I plan to skip Solids . . . STRESS, STRAIN For NOW

Fluid Mechanics

hydrostatics

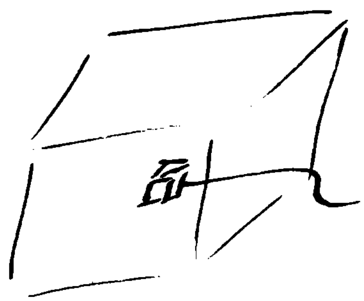
Average Volume density $= \dfrac{M}{V} \equiv \rho$ kg/m^3

We will see

Area densities

line densities

in P114



$\rho = \dfrac{dm}{dv}$

$dm = \rho\, dv$

Specific gravity $= \dfrac{\rho_{material}}{\rho_{H_2O \text{ at } 4°C}}$ $= 1000\, kg/m^3 = 1\, g/cm^3$

unitless

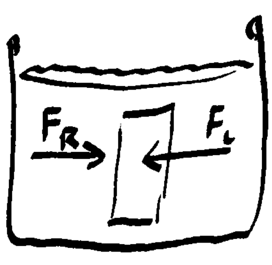
This has Nothing to do w/ gravity really

if specific gravity > 1 object will Sink in water at 4°C

< 1 " " float " " "

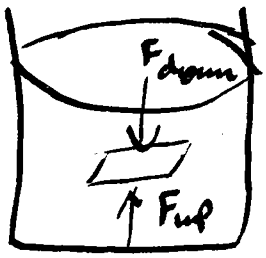
Consider a bucket of water with a (Saran Wrap / Plastic Wrap) divider

w/ fluid at rest



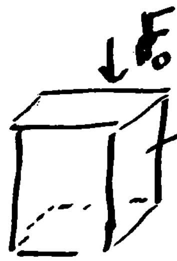
Total force of the fluid on the plastic wrap is 0 or it would Accelerate

$\therefore\ \bar{F}_L = \bar{F}_R$



Same if plastic wrap oriented this way

What is F_{down}?



Mass of fluid = ρ_{fluid}(Volume)

$$\therefore \quad F_{down} = F_0 + \rho V g$$

$$\frac{F_{down}}{\text{Area}} = \frac{F_0}{\text{Area}} + \frac{\rho(\text{Area})(\text{height})\,g}{(\text{Area})}$$

define F/Area = Pressure $\quad N/M^2 \equiv$ Pascal

in This case the F is constant over area

in some cases it may not be → go to differential limit

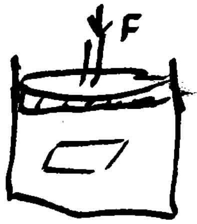
$$\text{Pressure} = \frac{dF_\perp}{dA}$$

$1\text{ atm} = 1.013 \times 10^5\ Pa$
$= 1013$ millibars
$= 14.70\ lb/in^2$

$$\boxed{P = P_0 + \rho g h}$$

Also $F_{up} = F_{down}$ $\quad \therefore P_{up} = P_0 + \rho g h$ as well!

IF we change F_0 on top of fluid w/ a Piston



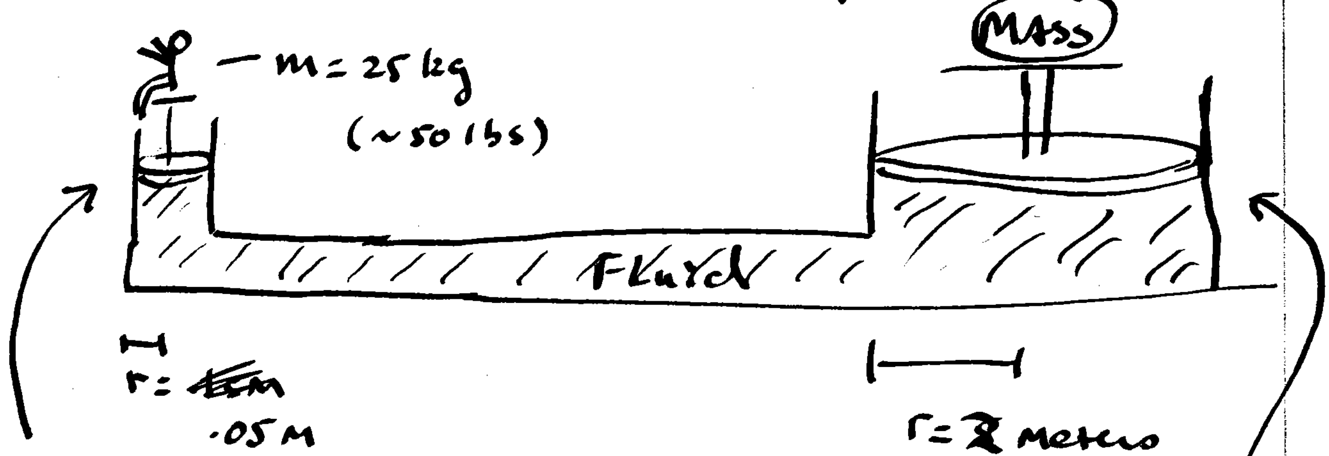
P on top and bottom of plastic wrap change ~~too~~ in response!

Pascal's Law:

Pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and to the walls of the containing vessel.

__Example__ __hydraulics__

A small child sits on a massless piston



$$P = \frac{F}{A} = \frac{(25)(9.8)}{\pi(.05)^2} = P = \frac{(\text{Mass})\,g}{\pi(2)^2}$$

$= \cancel{325}$ 31,194 Pa

equality from Pascal's law

$$\therefore\ 31{,}194\ Pa = \frac{\text{Mass}\ 9.8}{\pi(2)^2}$$

Mass = 40,000 kg

~80,000 lbs

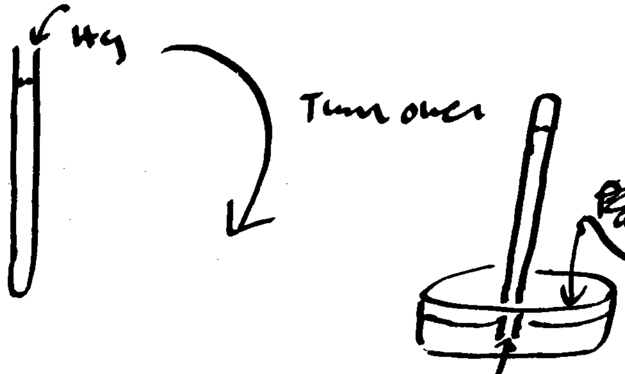
⇒ A baby can lift a loaded Truck!

Example

Mercury barometer

Hg

Turn over



~~$P_{atmosphere}$~~

$$P = P_0 + \rho g h$$

define $h=0$

$P_0 = P_{atmosphere}$

$\therefore P = P_{atm}$

$P = \underbrace{P_0}_{=0} + \rho g h$

$P = \rho g h$

These must be the same by Pascal's law

$$\therefore \quad P_{atm} = \rho g h$$

← height of column of Mercury

This is why one hears of pressure in inches of mercury!

1 mm Hg = pressure of 1 Torr

1 atmosphere ≈ 760 mm $= .76$ m Hg

760 Torr

Archimede's principle

When a body is completely or Partially submerged in a fluid, the ~~to~~ fluid exerts an upward force on the body equal to the weight of the displaced fluid.

bouyancy bouyant force

Example

Seawater
Specific gravity = 1.03

What fraction of an iceberg is submerged?

bouyant force = weight of displaced fluid = Weight of TOTAL iceberg

$$\text{specific gravity} = \frac{\rho_{material}}{\rho_{H_2O \text{ at } 4^\circ C}}$$

let V = Volume iceberg
x = submerged fraction

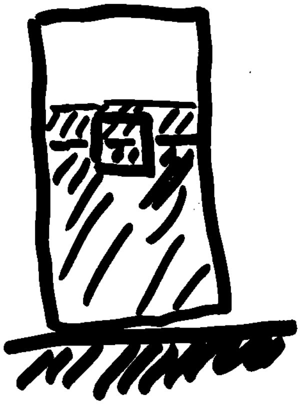
$$(\rho_{seawater})\, x\, V = (\rho_{ice})\, V$$

÷ both sides by ρ_{H_2O} at 4°C

$$(Sg_{seawater})\, x\, V = (Sg_{ice})\, V$$

$$x = \frac{\text{Spec. grav ice}}{\text{Spec. grav seawater}} = 89\%$$

Consider an object that floats in water but sinks in oil. When the object floats in water it is half submerged. If we slowly pour oil on top of the water so it completely covers the object, the object



1. Moves up
2. Stays in the same place
3. Moves down

Before oil

$$\vec{F}_{\text{BouyanT}} = \text{WT of Displaced water} \quad \hat{up}$$

After oil

$$\vec{F}_{\text{Bouyant}} = \text{WT of Displaced water} + \text{WT of Displaced oil} \quad \hat{up}$$

$|\vec{F}_{\text{Bouyant}}| = Mg$ in both cases

So, less water Displaced when oil present

$\Rightarrow$ object Moves up (1)

A boat carrying a large boulder is Floating on a lake. The boulder is thrown overboard and Sinks. The Water level in the lake (w/ respect to Shore)

1. Rises
2. Drops
3. Remains the same

WT displaced water

=

WT boat +

WT boulder

(Vol boulder) $\rho_{boulder}$

WT displaced water

=

WT boat plus

(Vol boulder) ρ_{water}

smaller

$\Rightarrow$ Water drops, less displaced 2