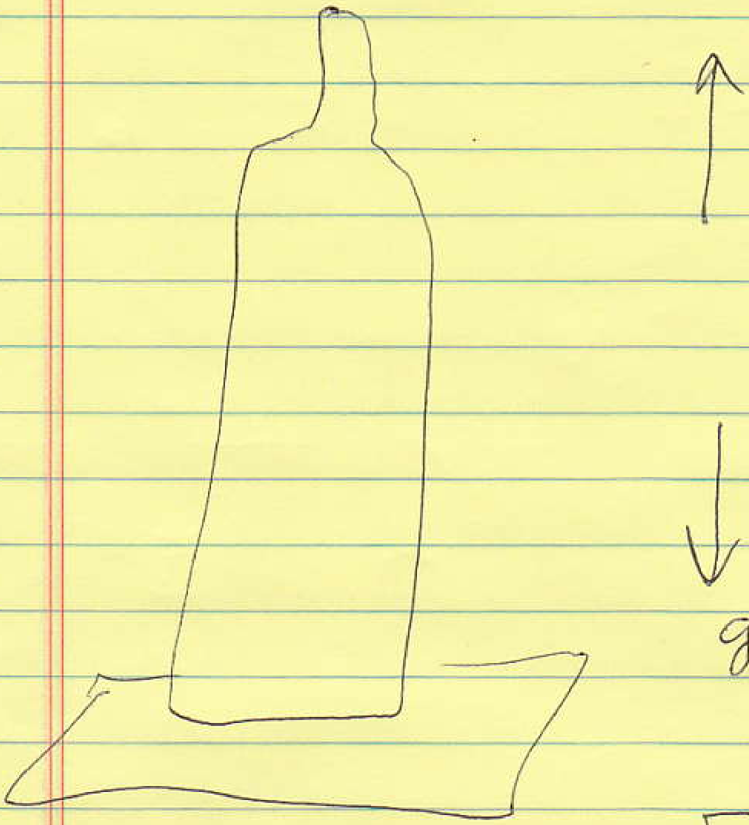

buoyant Force of air

$F_B \propto$ volume of $\underbrace{\text{air displaced}}_{=\text{ volume of object}}$

gravity pulls down

$F_g \propto$ gravitational mass

You need to hold volume constant when weighing tanks of gas (esp. Helium)

Later on, we'll use pressure, temperature & volume.

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webcomic on variance in gravitational strength & pole-vaulting:

http:// xkcd.com/852

HW due 2/1: Ch 1: 1, 2, 4, 6, 7
Reading for 2/1: 1.3, 1.4

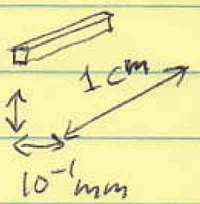
PHYS 2325 HW assigned 1/25: Solutions

0-24 length $\propto \sqrt{\text{area}}$, so if the ratio of areas (per person) is 1.5, then the ratio of distances (on average) between people is $\sqrt{1.5}$

0-25 The nose's surface isn't flat! A bumpy/crinkled/folded surface can have a lot of area but fit in a small volume.

0-26 $160\text{ ft} \times 360\text{ ft}$ = field area $= 5 \times 10^3\ m^2$
Let's estimate a blade of grass as taking up a square area of $2\text{mm} \times 2\text{mm} = 4\text{ mm}^2$
$= 4 \times (10^{-3} m)^2 = 4 \times 10^{-6} m^2$,
to get $\frac{5 \times 10^3}{4 \times 10^{-6}} \approx 10^9$ blades of grass

0-35



A hair's approx. dimensions & shape:
$.1mm \times .1mm \times 1cm$ (a skinny box).
Estimate density as that of H_2O: $1 g/cm^3$.
mass = density × volume $= \frac{1g}{cm^3} \times 10^{-2} cm \times 10^{-2} cm \times 1 cm$
$= 10^{-4} g = 10^{-7} kg$

0-37 $\frac{\text{surface area of Earth}}{\text{surface area of Mars}} = \left(\frac{\text{diameter of Earth}}{\text{diameter of Mars}}\right)^2 = 2^2 = 4$

$\Rightarrow \frac{\text{land area of Earth}}{\text{land area of Mars}} = \frac{30\% \times \text{S.A. of Earth}}{\text{S.A. of Mars}} = .3 \times 4 = 1.2$

$F = ma$

force = (inertial mass) × acceleration

$$\frac{\text{force}}{\text{acceleration}} = \text{inertial mass}$$

gravitional ~~field strength~~ force $\underbrace{\propto}_{\text{is proportional to}}$ gravitational mass

$F = mg$

gravitational force — gravitational mass — gravitational Field strength

9.8 m/s^2 on Earth's surface

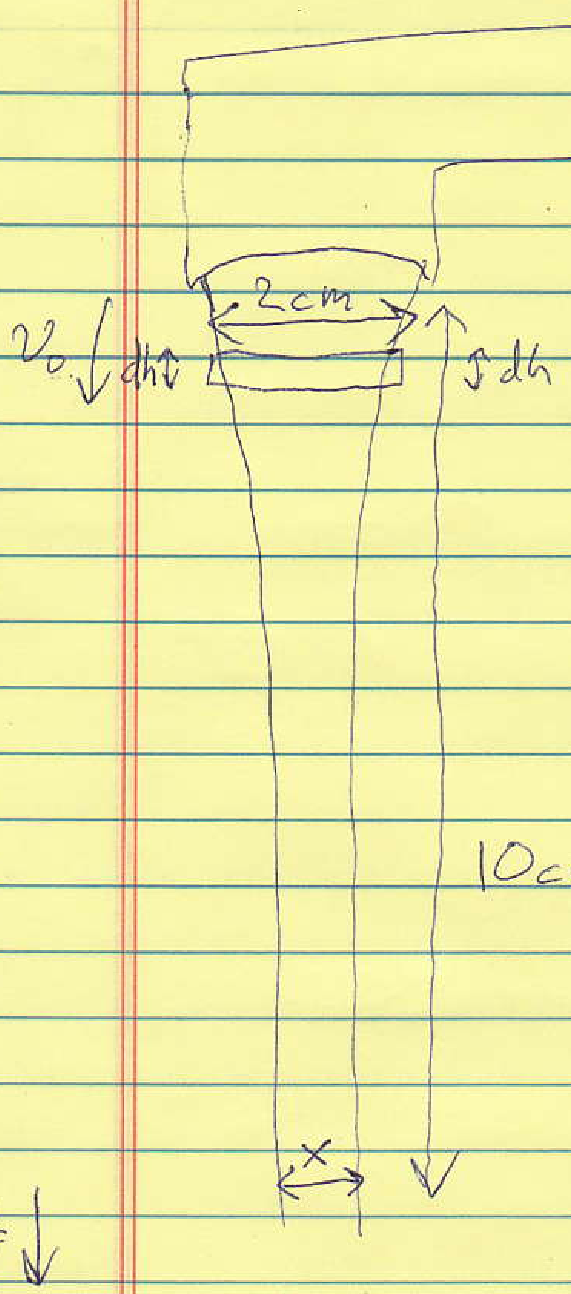
$F = m_i a$

gravitational force → $F = m_g g$

$\Rightarrow m_i a = m_g g$

$$\Rightarrow a = \frac{m_g}{m_i} g$$

Experiments show $a = g$



Need to know v_0

speed at top.

$$v_f^2 - v_0^2 = \underbrace{2 a \Delta y}$$

$a = 9.8 \, m/s^2$

$10cm = \Delta y$

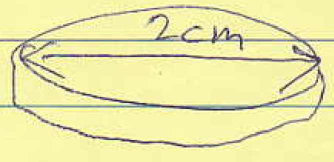
$x = ?$

Assume the density of the H_2O is constant.

~~bottom slice at~~

top slice

dh (small)



volume $= \pi (1cm)^2 \, dh$

bottom slice

$$\text{volume} = \pi \left(\frac{x}{2}\right)^2 dh$$

$$\text{volume} = \frac{\text{mass}}{\text{density}} \Rightarrow$$ total volume of H_2O conserved (if density is constant)

Look at flow in $\frac{\text{volume}}{\text{time}}$

$\frac{\text{volume}}{\text{time}}$ same at top & bottom

top : dt_{top} = time for slice to move down $\downarrow dh$

bottom: dt_{bottom} = time for slice to move down $\downarrow dh$

$$v_f = \frac{dh}{dt_{bottom}} \qquad v_0 = \frac{dh}{dt_{top}}$$

$$\frac{(2\,cm)^2}{x^2} = \frac{\text{volume}_{top}}{\text{volume}_{bottom}} = \frac{dt_{top}}{dt_{bottom}} = \frac{v_f}{v_0}$$

In more detail,

$$\frac{\text{volume}_{top}}{\text{volume}_{bottom}} = \frac{\pi (1cm)^2 \, dh}{\pi (x/2)^2 dh} = \frac{1 cm^2}{x^2/4}$$

$$= \frac{4 cm^2}{x^2}$$

$$\frac{\text{volume}_{top}}{dt_{top}} = \frac{\text{volume}_{bottom}}{dt_{bottom}}$$

$$\Rightarrow \frac{\text{volume}_{top}}{\text{volume}_{bottom}} = \frac{dt_{top}}{dt_{bottom}} = \frac{dt_{top}/dh}{dt_{bottom}/dh}$$

$$= \frac{1/v_0}{1/v_f} = \frac{v_f}{v_0}$$

because $v_0 = \frac{dt_{top}}{dh}$, $v_f = \frac{dt_{bottom}}{dh}$

$$v_f^2 - v_0^2 = 2a\Delta y \Rightarrow v_f = \sqrt{v_0^2 + 2a\Delta y}$$

$$\Rightarrow \frac{v_f}{v_0} = \sqrt{1 + \frac{2a\Delta y}{v_0^2}}$$

$$\Rightarrow \frac{4cm^2}{x^2} = \frac{\text{volume}_{top}}{\text{volume}_{bottom}} = \frac{v_f}{v_0} = \sqrt{1 + \frac{2a\Delta y}{v_0^2}}$$

$$\Rightarrow x^2 = \frac{4\,cm^2}{\sqrt{1+\frac{2a\Delta y}{v_0^2}}}$$

$$\Rightarrow x = \frac{2\,cm}{\sqrt[4]{1+\frac{2a\Delta y}{v_0^2}}}$$

Recall $a = 9.8\,m/s^2$ & $\Delta y = 10\,cm.$

If we can find v_0, then we can find x. Here's how to find v_0 by experiment:

$f = \frac{\text{volume}}{\text{time}}$ can be measured by seeing how long it takes for the pouring water to fill a known volume, like a 1L bottle. ($1L = 10^3 cm^3$).

Given f, $\quad f = \frac{\text{volume}_{top}}{dt_{top}} = \frac{\pi (2cm)^2\, dh}{dt_{top}}$

$$= \pi (2cm)^2 \underbrace{v_0}_{v_0 = \frac{dh}{dt_{top}}} \Rightarrow v_0 = \frac{f}{4\pi\, cm^2}$$