Physics Labs

Please watch the videos as we work through each of these labs. I will provide you with the equations from physics needed to solve each equation in the videos, and I want you to notice where we are using algebra in each as we write down the appropriate equation. Use the blank space on each page to do your calculations with me.

Problem 1: Elevator Drop: A worker drops a wrench down an elevator shaft. Where is it 1.5 seconds later? How fast is it going?

Problem 2: Ball Toss: Toss a ball straight up in the air. How long does it take to hit the ground? (HINT: Start timing the instant you let it go, and stop timing as soon as it hits the ground.)

Time in the air: ______________________________

Now let's find how high it went, and how fast you threw it. (Watch video here!)

Problem 3: Cliff Diving: A diver jumps from a cliff and 5 seconds later hits the water.

How tall is the cliff, and what speed do they hit the water?

Problem 4: Chemistry Lab: Aquariums You work at an aquarium, and they ask you to use water from two other tanks (12% and 27% salinity) to refill one that is 15 liters low (23% salinity). How much from each tank do you use?

Problem 5: Pressure at Depth: You build an underwater submersible that is designed to operate in the ocean at a depth of 300 meters. How much pressure with your robot experience at this depth?

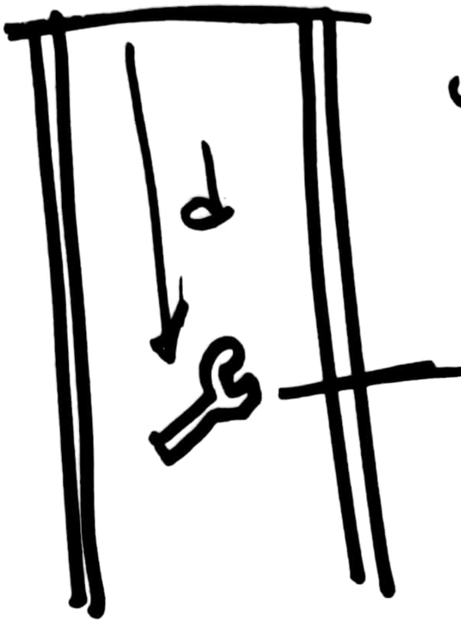
Problem 6: Dolphin Currents: Scientists drove a boat alongside a family of happy dolphins, and tracked their speed at 35 mph in still water. Then they tracked these dolphins and noticed that they took the same amount of time to swim 160 mph upstream as they did to travel 240 miles downstream. What is the speed of the current?

ANSWER KEY:

1. Wrench is 11m (36 feet) from starting point moving at 14.7 m/s (40 mph)
2. Answers vary.
3. The cliff is 122.6m (400 feet) high and they hit the water at 49 m/s (109 mph)
4. Take 4 liters from the 12% salinity tank and 11 liters from the 27% salinity tank
5. Pressure is 3 MPa
6. Current is 7 mph

Elevator Problem:

$$y = \cancel{v_0 t} - \frac{1}{2}gt^2$$



$t = 1.5$ sec

$d = ?$

$\forall$ = volume

v = velocity

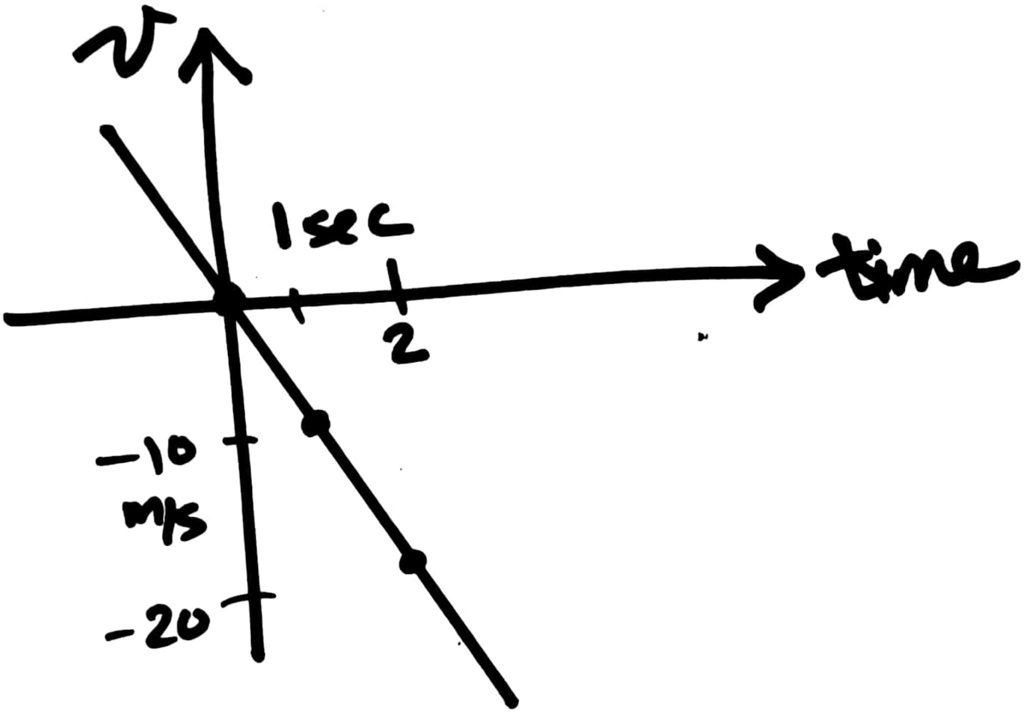
$$d = +\frac{1}{2}\left(9.81\frac{m}{s^2}\right)(1.5s)^2$$

$$d = 11m\left(\frac{3.28ft}{1m}\right) = 36.2'$$

$$v = \cancel{v_0} - gt = -\left(9.81\frac{m}{s^2}\right)(1.5s)$$

$$v = +14.7\frac{m}{s}\left(\frac{3.28'}{1m}\right) = \underline{\underline{48.2\frac{ft}{sec}}}$$

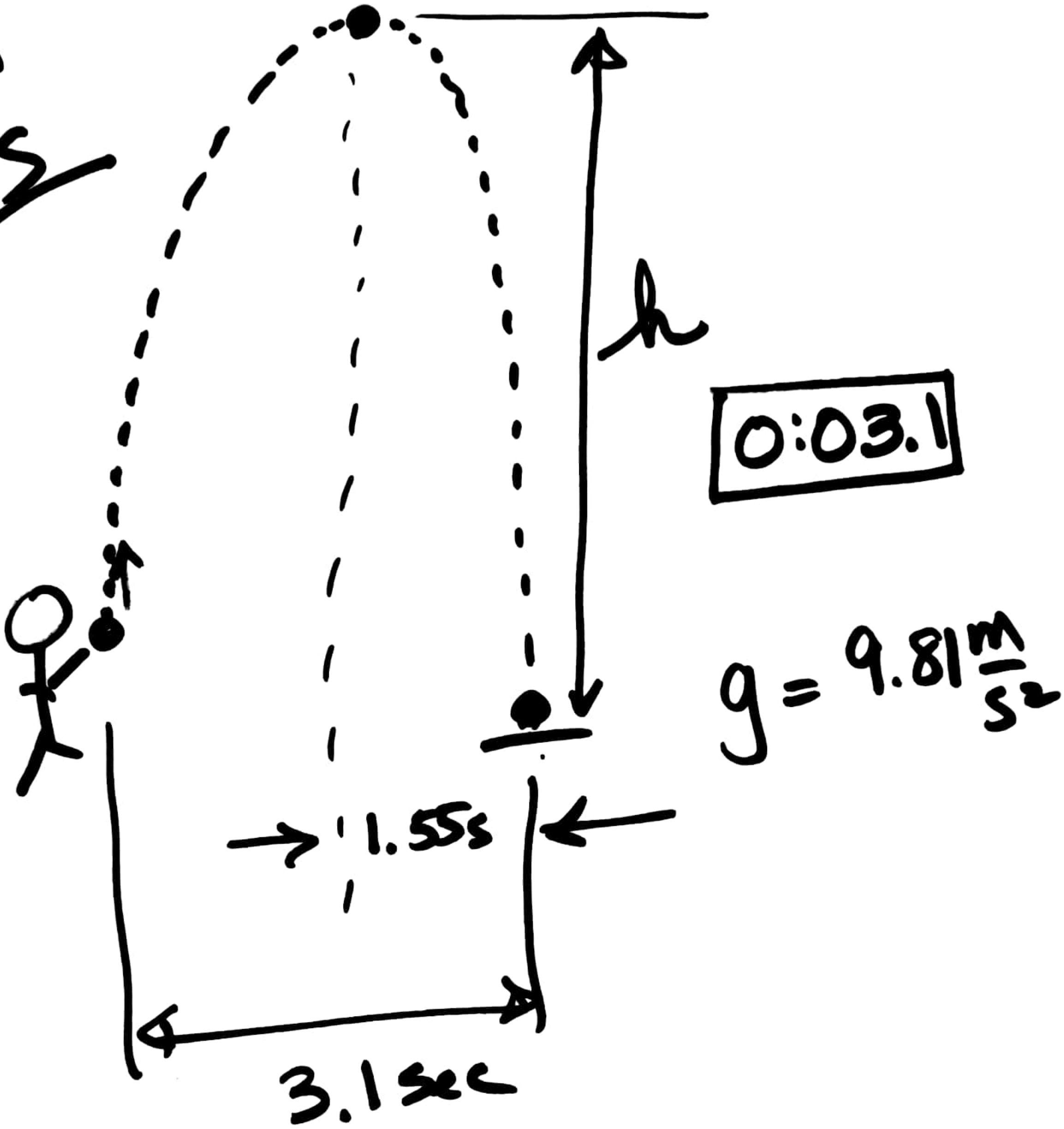
$$v = -gt = -10t$$



$$48.2 \frac{\cancel{ft}}{\cancel{sec}} \left(\frac{3600 \cancel{sec}}{1\,hr} \right) \left(\frac{1\,mile}{5280 \cancel{ft}} \right)$$

(40 mph after 1.5sec)

Ball Toss



$$t = \frac{1}{2}(3.1\ \text{sec}) = 1.55\ \text{sec}$$

$$h = \frac{1}{2} g t^2 = \frac{1}{2}\left(9.81 \frac{m}{s^2}\right)(1.55\,s)^2$$

$$h = \underline{\underline{11.78\,m}}\left(\frac{3.28\ ft}{1\ m}\right) = \underline{\underline{38.7'}}$$

$$t_0 = 4.5\ \text{sec}$$

$$t = \frac{1}{2}(4.5\ \text{sec}) = 2.25\text{sec}$$

$$h = \frac{1}{2} g t^2 = \frac{1}{2}\left(9.81 \frac{m}{s^2}\right)(2.25s)^2$$

$$\underline{h = 24.8m}\ (81.5')$$

$$v = ? \qquad v = \sqrt{2gh}$$

$$v = \sqrt{2\left(9.81\frac{m}{s^2}\right)(11.78m)} = 15\frac{m}{s}$$

$$v = 15\frac{m}{s}\left(\frac{1\text{Km}}{1000m}\right)\left(\frac{1\text{mi}}{1.6\text{Km}}\right)\left(\frac{3600s}{hr}\right)$$

$$v = 34\text{mph}$$

$$v = \sqrt{2gh}$$

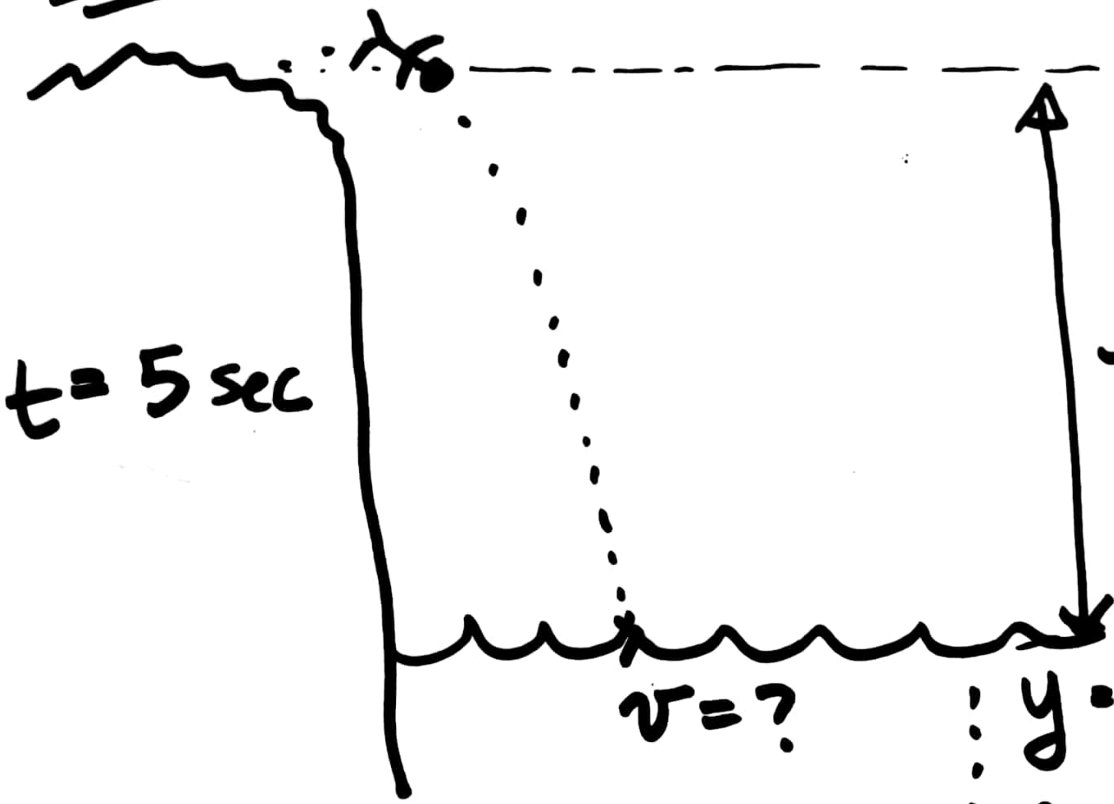
$$v = \sqrt{2(9.81 \tfrac{m}{s^2})(24.8\,m)}$$

$$\underline{\underline{v = 22 \tfrac{m}{s}}}$$

$$v = 22 \tfrac{m}{s} \left(\frac{1\,km}{1000\,m}\right)\left(\frac{1\,mi}{1.6\,km}\right)\left(\frac{3600\,s}{1\,hr}\right)$$

$$\underline{\underline{v = 50\,mph}}$$

Cliff Problem



$$y = \cancel{v_0 t}^{\,0} - \tfrac{1}{2} g t^2$$

$$v = \cancel{v_0}^{\,0} - g t$$

$$h = +\tfrac{1}{2} g t^2$$

$$h = \tfrac{1}{2}\left(9.81\,\tfrac{m}{s^2}\right)(5\,sec)^2$$

$$h = \boxed{122.6\,m}\left(\frac{3.28'}{1\,m}\right) = 399'$$

$$v = \left(9.81\,\tfrac{m}{s}\right)(5\,sec) = 49\,\frac{m}{s} = 160\,\frac{ft}{sec}$$

$$v = 160\,\frac{ft}{sec} \cdot \frac{1\,mi}{5280\,ft} \cdot \frac{3600\,s}{1\,hr} = \boxed{109\,mph}$$

$t = 2.5 \text{ sec}$

$$h = \frac{1}{2}gt^2 = \frac{1}{2}\left(9.81\frac{m}{s^2}\right)(2.5s)^2$$

$$h = 31\,m = \underline{\underline{100\,ft}}$$

$$v = gt = \left(9.81\frac{m}{s^2}\right)(2.5\,s)$$

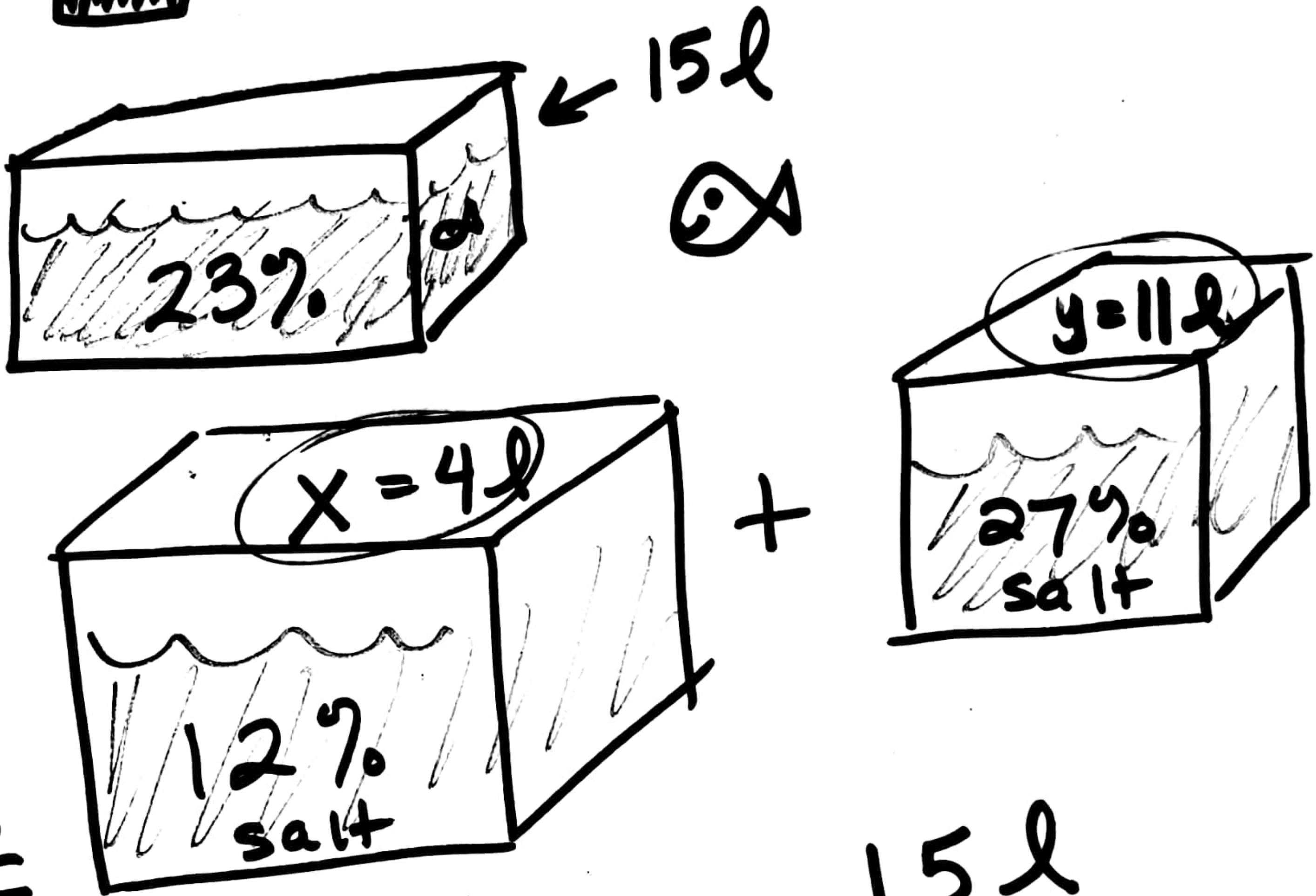
$$v = 24.5\frac{m}{s} = 80\frac{ft}{s}$$

$$v = 80\frac{ft}{sec}\left(\frac{3600\,s}{1\,hr}\right)\left(\frac{1\,mi}{5280'}\right)$$

$$\boxed{v = 54.5\,mph}$$

 +  $= ?$

$l = L$



$\frac{12}{100}$

$\rightarrow x + y = 15\,l$

$\rightarrow 0.12x + 0.27y = 0.23(15)$

Chemistry Lab

$$① \; x + y = 15$$

$$② \; 0.12x + 0.27y = 0.23(15)$$

$$② \; 0.12x + 0.27y = 3.45$$

$$① \; y = -x + 15$$

$$0.12x + 0.27(-x + 15) = 3.45$$

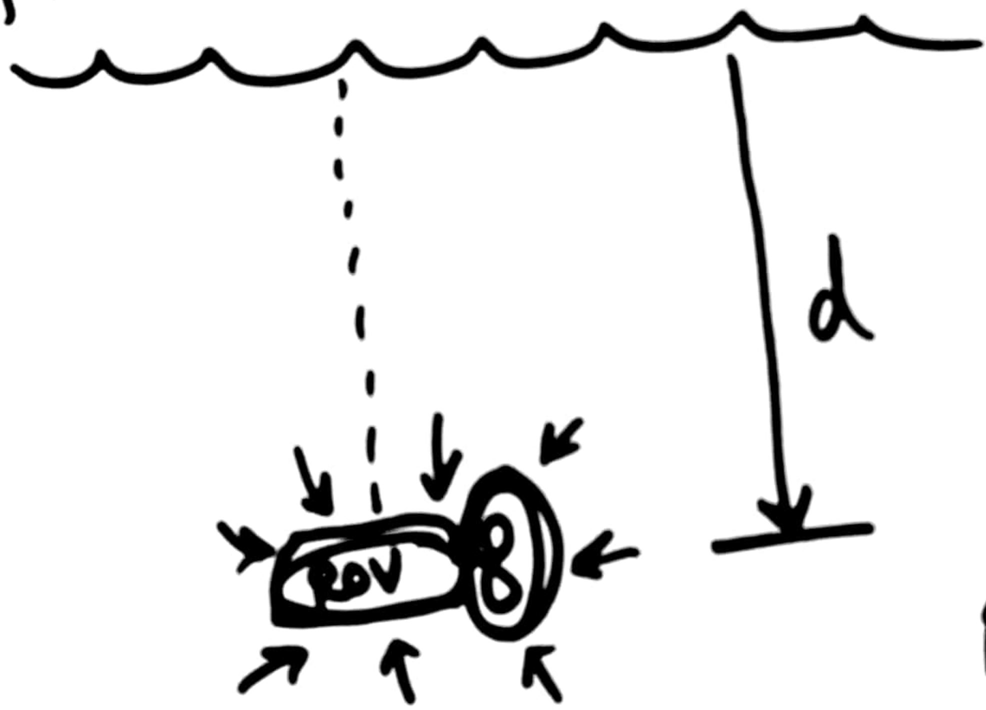
$$0.12x - 0.27x + \cancel{4.05} = 3.45$$
$$\cancel{-4.05} \quad -4.05$$

$$\frac{-\cancel{0.15}x}{\cancel{-0.15}_1} = \frac{-0.6}{-0.15}$$

$$\boxed{x = 4}$$

$$x + y = 15 \rightarrow y = -x + 15 = -4 + 15 \quad \boxed{\cancel{y=4}} \; \boxed{y = 11}$$

Pressure at Depth



$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$P = \rho g \cdot h$$

ρ = density

$g = 9.81 \frac{m}{s^2}$

h = depth

$$\frac{M}{\forall} \qquad \frac{m}{\forall}$$

$$\rho_{\text{fresh water}} = 1{,}000 \frac{kg}{m^3}$$

$$\rightarrow \rho_{\text{salt water}} = 1{,}027 \frac{kg}{m^3}$$

$$d = 300 m$$

$$P = \rho g d$$

$$\rightarrow P = \left(1027 \frac{kg}{m^3}\right)\left(9.81 \frac{m}{s^2}\right)(300 m)$$

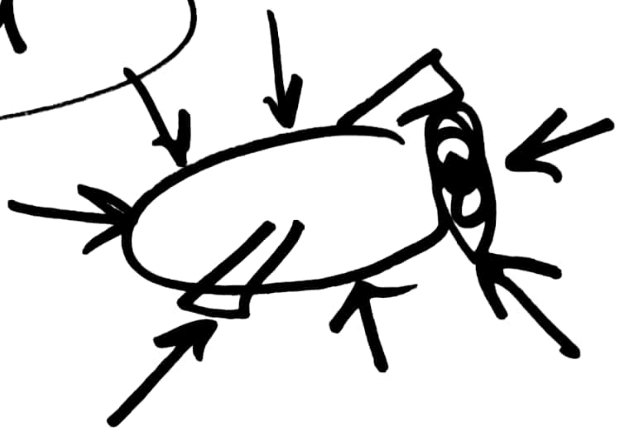
$$P = 3022461 \ Pa$$

$$\boxed{P = 3 MPa}$$

101.3 KPa

$P \leq 10\,\text{MPa}$

$d = ?$



$$\frac{P}{\rho g} = \frac{\cancel{\rho}\,\cancel{g}\,d}{\cancel{\rho}\,\cancel{g}}$$

$$d = \frac{P}{\rho g} = \frac{10 \times 10^{6}\,\text{Pa}}{\left(1027\,\frac{\text{kg}}{\text{m}^3}\right)\left(9.81\,\frac{\text{m}}{\text{s}^2}\right)}$$

$$\boxed{d \sim 1{,}000\,\text{m}}$$

Dolphins

Gulf of Mexico

35 mph
still water

28 mph $\rightarrow$

$\rightarrow$ 160 miles

$\leftarrow$ 42 mph

240 mi

X = speed of current = $\boxed{7 \text{ mph}}$

t = time

With the current: ① $240 = (35 + x)t$

against the current: ② $160 = (35 - x)t$

$$② \quad \frac{160}{(35-x)} = \frac{\cancel{(35-x)}\,t}{\cancel{(35-x)}}$$

$$② \quad t = \frac{160}{(35-x)}$$

$\downarrow$

$$(35-x) \cdot ① \quad 240 = \frac{(35+x)\,160}{\cancel{(35-x)}} \cdot \cancel{(35-x)}$$

$$(35-x)240 = (35+x)(160)$$

$$8400 - \cancel{240}x = 5\cancel{6}00 + 160 \cdot x$$

$$-5600 + \cancel{240}x \qquad -5\cancel{6}00 \qquad +240x$$

$$\frac{2800}{400} = \frac{4\cancel{0}0 \cdot x}{400}$$

$$\Rightarrow \boxed{x = 7 \text{ mph}}$$