Announcements

- Homework
  - Webwork due on Wednesday
  - I will also be opening up old WebWorK assignments for the partial credit until the date of the final. If you have missed some throughout the semester, this will be your chance to make up some points.
- Optimistically, I'd love to have Test 3 results back to you by Friday. Realistically, hopefully by next Monday
- Last physics lab (of your life?!) this week!
- This week we are in Supplementary Material 3, which can be found here.
- Polling: `rembold-class.ddns.net`

Review Question!

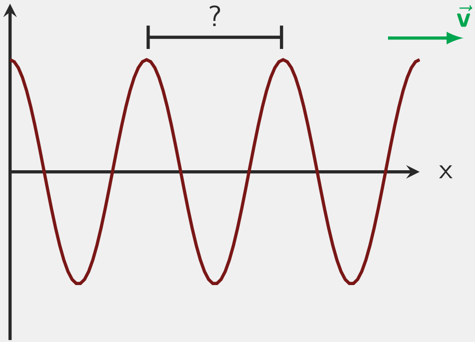
The wave to the right is traveling to the right at 30 m/s. It has a period of 5 ms. What is the length of the shown distance?

A. 167 µm

B. 15 cm

C. 150 m

D. 6 km



Solution: 15 cm

Two Sides of a Coin

- Light, or any traveling wave, varies is both space *and* time
  - If either one is held constant, we still get a wave
  - A mathematical description must include both pieces
  - For a wave moving in the positive x direction:

$$E = E_{peak} \cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda}\right)$$

  - The sign and variable of the spacial term determines direction of travel

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- Often simplified as

$$f(x,t) = A\cos(\omega t - kx)$$

  - A is the amplitude of the wave
  - ω is the usual angular frequency
  - k is the wavenumber and equal to $\frac{2\pi}{\lambda}$

Mathematical Wave Example

Determine the direction and speed of the below (non-electromagnetic) wave:

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$$20 = \frac{2\pi}{T} \quad \Rightarrow \quad T = \frac{2\pi}{20} = \frac{\pi}{10} = 0.314\,\mathrm{s}$$

$$0.5 = \frac{2\pi}{\lambda} \quad \Rightarrow \quad \lambda = \frac{2\pi}{0.5} = 4\pi = 12.57\,\mathrm{m}$$

$$v = \frac{\lambda}{T} = \frac{12.57}{0.314} = 40\,\mathrm{m/s} \text{ in the negative z direction}$$

Getting Intense

- Saw that with electromagnetic waves:

$$S \propto E^2$$

- This same relation holds for all waves: Intensity is proportional to amplitude squared:

$$I \propto A^2$$

  - Like the Poynting vector, units of intensity are $\mathrm{W/m^2}$.
- For light, intensity $\rightarrow$ brightness
- For sound, intensity $\rightarrow$ loudness
- Intensity depends on amplitude, not frequency or wavelength

Going through a Phase

- Cosine assumes our wave starts at a peak
- In general, the wave could start anywhere along its path
- Need a way to shift the wave back and forth:
  - Via a phase constant
    $$f = A\cos(\omega t - kx + \phi_0)$$
  - Measured in radians
  - Tells you where your wave began in its cycle

Understanding Check

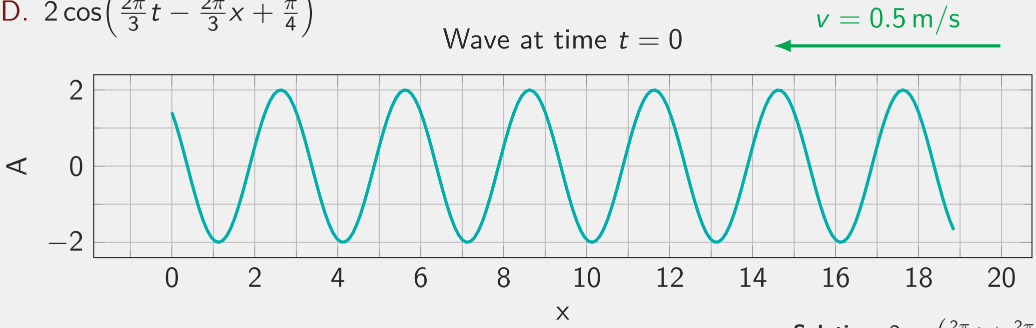
Which equation best describes the wave below?

A. $2\cos\left(\frac{2\pi}{6}t - \frac{2\pi}{3}x - \frac{\pi}{4}\right)$

B. $2\cos\left(\frac{2\pi}{6}t + \frac{2\pi}{3}x + \frac{\pi}{4}\right)$

C. $2\cos\left(\frac{2\pi}{3}t + \frac{2\pi}{6}x - \frac{\pi}{4}\right)$

D. $2\cos\left(\frac{2\pi}{3}t - \frac{2\pi}{3}x + \frac{\pi}{4}\right)$



Solution: $2\cos\left(\frac{2\pi}{6}t + \frac{2\pi}{3}x + \frac{\pi}{4}\right)$

Adding Waves

- In general, waves from a source may be:
  - Unpolarized:electromagnetic radiation with electric fields in all directions
  - Incoherent: waves of all different phases output
  - Chromatic: waves with a combination of different wavelengths
- To talk about how waves add, we need to eliminate all these variables:
  - Focus (a light pun!) on polarized, coherent, monochromatic light
  - Think laser light
- Waves follow the superposition principle, so their amplitudes will add at a given location at a given time

When Waves Meet

- The result of two waves meeting depends on the state of the two waves at that point in time
  - Both positive? A very strong positive addition
  - Both negative? A very strong negative addition
  - One positive and one negative? They will largely cancel one another out
- When waves add to form larger amplitudes: constructive interference
- When waves add to form smaller amplitudes: destructive interference