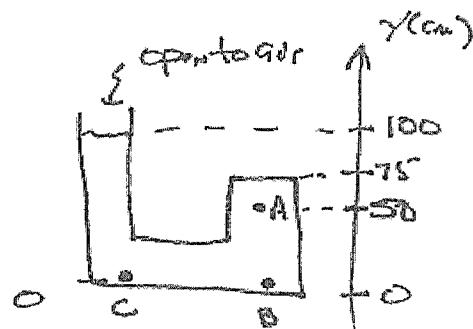


Physics 151

Practice Problems for

Fluids AND Periodic
Motion

#1



$$\text{Oil} \Rightarrow \rho = 900 \text{ kg/m}^3$$

a) What is gauge pressure at A? Gauge Pressure $\Rightarrow p - 1 \text{ atm}$

$$P_A = P_D + \rho g d A$$

$$P_D = \text{pressure at } 75\text{cm} \Rightarrow P_D = P_0 + \rho g d_D$$

$$\therefore P_A = P_0 + \rho g d_D + \rho g d_A = P_0 + \rho g (d_D + d_A)$$

$$d_D + d_A = 100\text{cm} - 50\text{cm} = 50\text{cm} = 0.5\text{m}$$

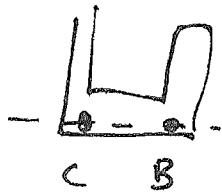
Gauge pressure $P_{\text{gauge}} = P_A - 1 \text{ atm}$ since P_0 is pressure at open end

$$P_0 = 1 \text{ atm} \Rightarrow P_{\text{gauge}} = 1 \text{ atm} + \rho g (d_D + d_A) - 1 \text{ atm}$$

$$\Rightarrow P_{\text{gauge}} = \rho g (d_D + d_A) = (900 \text{ kg/m}^3)(9.81 \text{ m}) (0.5 \text{ m}) = 4410 \text{ Pa} = 4.41 \text{ kPa}$$

$$\text{Unit: } \frac{\text{kg}}{\text{m}^3 \cdot \text{s}^2} = \frac{\text{kg} \cdot \text{m}}{\text{m}^3 \cdot \text{s}^2} = \text{N} \cdot \text{m}^{-2} = \text{Pa}$$

b.) $P_B - P_A = ?$



B AND C at SAME depth $\Rightarrow P_B = P_C$

$$P_C = P_0 + \rho g d_C \quad d_C = 100\text{cm} = 1\text{m}$$

$$\therefore P_B - P_A = P_0 + \rho g d_C - [P_0 + \rho g (d_B + d_A)]$$

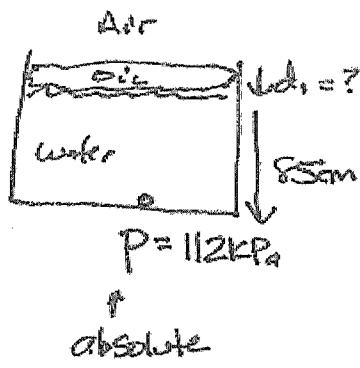
$$= P_0 + \rho g d_C - P_0 = \rho g (d_C - d_B - d_A)$$

$$= \rho g (d_C - d_B - d_A) = \rho g (1\text{m} - 0.5\text{m}) = \rho g (0.5\text{m}) = 4410\text{Pa}$$

again

c) $P_C - P_A ?$ since $P_C = P_B \Rightarrow 4410\text{Pa}$ again!

#2



For the oil $\rho_{oil} = 900 \text{ kg/m}^3$

Water $\rho_{water} = 1000 \text{ kg/m}^3$

At Boundary Between Oil and Water $P_B = P_0 + \rho_{oil} g d_1$

\nearrow
Boundary

At The Bottom : $P = P_B + \rho_{water} g (0.85m)$

Since $P_B = P_0 + \rho_{oil} g d_1 \Rightarrow P = P_0 + \rho_{oil} g d_1 + \rho_{water} g (0.85m)$

$$\Rightarrow P - P_0 - \rho_{water} g (0.85m) = \rho_{oil} g d_1$$

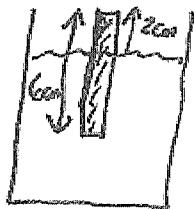
$$\Rightarrow (900 \text{ kg/m}^3)(9.8 \text{ m/s}^2) d_1 = (112000 \text{ Pa} - 101300 \text{ Pa}) - (1000 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(0.85m)$$

\nearrow
atmospheric
pressure

$$\Rightarrow (900 \text{ kg/m}^3)(9.8 \text{ m/s}^2) d_1 = 11200 \text{ Pa} - 101300 \text{ Pa} - 8330 \text{ Pa} = 2370 \text{ Pa}$$

$$\Rightarrow d_1 = \frac{2370 \text{ Pa}}{(900 \text{ kg/m}^3)(9.8 \text{ m/s}^2)} = 0.2687 \text{ m} = 26.87 \text{ cm} = 27 \text{ cm}$$

#3



What is cylinder's density?

Since Floating, the buoyant force must equal the cylinder's weight

$$\Rightarrow F_B = W_c$$

↑
Cylinder

$$F_B = \text{water} V_{\text{water}} g$$

↓
Water
displaced

$$W_c = f_{\text{cylinder}} V_{\text{cylinder}} g$$

$$\therefore f_{\text{water}} V_{\text{water}} g = f_{\text{cylinder}} V_{\text{cylinder}} g$$

$$\Rightarrow f_{\text{cylinder}} = f_{\text{water}} \frac{V_{\text{water}}}{V_{\text{cylinder}}}$$

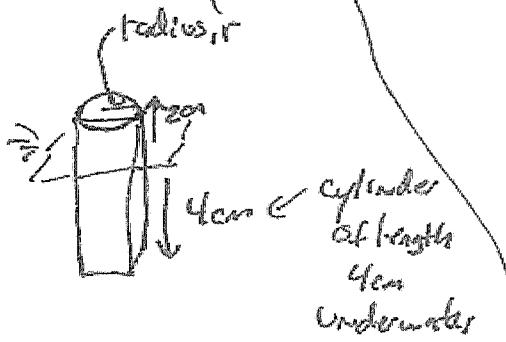
$V_{\text{water}} = \text{Volume of cylinder that is underwater}$

$$\therefore V_{\text{water}} = \pi r^2 (4\text{cm})$$

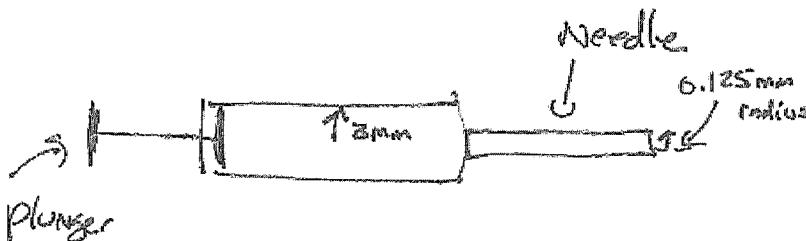
entire cylinder has same radius but is longer $\Rightarrow V_{\text{cylinder}} = \pi r^2 (6\text{cm})$

$$\Rightarrow f_{\text{cylinder}} = (1000 \text{kg/m}^3) \left(\frac{\pi r^2 (4\text{cm})}{\pi r^2 (6\text{cm})} \right) = (1000 \text{kg/m}^3) \left(\frac{2}{3} \right) = 666.66 \text{kg/m}^3 \approx 670 \text{kg/m}^3$$

Yes I cheated!
Since we are taking
a ratio, as long as the
bottom are in the
unit, everything
is OK.



#4



2mL Syringe

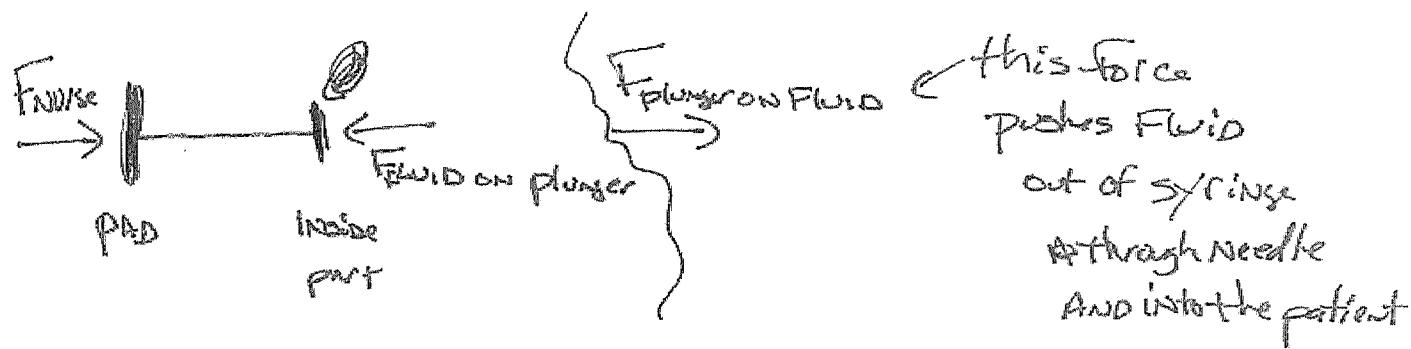
Has inner diameter of 6mm
⇒ inner radius of 3mm

Needle has diameter of 0.25mm
⇒ radius of 0.125mm

Plunger has 1.2cm diameter

a) What force on syringe to inject into a patient with 140/100 BP?

Let's get the trick part out of the way! While the nurse applies a force to the plunger ~~end~~, it is the ~~inside~~ part of the plunger INSIDE the syringe that pushes on the fluid.



The inside part of the plunger must be 3mm in radius to fit inside syringe → When we find pressure have to use 3mm radius AND Not the pad's radius

From the plunger's Fbd : $\sum F_x = M_{Ax}$

$$\Rightarrow F_{\text{Nurse}} - F_{\text{Fluid on plunger}} = M_{\text{plunger}} A_x$$

Smallest Force $\Rightarrow A_x = 0 \Rightarrow F_{\text{Nurse}} - F_{\text{Fluid on plunger}} = 0$

$$\Rightarrow F_{\text{Nurse}} = F_{\text{Fluid on plunger}} = P_{\text{Fluid}} A = P_{\text{Fluid}} \pi (0.003m)^2$$

↑
pressure
3mm = 0.003m

Assuming the Fluid is IDEAL \Rightarrow the pressure must be the same everywhere $\Rightarrow P_{\text{Fluid}} = P_{\text{Blood}}$
including inside the patient

140/100 \Rightarrow MAX pressure is 140 mmHg AND
Resting/minimum is 100 mmHg

So another condition for smallest force is $P_{\text{Fluid}} = 100 \text{ mmHg}$

Have to convert to Pascal : $100 \text{ mmHg} \times \frac{101300 \text{ Pa}}{760 \text{ mmHg}} = 13329 \text{ Pa}$
atmospheric pressure

$$\text{So Finally } F_{\text{noise}} = (13329 \text{ Pa})\pi (0.003 \text{ m})^2 \\ = 0.3769 \text{ N} = 0.38 \text{ N}$$

b) Nurse Empties Syringe in 2s? How fast is fluid in needle?

Continuity \Rightarrow Same Flow everywhere $Q = \frac{\text{Volume}}{\Delta t} = V A$

\uparrow speed \uparrow cross-section
 \uparrow Area of needle

$$Q = \frac{1 \text{ mL}}{2 \text{ s}} = \frac{1 \text{ mL}}{s} \quad \text{but need } \text{m}^3/\text{s} \text{ to get } \text{m/s}$$

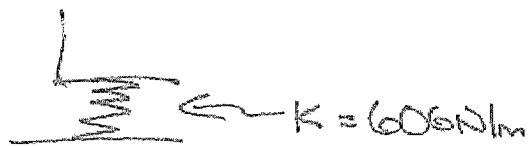
$$\text{Looking it up } 1 \text{ mL} = 1 \times 10^{-6} \text{ m}^3$$

$$\therefore Q = 1 \times 10^{-6} \text{ m}^3/\text{s} \Rightarrow 1 \times 10^{-6} \text{ m}^3/\text{s} = V \pi (0.125 \times 10^{-3} \text{ m})^2$$

\uparrow
0.125 mm

$$\therefore V = \frac{1 \times 10^{-6} \text{ m}^3/\text{s}}{\pi (0.125 \times 10^{-3} \text{ m})^2} = 20.37 \text{ m/s} = 20 \text{ m/s}$$

#5



Empty chair oscillates with $T = 0.90\text{ s}$ ← CHAIR'S MASS
is not zero.

What is Astronaut's mass if $T = 2.0\text{ s}$ when sitting in chair?

First find mass of chair : $T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow T^2 = (2\pi\sqrt{\frac{m}{k}})^2 = 4\pi^2 \frac{m}{k}$

$$\Rightarrow m = \frac{T^2 k}{4\pi^2}$$

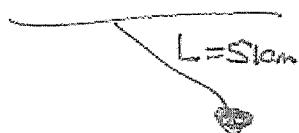
$$so M_{\text{chair}} = \frac{(0.90\text{ s})^2 (600\text{ N/m})}{(4\pi^2)} = 12.46\text{ kg}$$

$$\text{Unit: } \frac{\text{N}}{\text{m}} = \frac{\text{kg} \cdot \text{m/s}^2}{\text{m}} = \text{kg}$$

$$M_{\text{chair}} + M_{\text{astronaut}} = \frac{(2.0\text{ s})^2 (600\text{ N/m})}{(4\pi^2)} = 67.051\text{ kg}$$

$$\Rightarrow M_{\text{astronaut}} = 67.051\text{ kg} - 12.46\text{ kg} = 54.59\text{ kg} = 54.6\text{ kg}$$

#6



$$51\text{cm} \times \frac{m}{100\text{cm}} = .51m$$

Pendulum Completes 10⁹ cycles in 132s

$$\Rightarrow T = \frac{132\text{s}}{10^9} = 1.211\text{s}$$

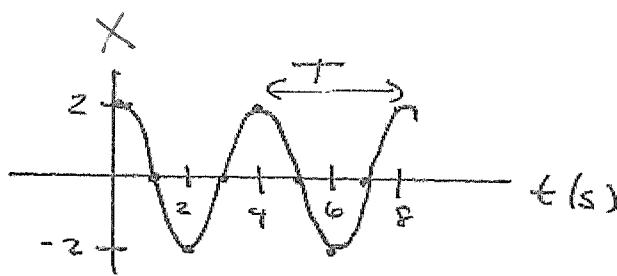
For simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$ $\Rightarrow T^2 = (2\pi\sqrt{\frac{L}{g}})^2 = 4\pi^2 \frac{L}{g}$

$$\Rightarrow g = \frac{4\pi^2 L}{T^2} = \frac{4\pi^2 (.51m)}{(1.211\text{s})^2} = 13.7 \text{ m/s}^2$$

#1

peak-to-peak
time

$$a) T = 8s - 4s = 4s$$



$$A = 2m$$

Max Distance

Draws A position graph is Amplitude is doubled and frequency is HALVED.

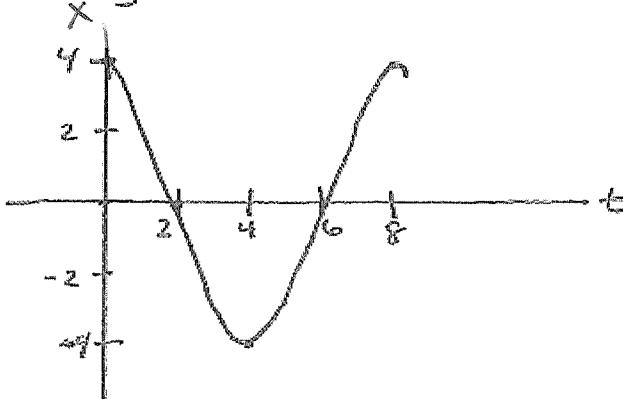
Q1

In the original graph: The Amplitude is $2m$ $\Rightarrow A_{new} = \underline{4m}$

the period is $T = \overline{8s} - 4s = 4s \Rightarrow f = \frac{1}{4s} = 0.25\text{Hz}$

$$\Rightarrow f_{new} = \frac{1}{2} (0.25\text{Hz}) = 0.125\text{Hz} \Rightarrow T_{new} = \frac{1}{0.125\text{Hz}} = 8s$$

So using SAME scale:



3-0235 — 50 SHEETS — 5 SQUARES
3-0235 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FULLER

b.) Starting from $A = 2M$, $T = 4s$

If Amplitude and spring constant are the same
but mass is quadrupled.

$$T_{\text{old}} = 2\pi\sqrt{\frac{m}{k}} \quad \text{So Quadrupling mass}$$

$$\Rightarrow T_{\text{new}} = 2\pi\sqrt{\frac{4m}{k}} = (2\pi\sqrt{\frac{m}{k}})\sqrt{4} = T_{\text{old}} \times 2$$

$$\Rightarrow T_{\text{new}} = 2T_{\text{old}} = 2(4s) = 8s$$

$$A_{\text{new}} = A_{\text{old}} = 2m\theta$$

