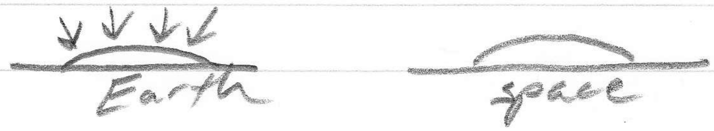
Physics II

"More Pressure Problems"

(1)

1. In space, there is no air pressure to push against the outside of the suction cup



3. $P = \frac{F}{A}$

$A_{plate} = \pi r^2 = \pi(0.09m)^2 = 0.0254m^2$

order switched. "Oops!"

$F_{plate} = mg = 0.3kg(9.8m/s^2) = 2.94N$

$P = \frac{2.94N}{0.0254m^2} = 115.7pa = 0.0168psi$

gauge pressure

2. $P = \frac{F}{A}$ ← $\pi r^2 = \pi(3in)^2 = 28.3in^2$

14.7psi (atmosphere)

$14.7psi = \frac{F}{28.3in^2}$

$F = 416$ pounds

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4. $P = \frac{F}{A}$ $2m^2$

$F = (40kg + 80kg)\, 9.8 m/s^2$

$= 1176N$

m a

$P = \frac{1176N}{2m^2} = 588 pa = 0.0853 psi$

gauge pressure

5. $P = \rho g h = 1000 kg/m^3 (9.8 m/s^2)\, 76.2m = 746{,}760 pa$

$250ft = 3000 in = 7620 cm = 76.2 m$

108 psi

gauge pressure

6. $P = \rho g h$

$2psi \left(6895 \frac{pa}{psi}\right) = 13790 pa$

$13790 pa = 1000 kg/m^3 (9.8 m/s^2)\, h$

$h = 1.41 m$

③

7 $PV = nRT$

since 50g is the increase in mass, this change is due to the increase in pressure, so we can use the gauge pressure of 50psi, rather than the actual pressure of 64.7psi

$50\,psi\left(6895\,pa/psi\right) = 344{,}750\,pa$

$T = 20°c + 273.2 = 293.2K$

$344{,}750\,pa\left(0.002\,m^3\right) = n\left(8.31\,J/K\,mol\right)\left(293.2K\right)$

$V = 2\ell$

$n = 0.283\,mol$

$\text{molar mass} = \dfrac{5\,g}{0.283\,mol} = 17.7\,g/mol$

3.5

8. a) $PV = nRT$

$P = 15.7\,psi\left(6895\,pa/psi\right) = 108{,}252\,pa$
$V = 1\,m^3$ ← I made it up
$T = 21°c + 273.2 = 294.2\,k$

$108{,}252\,pa\,(1\,m^3) = n\left(8.31\,j/k\,mol\right)294.2\,°k$

$n = 44.3\,mol$

$44.3\,mol\left(\frac{0.004\,kg}{mol}\right) = 0.178\,kg$

$\rho = \frac{m}{V} = \frac{0.178\,kg}{1\,m^3} = 0.178\,kg/m^3$
$= 0.000178\,g/ml$

b) Balloon volume $= \frac{4}{3}\pi r^3$
Ball. Vol $= \frac{4}{3}\pi(0.127\,m)^3 = \underline{0.00858\,m^3}$
diameter = 10 in = 25.4 cm = 0.254 m
radius $= \frac{0.254\,m}{2} = 0.127\,m$

Air density $\approx 1.2\,kg/m^3$
Displaced air mass $= 1.2\,kg/m^3\,(0.00858\,m^3)$
$= \underline{0.0103\,kg}$

8b (contd.)

Density of helium (from prev Q.) = 0.178 kg/m³

Helium mass = Balloon Vol (Helium Density)
= 0.00858 m³ (0.178 kg/m³)
= 0.00153 kg

Archimedes Principle ⇒ Buoyant force
= weight of displaced
fluid

Weight of displaced air = mg = 0.0103 kg (9.8 m/s²)
= 0.1009 N

Net force = Buoyant force − Weight of balloon

Balloon weight = Balloon mass (g)

Helium mass (0.00153 kg)
+ latex mass (0.001 kg)
= 0.00253 kg

Balloon weight = 0.00253 kg (9.8 m/s²) = 0.0248 N

Net Force = 0.1009 N − 0.0248 N
= 0.0761 N upward

8c. Net force from 1 balloon $= 0.0761N$

$$F = ma$$

$$0.0761 = m(9.8 m/s^2)$$

"mass" $= 0.00777 kg$

$$0.00777 kg\left(2.2 \frac{lbs}{kg}\right) = 0.0171 \text{ lbs/balloon}$$

$$\frac{150 \text{ lbs}}{0.0171 \frac{lbs}{balloon}} = 8780 \text{ balloons}$$

9. Mannequin mass = Mass of $20l$ of H_2O

$$20 l H_2O = 20 kg$$

Mannequin Volume $= 20l + 30l = 50l$

Mannequin Density $= \frac{20 kg}{50 l} = 0.4 kg/l$ or $400 kg/m^3$

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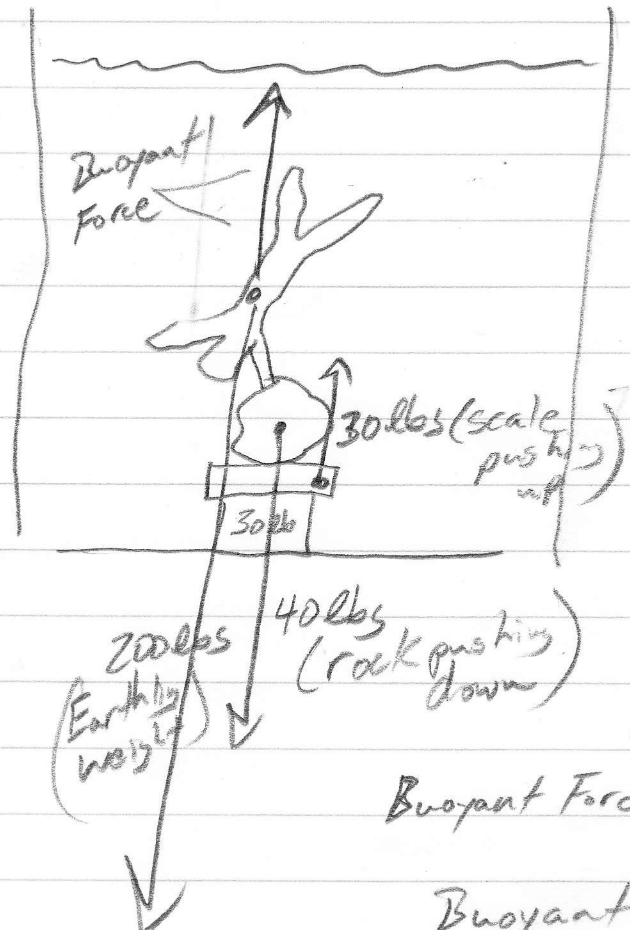
10.



Net Force = 0 lbs
so total upward force = total downward force

Buoyant Force + 30 lbs = 200lbs + 40lbs

Buoyant force = 210 lbs

This is the weight of displaced H_2O,

$$\frac{210 \text{ lbs}}{2.2 \text{ kg/lbs}} = 95.5 \text{kg} \Rightarrow 95.5 \text{ liters of } H_2O \text{ displaced.}$$

Earthling's Volume = 95.5 l

7

11. $P = \frac{F}{A}$ ← 300 lbs = 136 kg = 1336 N

A ← area of piston $= \pi r^2 = \pi(0.06m)^2 = 0.0113 m^2$

300 lbs

$P = \frac{1336N}{0.0113m^2} = 118,128 \text{ pa}$ ← gauge pressure

Actual pressure in cylinder must be atmospheric press + gauge press

$P = 101,350 \text{ pa} + 118,128 \text{ pa} = 219,478 \text{ pa}$ ← Pressure to unstick cylinder

Since V and n are constant before the cylinder unsticks, we do not need their actual values to use $PV = nRT$

Solving for the constant, we have $\frac{V}{nR} = \frac{T}{P}$

or, you can say $\frac{T_1}{P_1} = \frac{T_2}{P_2}$

In the beginning, $\frac{V}{nR} = \frac{294.2k}{101,350 \text{ pa}} = 0.00290 \frac{k}{pa}$

$21°C + 273.2 = 294.2k$

So, in the end, $\frac{V}{nR} = \frac{T}{P} \Rightarrow 0.00290 \frac{k}{pa} = \frac{T}{219,478 \text{ pa}}$

$T = 637.1k$

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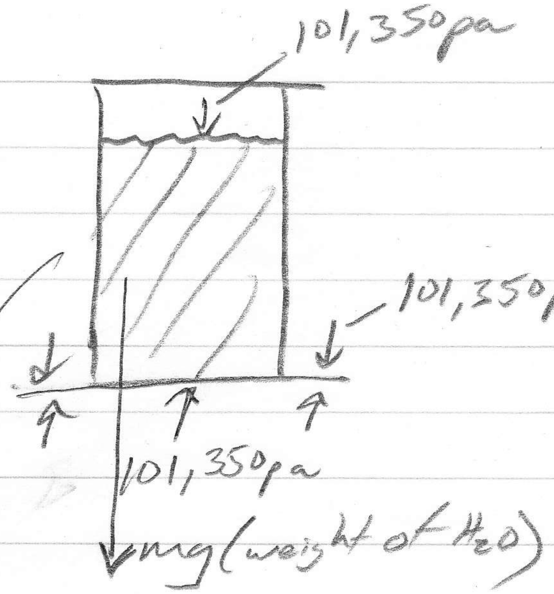
12.



Before water drops

Area of H_2O surface and jar opening

$= \pi r^2 = \pi (0.05m)^2$

$= 0.00785 m^2$

$P = \frac{F}{A}$ ← Force of air; A ← Area of H_2O surface; P ← Air Pressure

$101,350pa = \frac{F_{Air}}{0.00785 m^2}$

$\underline{F_{Air} = 796N}$

Volume $H_2O = Ah$

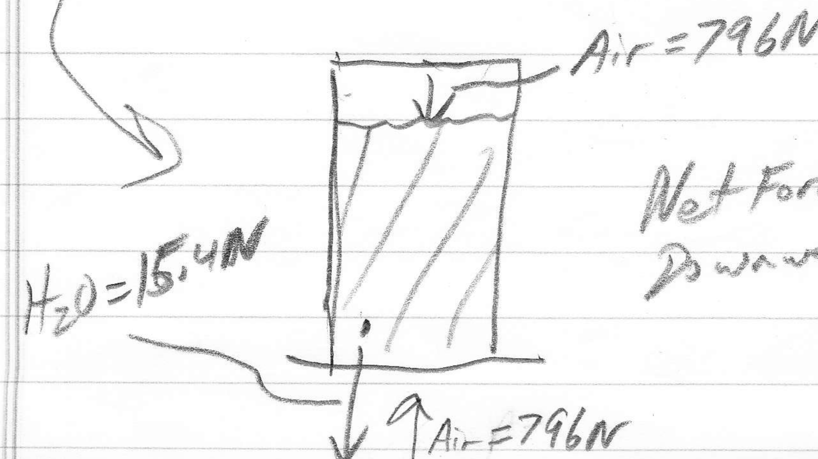
$= 0.00785 m^2 (0.2m)$

$= 0.00157 m^3$

Mass $H_2O = \rho V = 1000 kg/m^3 (0.00157 m^3)$

$= 1.57kg$

Weight $H_2O = mg = 1.57kg (9.8 m/s^2) = 15.4N$



Net Force Downward $= 796N + 15.4N - 796N$

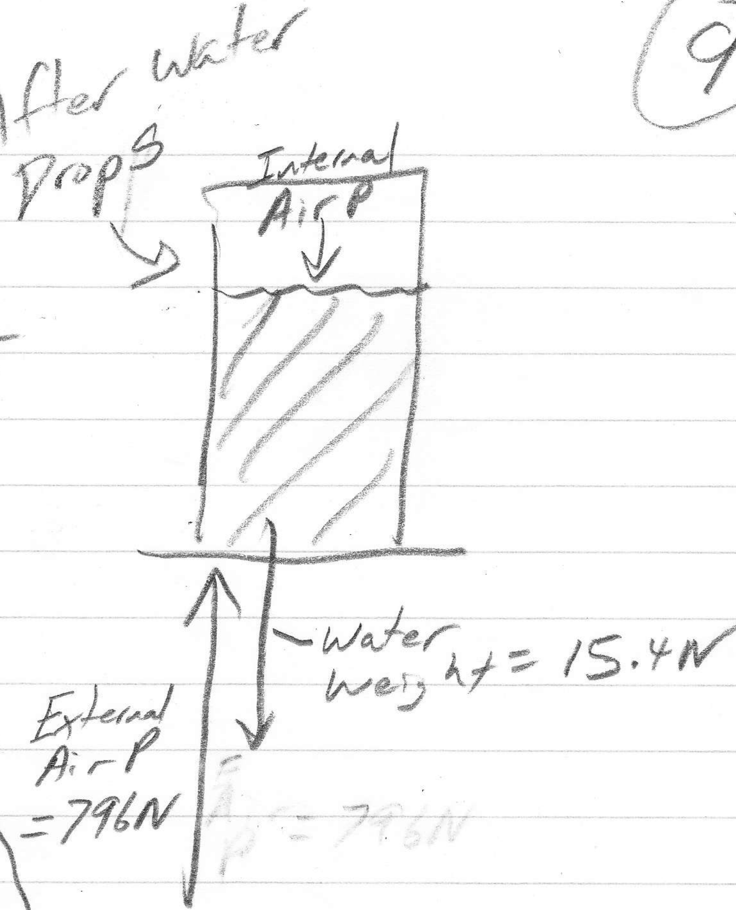
$= 15.4N$

So, water drops

12 (contd.)

After water drops a little, it stabilizes

Net force = 0



External Air Force = Internal Air Force + H_2O weight

796N = Internal Air Force + 15.4N

Internal Air Force = 780.6N

$$P = \frac{F}{A} = \frac{780.6N}{0.00785m^2} = 99{,}439pa$$

from previous page

constant

$$PV = nRT$$

so $P_1V_1 = P_2V_2$

$V_1 = Ah$
$= 0.00785m^2(0.04m)$ ← 20% of 20cm
$= 0.000314m^3$

$101{,}350pa(0.000314m^3) = 99{,}439pa(V_2)$

original internal Air P. original internal air volume

$V_2 = 0.000320m^3$

Final Interior Air Volume

12 (contd)

$0.000320 m^3$ = Final Air Volume

$V = aH$

$0.000320 m^3 = 0.00785 m^2 (h)$

$h = 0.0408 m$

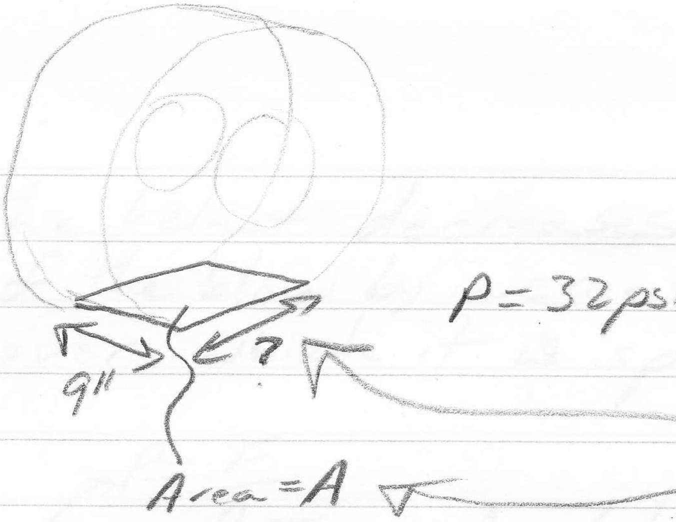
4.08 cm = distance from water to New top of jar

Original distance was 4 cm

/

11

13.



Assume that the force of the car's weight is evenly distributed across it's four tires contact areas (A).

$$\frac{3000\,lbs}{4\,tires} = 750\,\frac{lbs}{tire}$$

$$P = 32psi = \frac{F}{A} = \frac{750\,lbs}{A}$$

$$32psi\,(A) = 750\,lbs$$

$$A = 23.4\,in^2$$

$$A = 9in\,(?) = 23.4\,in^2$$

$$? = 2.6\,in$$

14. The helmet decreases the pressure of the blow by increasing the area over which it is spread.

$$P = \frac{F}{A}$$ as A gets bigger, P decreases as long as F remains constant.

less pressure means the force is not concentrated in as small an area

[Padding increases the acceleration period, thus decreasing acceleration. This decreases force, since F=ma.]

Padding decreases acceleration

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15. The pressure in the balloon has increased.

$$P = \frac{F}{A}$$

F: $ma = 0.4kg(9.8 m/s^2) = 3.92N$

A: $\pi r^2 = \pi(0.05m)^2 = 0.00785 m^2$

$$P = \frac{3.92N}{0.00785m^2} = 499.3pa = 0.072psi$$

The pressure in the balloon has increased by about this much.
Pascal's principle supports this.

16. To calculate liftable payload you will need the net force on the balloon

$$\Sigma F = \text{Buoyancy} - \text{Weight}$$

Buoyancy: calculate this by determining the weight of displaced air

Weight: add up all of the balloon mass (including hot air). One tricky part is the mass of plastic. The surface area of a sphere is $4\pi r^2$. Use that area and the mass area ratio of $19.5 g/m^2$ to get plastic mass.

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17. Pascal's principle $\rightarrow \frac{F_{in}}{A_{in}} = \frac{F_{out}}{A_{out}}$

g's cancel out

In this case, $F = mg \Rightarrow \frac{m\cancel{g}_{in}}{A_{in}} = \frac{m\cancel{g}_{out}}{A_{out}}$

$? \rightarrow \frac{M_{in}}{A_{in}} = \frac{M_{out}}{A_{out}} \leftarrow 1000kg$

$A_{in} = \pi r^2$
$= \pi (0.04m)^2$
$= 0.005027m^2$

$\pi (2m)^2$
$= 12.6m^2$

$$\frac{M_{in}}{0.005027m^2} = \frac{1000kg}{12.6m^2}$$

$M_{in} = 0.399kg$

18. $\frac{F_{in}}{A_{in}} = \frac{F_{out}}{A_{out}}$ ← Tube

Foot

$A_{out} = \pi (0.5cm)^2 = 0.79 cm^2$

$\frac{50N}{100cm^2} = \frac{F_{out}}{0.79cm^2}$ $F_{out} = 0.39N$