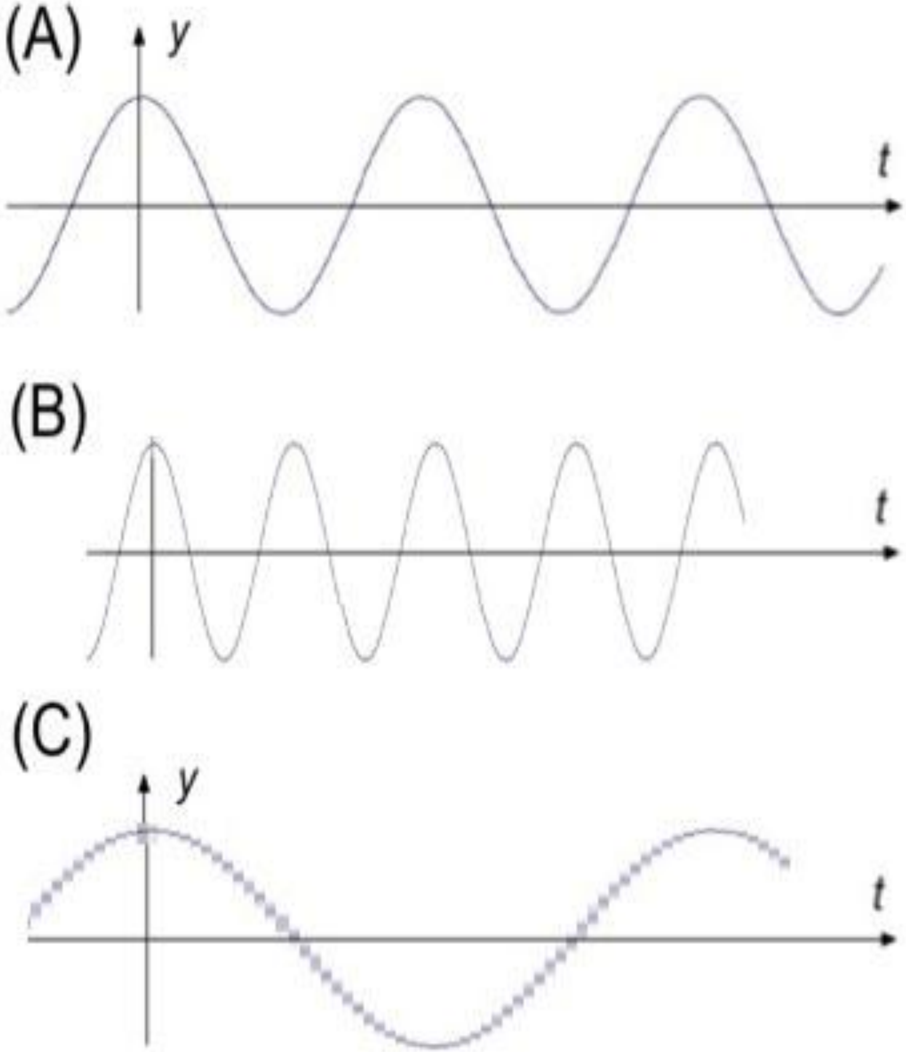
What does changing ω_0 do to this graph?

cos(θ)



cos($\omega_0 t$)





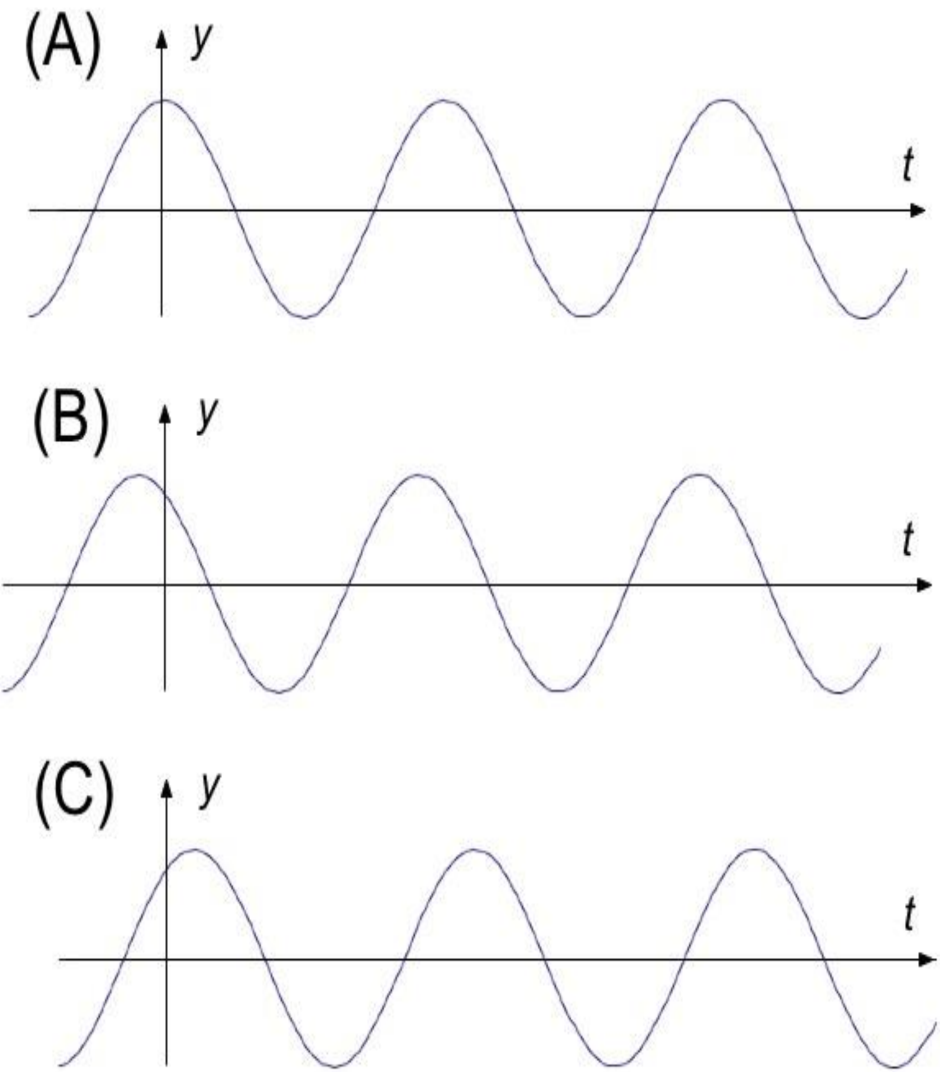
If curve (A) is

$$A\cos(w_0 t)$$

which curve is

$$A\cos(2w_0 t)?$$

1. (A)
2. (B)
3. (C)
4. None of the above.



Which of these curves is described by

$$A\cos(w_0 t + f)$$

with $\phi > 0$ (and $\phi << 2\pi$)?

1. (A)
2. (B)
3. (C)
4. None of the above.