Physics 101.

Lecture 29

Mon. March 17, 2003.

Topics Covered.

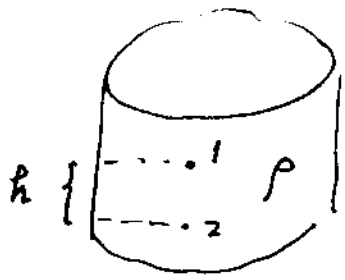
- Pressure in a fluid.
- Pascal's Principle
- Buoyancy, ~~fluid flows~~.

Ref. 15-1, 2, 3, 4, 5. 6, ~~7~~.

- The pressure in a fluid acts equally in all directions, and acts at right angles to any surface.

- Pressure and depth at static equilibrium,

$$P_2 = P_1 + \rho g h.$$



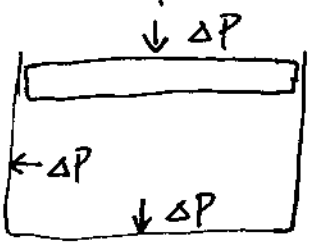
- Pascal's Principle.

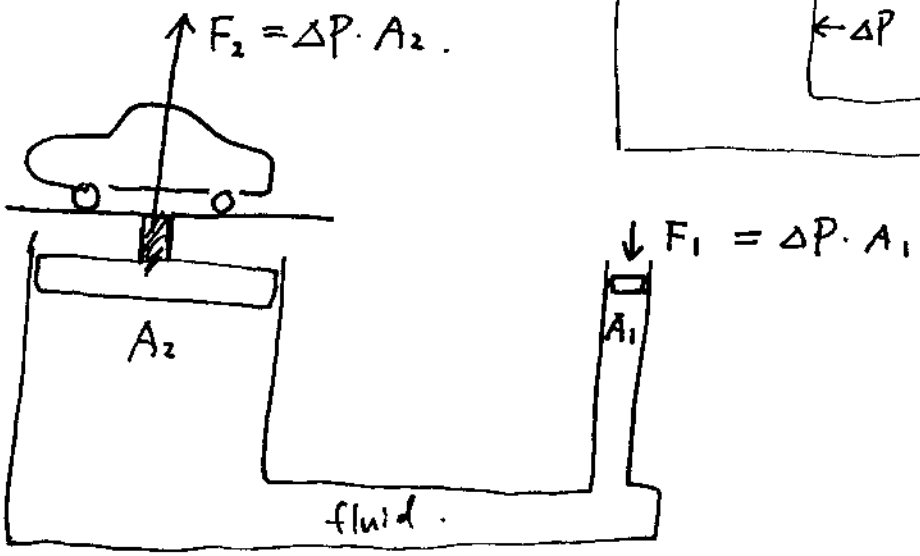
An external pressure applied to an enclosed fluid is transmitted unchanged to every point in the fluid.

i.e. ΔP is the same everywhere (enclosed system)

e.g. Hydraulic Lift

Pascal's principle.





Since ΔP is the same everywhere,

$$\frac{F_2}{A_2} = \frac{F_1}{A_1}.$$

$$F_2 = \frac{A_2}{A_1} F_1. \gg F_1 \quad \left(\text{if we choose } A_2 \gg A_1\right)$$

"Magnify" force F_1 !

But No free lunch ! — We can't save work.

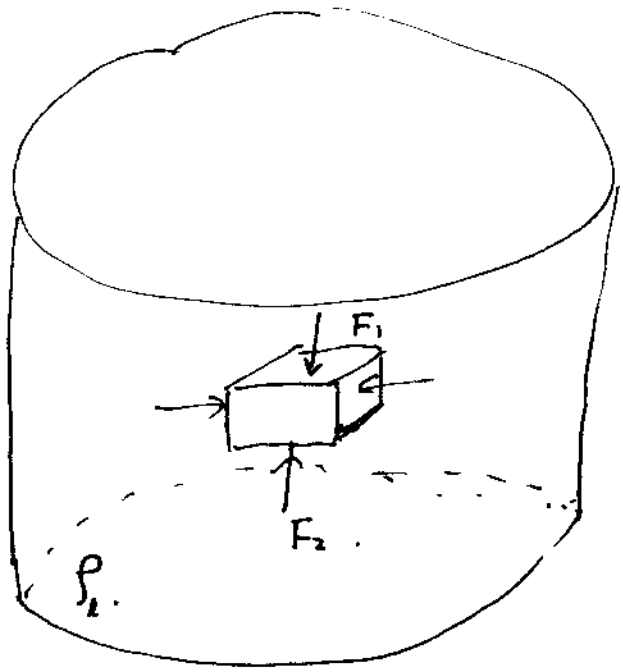
e.g. if we want to lift the car by a distance d_2, we would have to apply F_1 by a distance d_1

$$d_1 = \frac{A_2}{A_1} \cdot d_2. \gg d_2. \quad (d_1 A_1 = d_2 A_2 = \text{Volume})$$

$$F_1 d_1 = F_2 d_2. = W \quad (\text{same work}).$$

• Buoyancy (Floating force)

The fluid exerts a net upward force on the cube. B.



$F_{Lateral} = 0$ (cancelled)

$\therefore \quad B = F_2 - F_1$

$= P_2 \cdot A - P_1 \cdot A$.

$= \rho g h A$ (ρ — density of the fluid)

$= \rho g V$

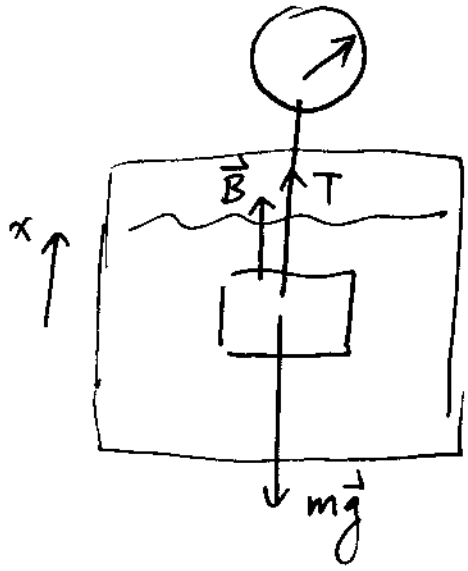
i.e.: An object completely immersed in a fluid experiences an upward buoyant force whose magnitude is equal to the weight of fluid displaced by the object.

This is Archimede's Principle:

In general, if the object only partly immersed in the fluid, e.g. if a volume V is submerged in the fluid, Then, $B = \rho g V$.

V = Volume of displaced fluid. ≠ volume of object.

- e.g. Apparent weight of a completely immersed object.



$$T + B - mg = 0$$

$$T = mg - B$$

$$= \rho_s \cdot Vg - \rho_\ell \cdot Vg$$

$$= \rho_s V g \left(1 - \frac{\rho_\ell}{\rho_s}\right)$$

$$= mg \left(1 - \frac{\rho_\ell}{\rho_s}\right)$$

e.g. p. 478.