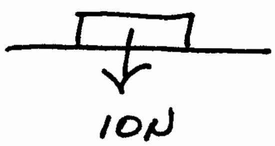
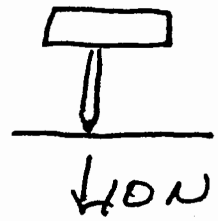
PRESSURE

Pressure = force per unit area.

Tells the way in which force is distributed

Obviously its not the same thing to apply 10 N force uniformly over a large area as to apply it over a v. small area



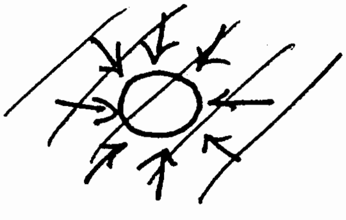


$$P = \frac{F}{A}$$

Since the pressure may vary from point to point technically

$$P = \lim_{A \to 0} \left(F/A \right)$$

Within a fluid there is a force exerted in all directions

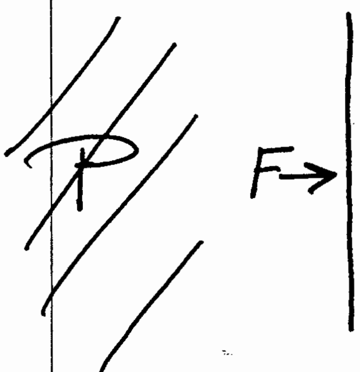


$$\bar{P} = \frac{\text{normal force on surf}}{\text{surface area}}$$

(nb Newton's 3^{rd} law says that if outside fluid is providing F per unit area inward Vol is providing F outward)

11 **PASCAL'S LAW** | Pressure applied to an enclosed fluid is transmitted ~~throughout~~ fluid and to container

Also - fluid at pressure P is exerting a force outward on the walls of the container



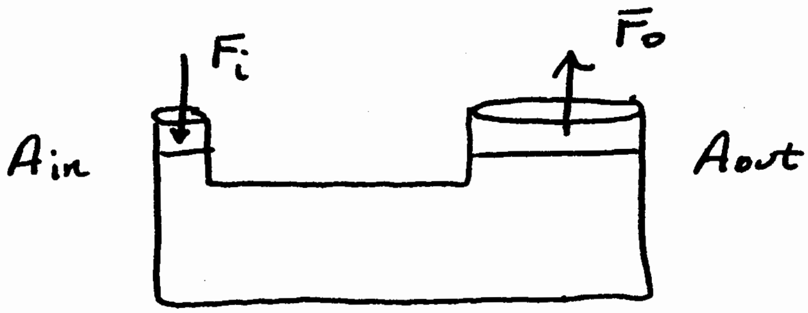
Tire pressure of a typical radial tire is 24 lb/in² as registered on a conventional tire guage. This is called *guage pressure* and is really the pressure difference between inside + outside pressure

$P_{inside} = P_{gauge} + P_{out} = 38.7\ lb/in^2$

$P_{outside} = 1\ atm = 14.8\ lb/in^2$

There is a net outward force of $24\ lb/in^2 = 1.65\times10^5\ N/m^2$ or a total outward force of $38.7\ lb/in^2 = 2.67\times10^5\ N/m^2$ balanced partially by the external pressure of $14.7\ lb/in^2 = 1.01\times10^5\ N/m^2$

HYDRAULIC LEVER



Input force F_i on area $A_i \ll A_o$; thus

$$\Delta P_i = \frac{F_i}{A_i}$$

By Pascal's law

$$\Delta P_i = \Delta P_o$$

$$\frac{F_i}{A_i} = \frac{F_o}{A_o}$$

$$F_o = F_i \frac{A_o}{A_i} \quad (\gg A_i)$$

We have effectively "magnified" the input force by the ratio of areas. Doesn't this violate some work/energy relation

<u>No!</u>

Suppose piston at i is displaced by an amt d_i; a volume of water $V_i = d_i A_i$ will be displaced

Now

$$V_o = d_o A_o = V_i = d_i A_i$$

$$d_o = \frac{A_i}{A_o} d_i \; (\ll d_i)$$

thus the resultant displacement is small

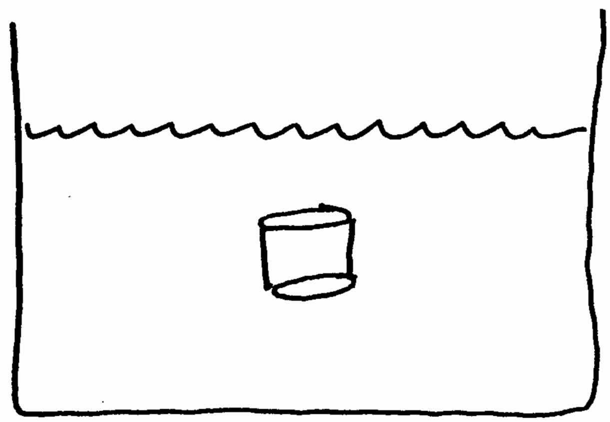
$$W_{in} = F_i d_i$$

$$= F_o \frac{\cancel{A_i}}{\cancel{A_o}} \cdot d_o \frac{\cancel{A_o}}{\cancel{A_i}}$$

$$= F_o d_o = W_o$$

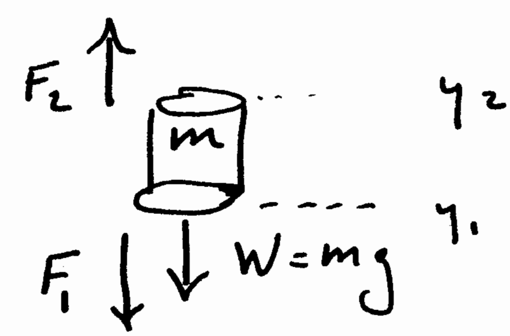
Input work & output work are the same

Pressure in static fluids (This will be developed further as Bernoulli's Eqn



Consider mass of H_2O m, in static equilibrium

FREE BODY EQN



Independent of anything else, if water is static

$$F_2 = F_1 + mg$$

Now force comes, of course, from pressure,

$$F_2 = P_2 A = F_1 + mg = P_1 A + mg$$

$$mg = \rho V g = \rho A \Delta y g$$

$$P_2 \cancel{A} = P_1 \cancel{A} + \rho \cancel{A} g (y_2 - y_1)$$

$$\boxed{P_2 = P_1 + \rho g (y_2 - y_1)}$$

If we define the surface of the fluid

where $P_0 = P_1 = 1\,\text{atm}$ $\qquad P_2 = P$

$y_1 = 0$ $\qquad y_2 = -h$

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

I just bought a cheapo CASIO watch which is s'posed to be watertight down to 50 m

$$P(50\,\text{m}) = P_0 + \rho g h$$

$$= 1\times10^5\,\text{Pa} + 1000\,\text{kg/m}^3 \cdot 9.8\,\text{m s}^{-2} \cdot 50\,\text{m}$$

$$= 1\times10^5\,\text{Pa} + 4.9\times10^5\,\text{Pa}$$

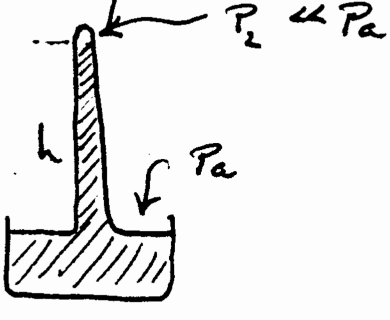
must withstand $\approx$ 5 atm additional pressure

This is a hydraulic press; apply a small force F_2 in a small cylinder connected to a large cylinder + get a large mechanical advantage

e.g. Rack in service station
Barber chair
Hydraulic brakes

Blaise Pascal's (1623-1662) principle
"Pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and to the walls of the enclosing vessel"

Mercury Barometer



$$P_a = \rho g h$$

$$P_a = 1.0 \times 10^5 \, N m^{-2}$$

$$g = 9.8 \, m s^{-2}$$

$$\rho_{mercury} = 1.36 \times 10^4 \, kg \, m^{-3}$$

$$h = \frac{P_a}{\rho g} = \frac{1.0 \times 10^5 \, N m^{-2}}{9.8 \, m s^{-2} \; 1.36 \times 10^4 \, kg \, m^{-3}}$$

$$h = 0.75 \, m = 750 \, mm$$

(760 is about normal atm pressure