Physics 2C 1/9/20

& clicker reg!

(1) Clarifications, website password, etc.
(2) Buoyancy & Archimedes' Principle
(3) Continuity Equation
(4) Bernoulli's Equation
(5) Waves - Overview

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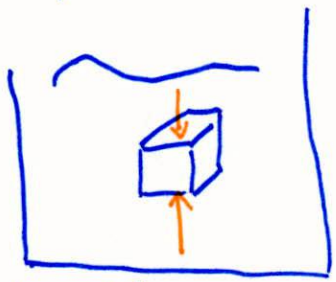
(2) Buoyancy   When does something float?

- a submerged object feels a <u>buoyant</u> force from surrounding fluid
- arises due to difference in pressure at bottom vs. top



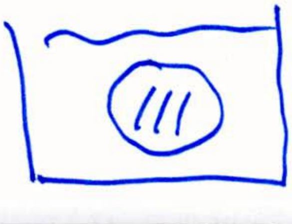
How big?

Archimedes' Principle
$$\boxed{F_{buoy} = \rho_{\substack{\text{surrounding}\\\text{fluid}}}\, g\, V_{displaced}}$$

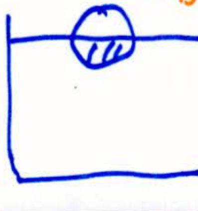
The surrounding water pushes up w/ exactly the same force it would if there were water there! (the water doesn't "know" there's a different object there)

What is $V_{displaced}$?

$F_{buoy} > m_{obj}\, g \Rightarrow$ Float!
$F_{buoy} < m_{obj}\, g \Rightarrow$ Sink!



$V_{disp} = V_{obj}$



$V_{disp} \neq V_{obj}$

2

7. Blocks a, b, and c in **FIGURE Q14.7** have the same volume. Rank in order, from largest to smallest, the sizes of the buoyant forces F_a, F_b, and F_c on a, b, and c. Explain.

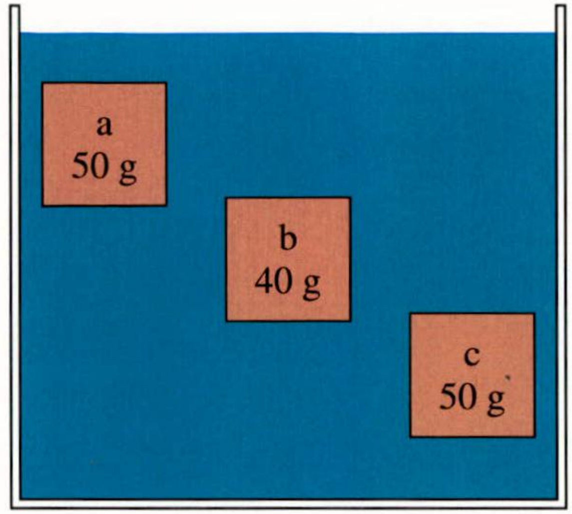


FIGURE Q14.7

(A) $F_a > F_b > F_c$

(B) $F_c > F_b > F_c$

(C) $F_a = F_c > F_b$

(D) All same

$F_{buoy} = \rho_{water}\, g\, \underline{V_{disp}}$

same for all!

9. The two identical beakers in **FIGURE Q14.9** are filled to the same height with water. Beaker B has a plastic sphere floating in it. Which beaker, with all its contents, weighs more? Or are they equal? Explain.

which weighs more water or ball ?

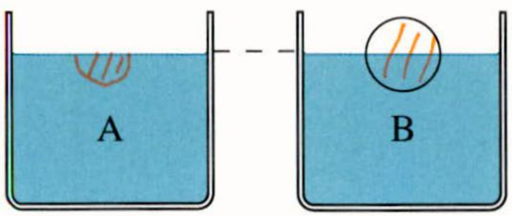


FIGURE Q14.9

$m_{ball}\, g = F_{buoy}$

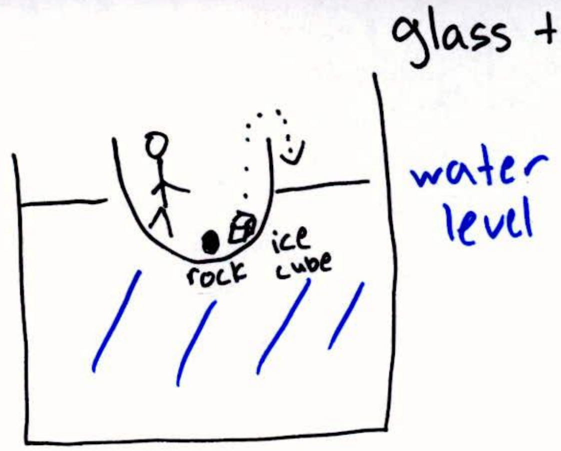
$F_{buoy} = \rho_{water} V_{disp}\, g$

$\Rightarrow m_{ball} = \rho_{water} V_{disp} = m_{water,\,disp}$

(A) A

(B) B

(C) Same weight



What happens to the water level when you throw ice overboard

(A) rises

(B) falls

(C) stays same

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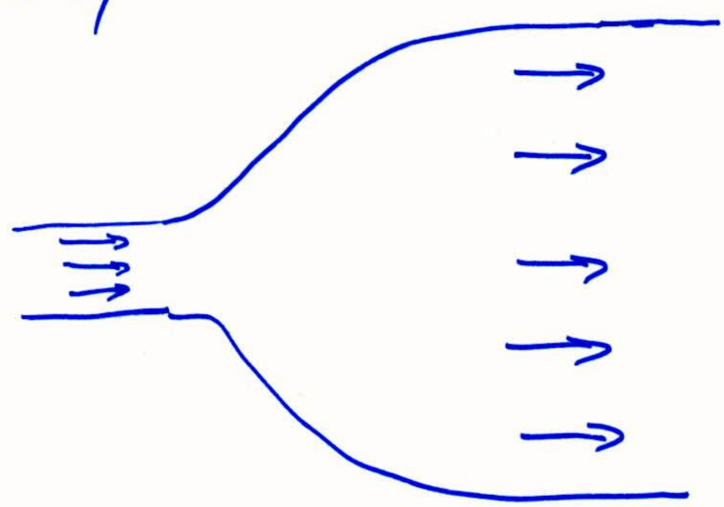
3 Continuity



$$v_1 A_1 = v_2 A_2$$

(why? because incompressible = volume stays same)

$V_1 = A_1 v_1 \Delta t$ (enters)

$V_2 = A_2 v_2 \Delta t$ (leaves)

The Mississippi River seems to speed up from 2 m/s to 4 m/s with no apparent change in width. What can you infer about the depth? (4)

(A) decreased to $\frac{1}{4}\times$ the initial depth

(B) decreased to $\frac{1}{2}\times$ the initial depth

(C) increased to $2\times$ the initial depth

(D) increased to $4\times$ the initial depth

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(4) Bernoulli's Equation

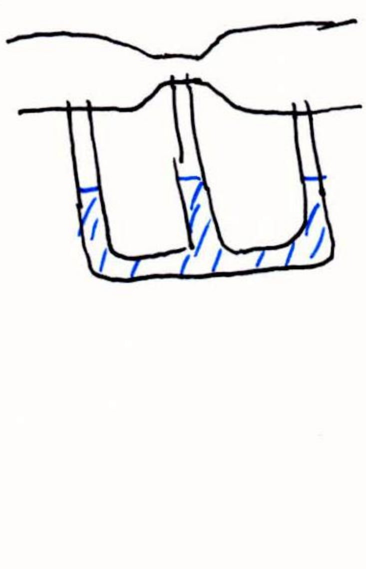
pressure, speed, height (increases ↑), density

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

proof

- relies on same streamline
- consequense of conservation of energy

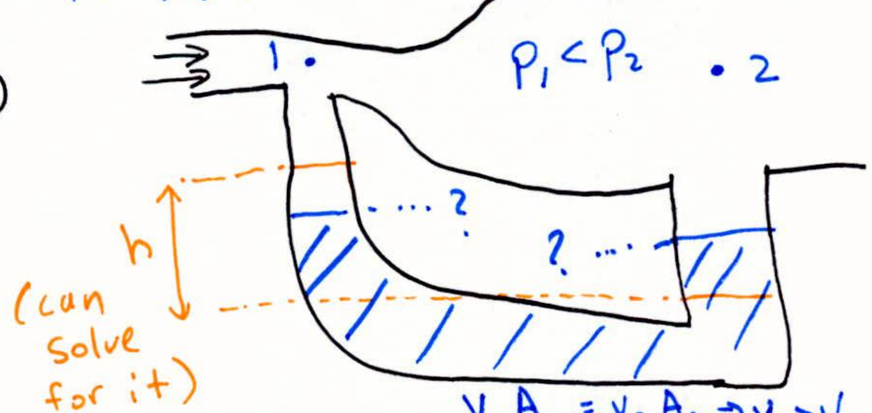
Venturi tube demo



← What happens to center fluid as you start blowing air?

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

An incompressible gas moves through the following air tube. How does the water level compare for the 2 columns?



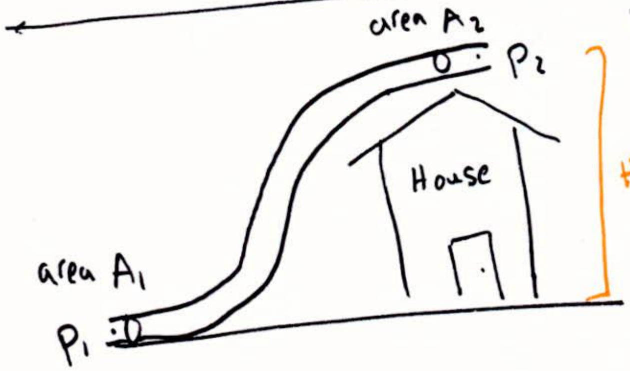
$V_1 A_1 = V_2 A_2 \Rightarrow V_1 > V_2$

(A) The water level on the left is higher

(B) The water level on the right is higher

(C) The two water levels are the same

Water is flowing up this tube from the ground to the roof. P_1 and P_2 are points in the tube.



Is it possible for the pressure @ these two points to be equal?

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g H$

(A) Yes, if $A_1 > A_2$

(B) Yes, if $A_2 > A_1$

(C) No, that's impossible

If $P_1 = P_2$

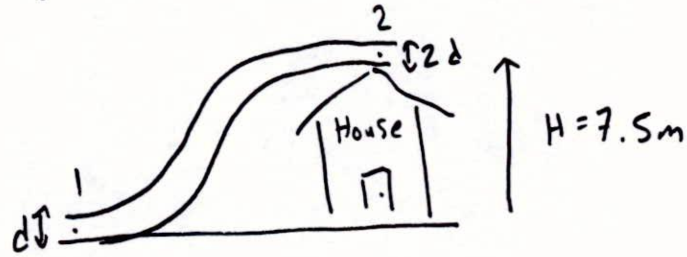
$\frac{1}{2}\rho v_1^2 = \frac{1}{2}\rho v_2^2 + \rho g H$

$\Rightarrow v_1 > v_2$

$\Rightarrow A_2 > A_1$

Assume the tube doubles in diameter, and the roof is 7.5 m above the ground. How fast is the water moving when it gets to the roof?

$P_1 = P_2$ as before



$$v_1 = 4v_2$$

$$\cancel{P_1} + \frac{1}{2}\rho v_1^2 + \cancel{0} = \cancel{P_2} + \frac{1}{2}\rho v_2^2 + \rho g H$$

$$\frac{1}{2}\cancel{\rho}(16 v_2^2) = \frac{1}{2}\cancel{\rho} v_2^2 + \cancel{\rho} g H$$

$$\frac{15}{2} v_2^2 = gH \Rightarrow v_2 = \sqrt{\frac{2gH}{15}}$$

$$= 3.1 \text{ m/s}$$

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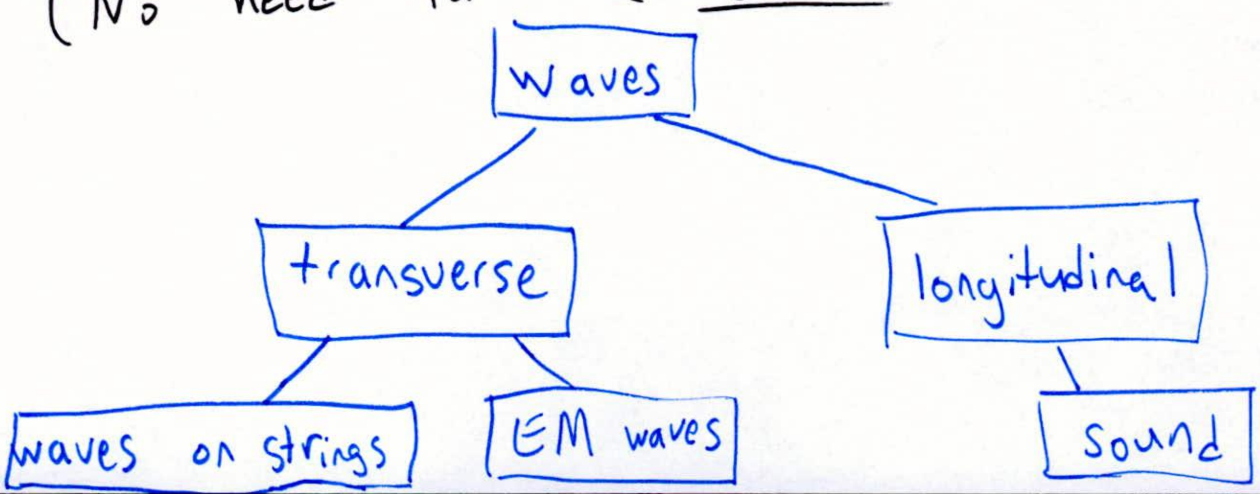
5 What is a wave?

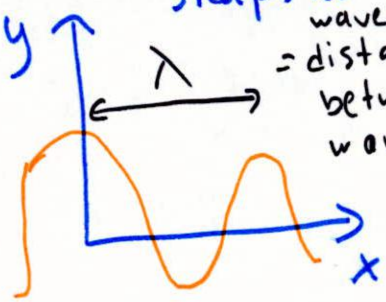
wave: The propagation of energy over long distances w/o the net transport of matter

(No need for a medium - textbook is wrong!)



Pictorially

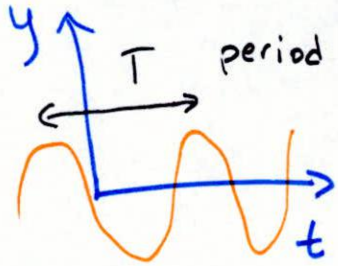
"snapshot"



wavelength = distance between wave crests

(A)

"history"



period, $f = \frac{1}{T}$ frequency

(B)

which graph could you get λ from?

~~Mathe~~

k : "wave number" $k = \frac{2\pi}{\lambda}$

ω : "angular frequency" $\omega = 2\pi f$

To go from spatial domain to time domain need wave speed $\boxed{v = \lambda f = \frac{\omega}{k}}$

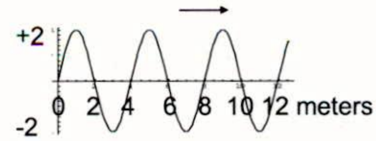
Mathematically

wave "amplitude" (disturbance) is a ~~2D~~ function of (x, t)

$$\boxed{y(x,t) = A\cos\left[kx \mp \omega t + \phi_0\right]}$$

(3 clicker questions)

The following is a snapshot at t=0 for a transverse wave traveling ***to the right*** with velocity 2 m/s. Which of the following equations is correct for this wave?



1. $y(x,t) = 2\sin\left[\left(\frac{\pi}{2}\right)x - (\pi)t\right]$
2. $y(x,t) = 2\sin\left[(\pi)x - \left(\frac{\pi}{2}\right)t\right]$
3. $y(x,t) = 2\sin\left[\left(\frac{\pi}{2}\right)x - \left(\frac{\pi}{2}\right)t\right]$
4. $y(x,t) = 2\sin[(\pi)x - (\pi)t]$
5. **None of the above.**

$\lambda = 4\ m$

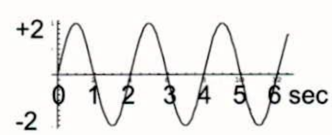
$K = \frac{2\pi}{\lambda} = \frac{\pi}{2}\ m^{-1}$

$v = \lambda f = \frac{\omega}{K}$

$\Rightarrow \omega = Kv = \left(\frac{\pi}{2} m^{-1}\right)\left(2\ m/s\right)$

$= \pi\ s^{-1}$

The following is a history at x= 0 meter of a transverse wave traveling ***to the left*** with velocity 2m/s. Which of the following equations is correct for this wave?



1. $y(x,t) = 2\sin\left[\left(\frac{\pi}{2}\right)x + \left(\frac{\pi}{2}\right)t\right]$
2. $y(x,t) = 2\sin\left[\left(\frac{\pi}{2}\right)x + (\pi)t\right]$
3. $y(x,t) = 2\sin\left[(\pi)x + \left(\frac{\pi}{2}\right)t\right]$
4. $y(x,t) = 2\sin[(\pi)x + (\pi)t]$
5. **None of the above.**

$T = 2\ s \Rightarrow \omega = \frac{2\pi}{T} = \pi$

$K = \frac{\omega}{v} = \frac{\pi}{2}$

x=3m, t=1s, wave at max

A transverse wave is traveling to the right with velocity 2m/s and wave length 4m. The following graph describes how the particle at x=3m vibrates. Draw a snap shot of the wave at t=1 second.