PH202 Recitation 6: Hydrostatics

Problem 1: Calculate depth of water needed to have a pressure of 1 atm

well we know $P = \rho g h$

$$\Rightarrow P_{atm} = \rho g h$$

$$\Rightarrow h = \frac{P_{atm}}{\rho g}$$

$$\Rightarrow h = \frac{101325\ Pa}{(1000\ kg/m^3)(9.8\ m/s^2)}$$

$$\Rightarrow h = 10.3\ m$$

b) mercury instead of water?

$$h = \frac{P_{atm}}{\rho g}$$

$13.69 g/cm^3$

$$\Rightarrow h = \frac{(101325\ Pa)}{(13,690\ kg/m^3)(9.8\ m/s^2)}$$

$$\Rightarrow \frac{13.69\ g}{cm^3}\left(\frac{100\ cm}{m}\right)^3 \frac{1\ kg}{1000\ g}$$

$$= 13,690\ kg/m^3$$

$$\Rightarrow h = .755\ m$$

c) reasons why we use mercury instead of water in barometers

1) only need .755m of Hg instead of 10.3 of water
2) ~~[crossed out]~~ Specific heat of Hg < H_2O so it is more easy to regulate its temperature and keep its temperature with that of the Earth
3) Freezing point of Hg < H_2O so it can be outside in cold areas
4) Boiling point of Hg > H_2O so it doesn't lose volume as easily

Problem 2: IV infusions using gravitational force

$\rho_{fluid} = 1.00\, g/mL$

minimum height for IV bag above entry point for IV to flow?

$P_{blood} = 18\, mmHg$ and collapsable bag

well we know that if the bag is collapsable => P_{atm} at IV the entire time

we know that in order for the fluid to flow, the minimum height needed is when the pressures are equal. If the pressure of the fluid is slightly increased => fluid flows

$P_{fluid} \geq P_{blood}$

$\Rightarrow P_{atm} + \rho g h \geq P_{atm} + P_{blood}$

$\Rightarrow \rho g h_{min} = P_{blood}$

$1\, g/mL = 1\, kg/L = 1000\, kg/m^3$

$1\, mmHg = 133\, Pa$

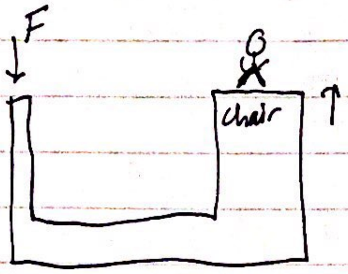
or $760\, mmHg = 1\, atm$

$\Rightarrow h_{min} = \frac{P_{blood}}{\rho g}$

$\Rightarrow h_{min} = \frac{18\, mmHg \times \frac{133\, Pa}{1.0\, mmHg}}{(1.0 \times 10^3\, kg/m^3)(9.80\, m/s^2)} = .244\, m$

=> at least .244m above entry point is needed for fluid to flow

Problem 3: barber raises customer in a hydraulic chair
force of 150N to piston area $0.01m^2$
chair attached to piston of area $0.1m^2$
$m_{chair} = 5kg$



By pascal's principle we know that the pressure inside the pistons will be equal

$$\Rightarrow \quad P_{barber} = P_{chair}$$

barber = 1 chair = 2

$$\Rightarrow \quad \frac{F_{barber}}{area_{barber}} = \frac{F_{chair}}{area_{chair}}$$

$$\Rightarrow \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\Rightarrow \quad F_1 \cdot \frac{A_2}{A_1} = F_2$$

$$\Rightarrow \quad F_2 = F_{chair} = 150N\left(\frac{.1m^2}{.01m^2}\right) = 1500N$$

10x mechanical advantage

now we know $F=mg$ for weight

$$\Rightarrow \quad \frac{F}{g} = m = \frac{1500N}{9.8\ m/s^2} = 153\ kg$$

mass of chair $= 5kg \Rightarrow 148kg$ person

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Problem 4: fisherman with mass 75kg falls asleep on chair (5kg)

4 legs on ground with radius 2cm.

What is average pressure exerted on ground

well, we know that $P = \frac{F}{A}$

$\Rightarrow$ $F = mg$

$= (75kg + 5kg) \cdot 9.8 m/s^2$

$= 784N$

$A = \pi r^2$ for circle

$= 4\pi r^2$ for 4 legs

$= 4\pi(.02)^2$

$= .005\ m^2$

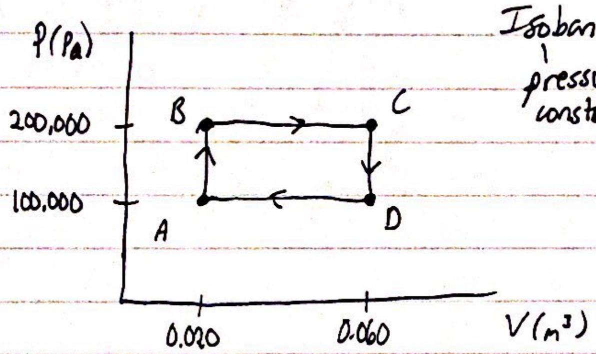
$\Rightarrow$ $P = \frac{F}{A} = \frac{784N}{.005m^2} = 156000\ Pa$

PH202 Recitation 5: Thermo Part 3: PV Diagrams

Problem 1: 1 mol of monatomic ideal gas in 4 step cycle
all processes are either isobaric or isochoric

state	A	B	C	D
$P(Pa)$	100,000	200,000	200,000	100,000
$V(m^3)$	0.020	0.020	0.060	0.060
$T(K)$	?	?	?	?

a) Sketch the PV diagram



Isobaric and isochoric => straight lines
pressure constant / volume constant

b) Determine the temperature at each point.

Well, we know this is an ideal gas

$\Rightarrow PV = nRT$

$\Rightarrow T = \dfrac{PV}{nR}$

depending on rounding

$T_A = \dfrac{(100{,}000)(Pa)(.020)(m^3)}{(1\,mol)(8.314\,\frac{J}{mol\,K})} = 241\,K \qquad T_B = \dfrac{2P_A V_A}{nR} = 2T_A = 482\,K \text{ or } 481\,K$

$T_C = \dfrac{2P_A \cdot 3V_A}{nR} = 6 \cdot T_A = 1446\,K \text{ or } 1443\,K \qquad T_D = \dfrac{P_A \cdot 3V_A}{nR} = 723\,K \text{ or } 722\,K$

State	A	B	C	D
$T(K)$	241	482	1446	723

c) Calculate W, Q, and ΔE for each step

Well we know 3 things that will help us.

$\Delta E = Q + W$

$\Delta E = \frac{3}{2} n R \Delta T$

$W = -p\Delta V$ or the area under the curve during that step

Using these 3 simultaneously will allow us to solve for each term

So we know isochoric $\Rightarrow \Delta V = 0 \Rightarrow W = 0$

So $A \to B$ and $C \to D$ have $W = 0$

We also know for a cycle that $\Delta E = 0$

Work for $B \to C$ and $D \to A$ is $W = -p\Delta V$

$W_{A\to B} = -(200{,}000\,Pa)(.06 - .02\,m^3) = -8000J$ > add all W together to get the work done in a cycle

$W_{D\to A} = -(100{,}000\,P_a)(.02 - .06) = +4000J$

For ΔE we know $\Delta E = \frac{3}{2} n R \Delta T$

So $\Delta E_{A\to B} = \frac{3}{2} n R (T_B - T_A) = \frac{3}{2}(1\,mol)(8.314 \frac{J}{mol\,K})(482 - 241\,K) = 3006J$ or $3005J$

$\Delta E_{B\to C} = \frac{3}{2} n R (T_C - T_B) = \frac{3}{2}(1\,mol)(8.314 \frac{J}{mol\,K})(1446 - 482\,K) = 12022J$

$\Delta E_{C\to D} = \frac{3}{2} n R (T_D - T_C) = \frac{3}{2}(1\,mol)(8.314 \frac{J}{mol\,K})(723 - 1446\,K) = -9017J$

$\Delta E_{D\to A} = \frac{3}{2} n R (T_A - T_D) = \frac{3}{2}(1\,mol)(8.314 \frac{J}{mol\,K})(241 - 723) = -6011J$

path	$A \to B$	$B \to C$	$C \to D$	$D \to A$ ~~cycle~~	cycle
description	isochoric	isobaric	isochoric	isobaric	cycle
ΔE (J)	+3006J	+12022	-9017	-10011	0
Q (J)	+3006	+20022	-9017	-6011	+4000J
W (J)	0	-8000	0	4000J	-4000J

To double check, make sure that the components across adds up to the final values of the cycle.

$\Delta E = Q + W$ for each step and for the full cycle itself.

Example: $Q_{A\to B} + Q_{B\to C} + Q_{C\to D} + Q_{D\to A} = Q_{cycle}$ and so on.