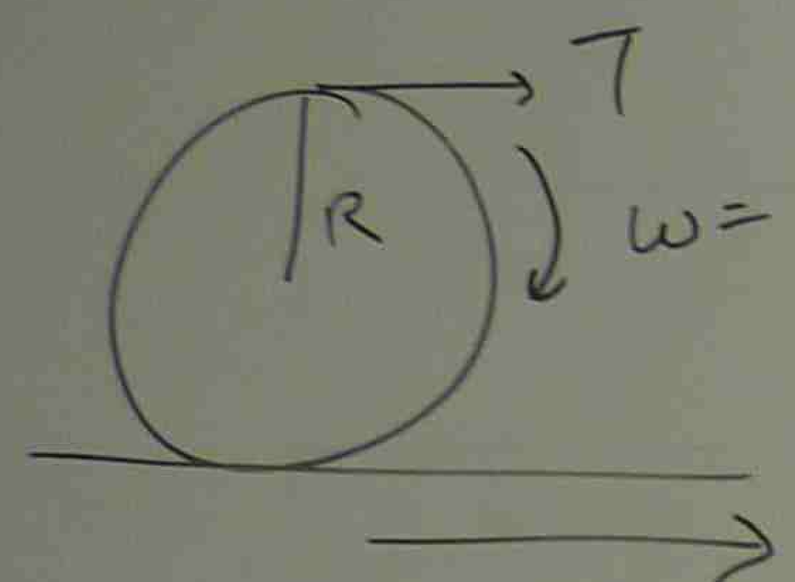
TORQUE & EQUILIBRIUM



ω = ANGULAR VELOCITY

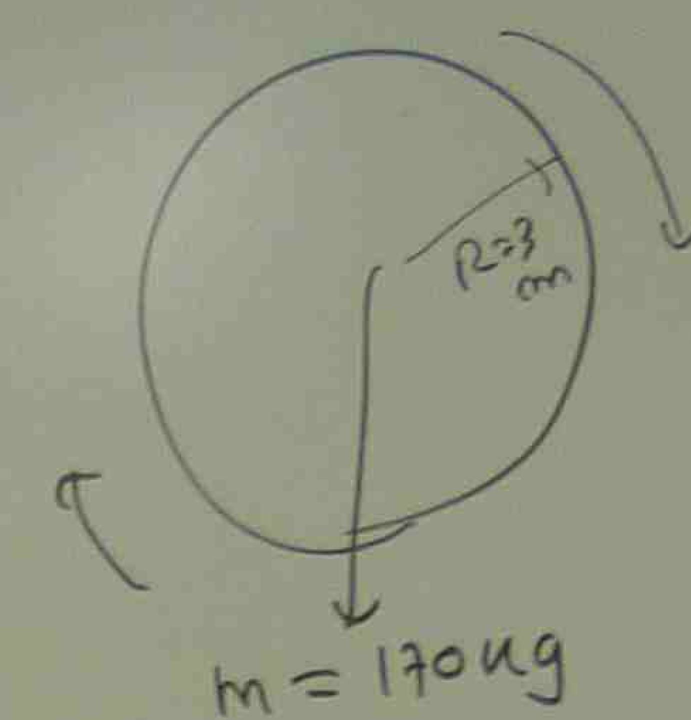
V = LINEAR VELOCITY

$V = \omega \times R$

KINETIC ENERGY $\Rightarrow K = \frac{1}{2} I \omega^2$

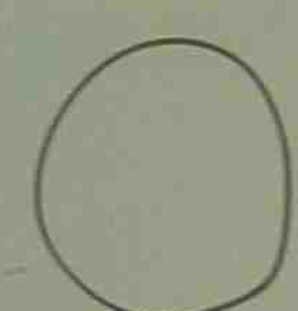
I = MOMENT OF INERTIA
ω = ANGULAR VELOCITY RAD/S

PD A ROLLING OBJECT HAS LINEAR VELOCITY
342.5 m/s, RADIUS = 3 m
MASS = 170 kg.
CALCULATE TOTAL KINETIC ENERGY



$$K = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2$$

$$\omega = \frac{V}{R}$$



$$I = \frac{1}{2} m R^2$$

$$K = \frac{1}{2} \times \left(\frac{1}{2} m R^2\right)\left(\frac{V}{R}\right)^2 + \frac{1}{2} m v^2$$

$$= \frac{1}{4} m R^2 \times \frac{v^2}{R^2} + \frac{1}{2} m v^2$$

$$= \frac{1}{4} m v^2 + \frac{1}{2} m v^2$$

$$K = \frac{3}{4} m v^2 = \frac{3}{4} \times 170 \times (342.5)^2$$

$$= 1.5 \times 10^7 \text{ J}$$

$\frac{1}{2} m v^2$

2

$) \left(\frac{v}{R}\right)^2 + \frac{1}{2} m v^2$

$\times \frac{v^2}{R^2} + \frac{1}{2} m v^2$

$+ \frac{1}{2} m v^2$

$= \frac{3}{4} \times 170 \times (342.5)^2$

$= 1.5 \times 10^7 \ J$

EQUILIBRIUM

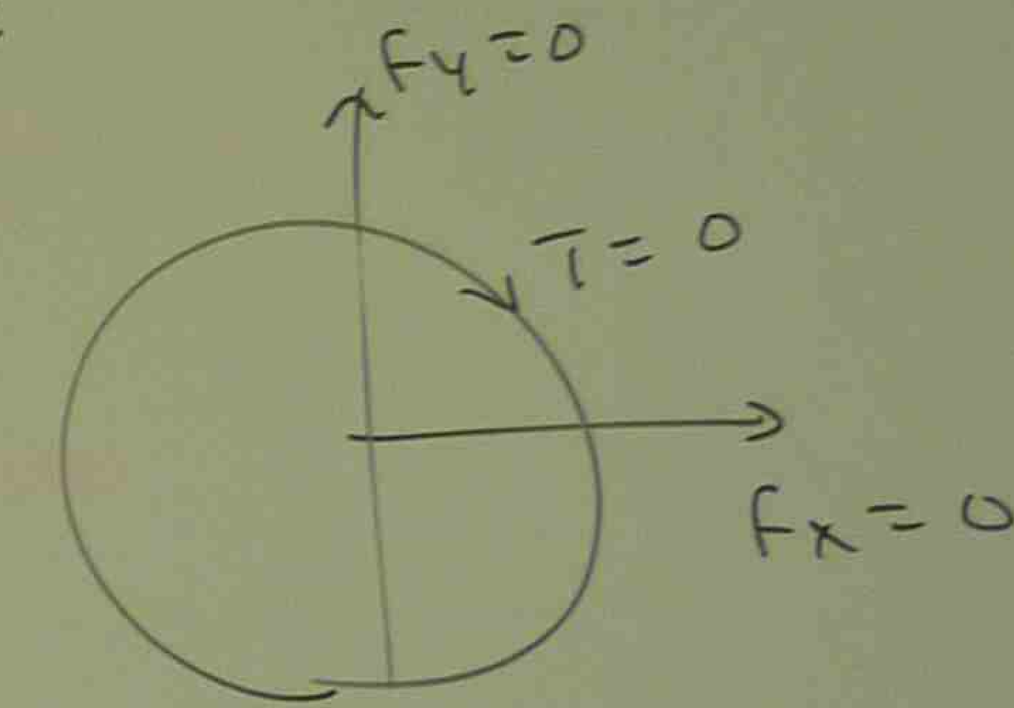
THE LINEAR MOMENTUM $\vec{P}$ = CONSTANT

ANGULAR MOMENTUM $\vec{L}$ = CONSTANT

RATE OF CHANGE OF $P = 0 \longrightarrow$ EQUILIBRIUM

$$\frac{dP}{dt} = 0 \qquad F_{NET} = \frac{dP}{dt} = 0$$

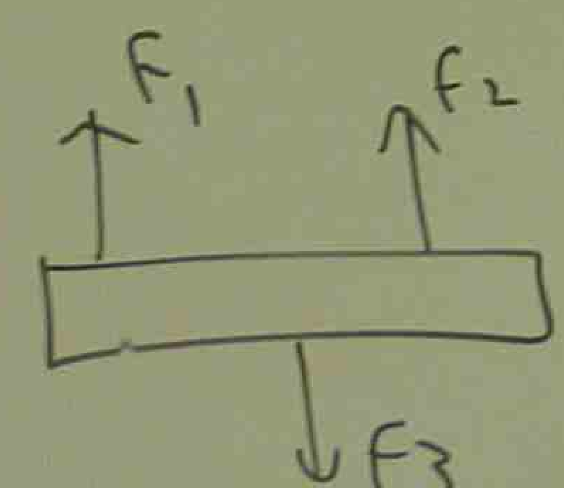
$\uparrow$ FORCE



$F_{NET} = 0 \longrightarrow \sum F_x = 0$

$\sum F_y = 0$

$\tau_{NET} = 0$



$\uparrow F_1 + F_2 = \downarrow F_3$

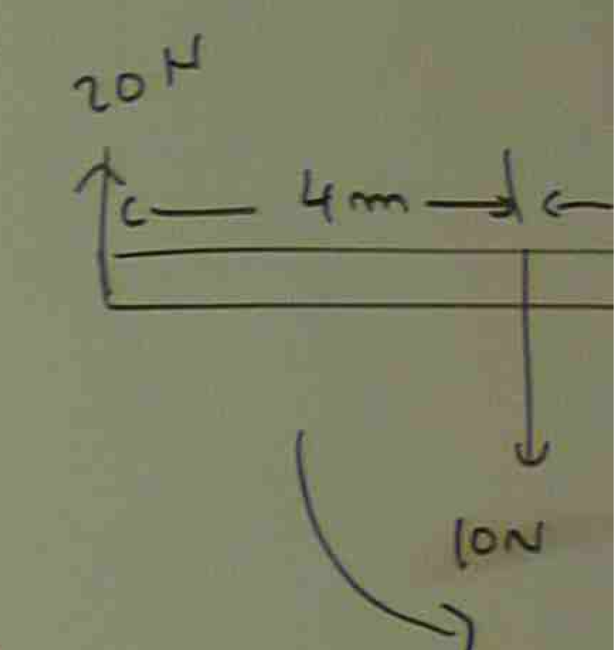
P9

THE FIGURE GIV

OF A UNIFORM RO

(a) CAN YOU FIN

UNIFORM FORC



(a) CENTRE

@ a $\circlearrowleft$ =

$F_2 \times (1+1) + 10$

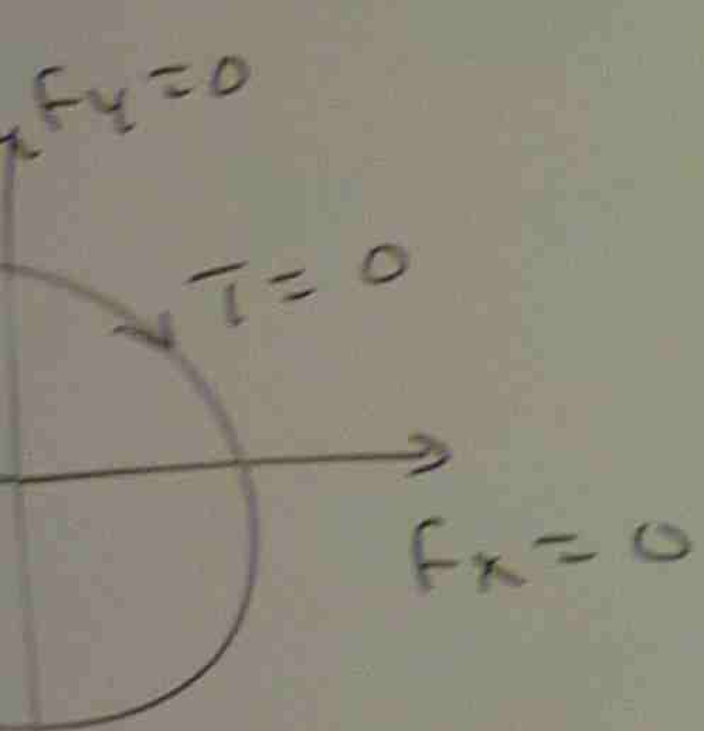
$2F_2 + 20$

$2F_2 + 20$

$2F_2 =$

$F_2 =$

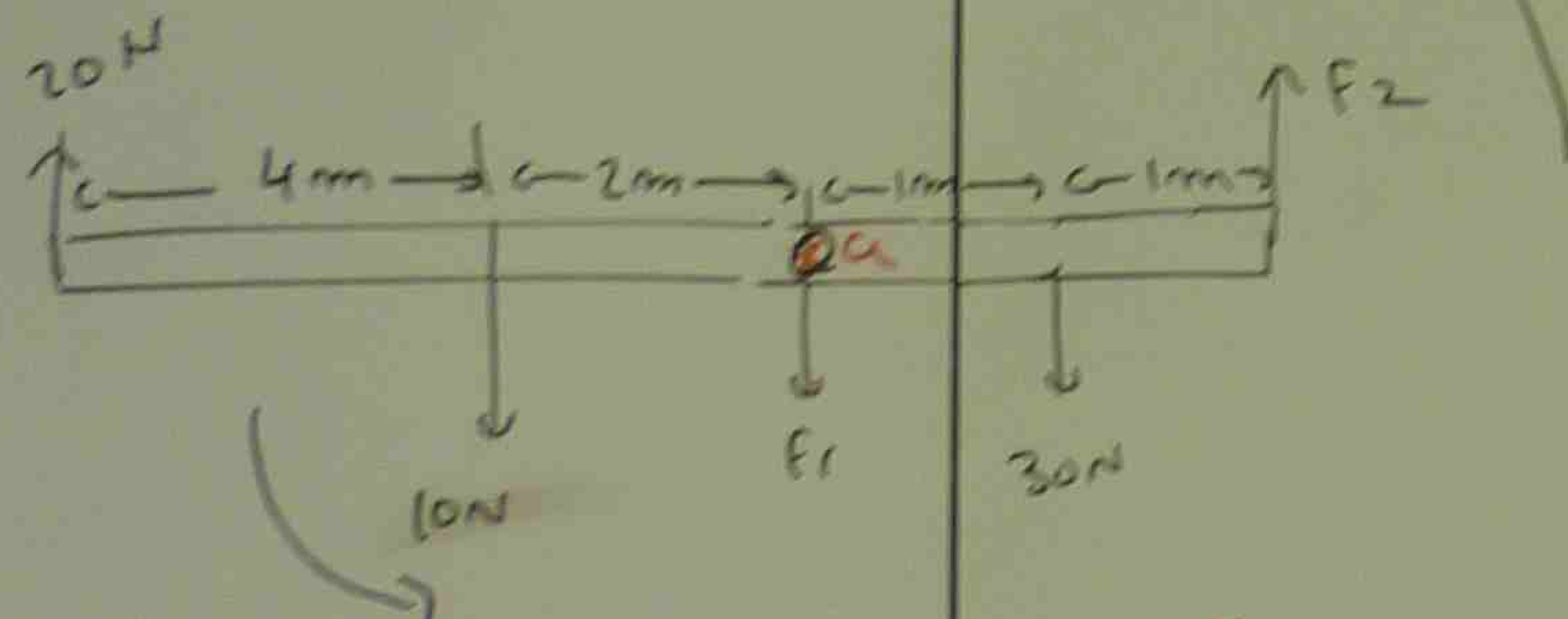
um



pb

THE FIGURE GIVES AN OVERVIEW OF A UNIFORM ROD IN STATIC EQUILIBRIUM

(a) CAN YOU FIND THE MAGNITUDE OF UNIFORM FORCES F_1 & F_2



(a) CENTRE OF MOMENT

@ a $\circlearrowleft = \circlearrowright$

$$F_2 \times (1+1) + 10 \times 2 = 30 \times 1 + 20(4+2)$$

$$2F_2 + 20 = 30 + 120$$

$$2F_2 + 20 = 150$$

$$2F_2 = 130$$

$$F_2 = 65\ N$$

$$\sum F_y = 0$$

$$\uparrow F = \downarrow F$$

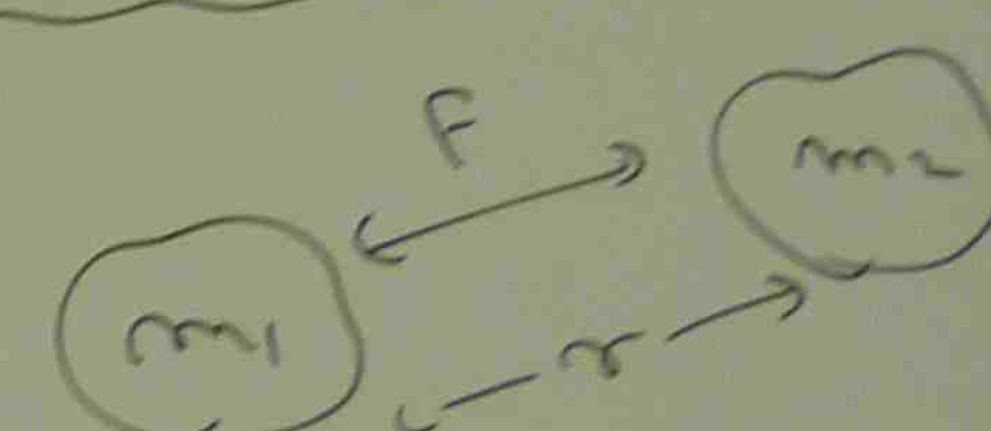
$$20 + F_2 = 10 + F_1 + 30$$

$$20 + 65 = 10 + F_1 + 30$$

$$85 = 40 + F_1$$

$$F_1 = 85 - 40 = 45\ N$$

GRAVITATION



m_1, m_2 = MASS

F = FORCE

r = DISTANCE BETWEEN m_1 & m_2

G = CONSTANT

$$F = G\frac{m_1 m_2}{r^2}$$

$G = 6.67 \times 10^{-11}\ m^3/kg$

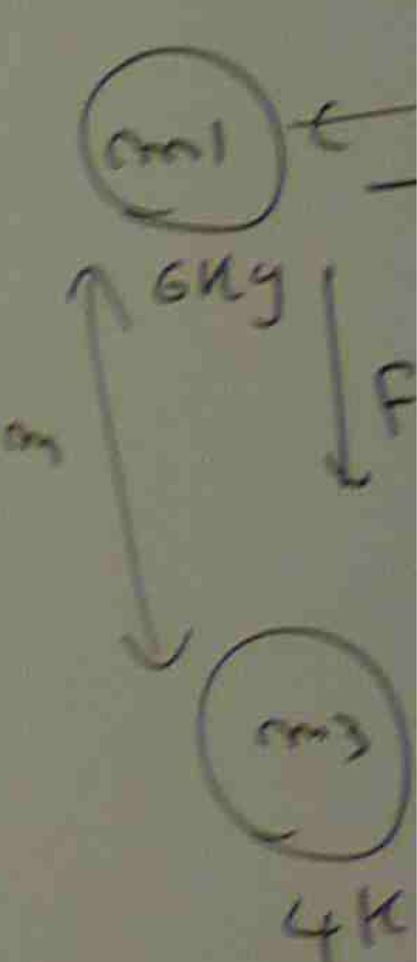
pb

$m_1 = 6\ kg,$

$d = 2\ cm.$

FIND F_{NET}

TO OTHER P



+ 30

30

SN

MASS

NCE BETWEEN

m2

UT

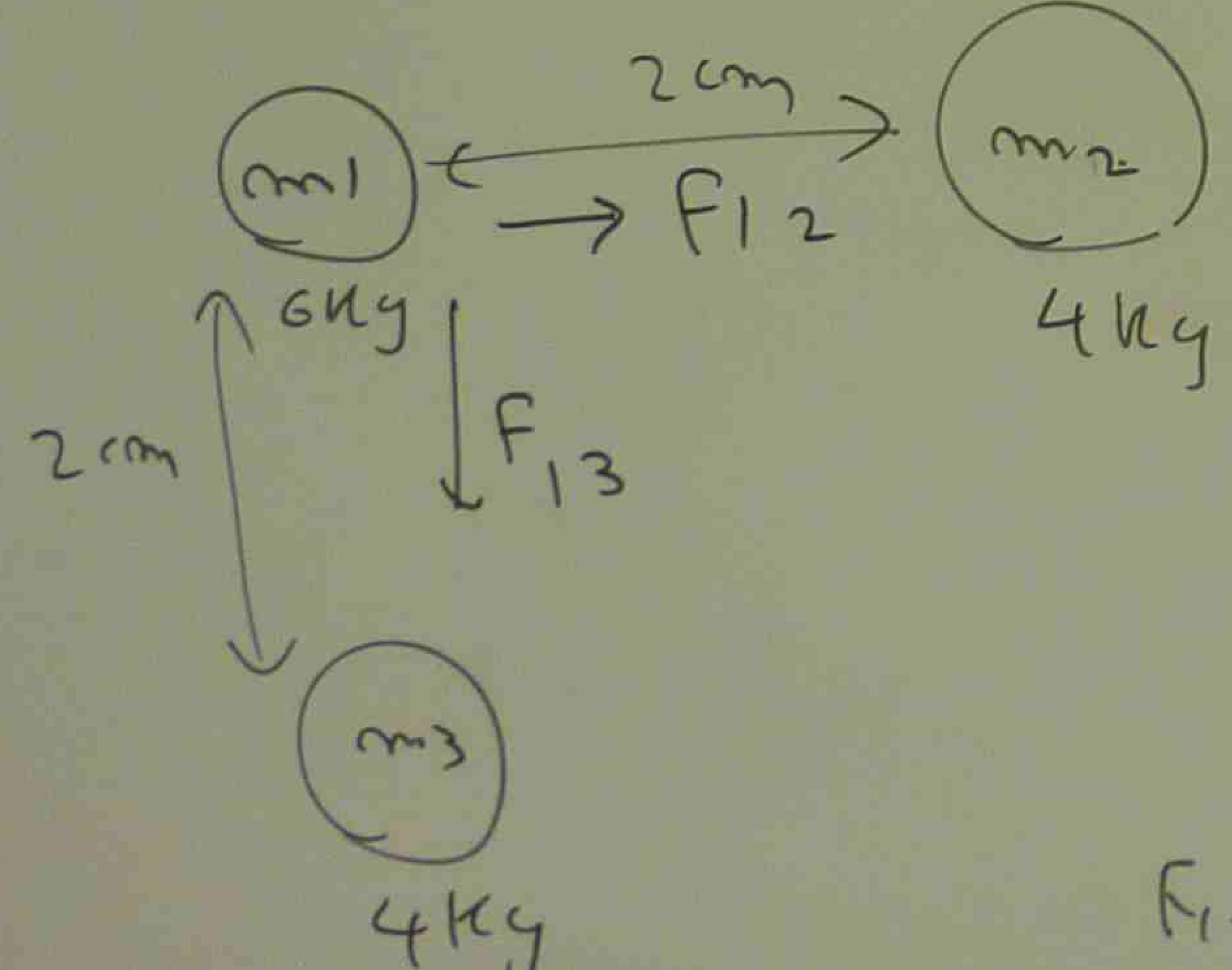
$$F = G\,\frac{m_1 m_2}{r^2}$$

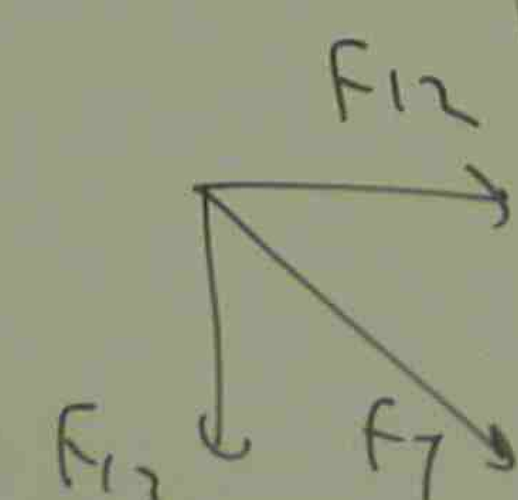
$$G = 6.67 \times 10^{-11}\ m^3/kg\text{-}s^2$$

pb $m_1 = 6\ kg,\ m_2 = m_3 = 4\ kg$

$d = 2\ cm.$

FIND F_{NET} ON PARTICAL 1 DUE TO OTHER PARTICLES





$$F_{NET} = \Sigma F$$

$$F_{12} = G \times \frac{m_1 m_2}{r^2}$$

$$= 6.67 \times 10^{-11} \times \frac{6 \times 4}{\left(\frac{2}{100}\right)^2}$$

$$= 6.67 \times 10^{-11} \times \frac{6 \times 4}{\frac{4}{10^4}}$$

$$= 6.67 \times 10^{-11} \times 10^4 \times 6$$

$$= 6.67 \times 10^{-7} \times 6 = 40 \times 10^{-7}\ N$$

$$F_{31} = G \times \frac{m_1 m_2}{r^2}$$

$$= 6.67 \times 10^{-11} \times \frac{4 \times 6}{\frac{4}{10^4}}$$

$$= 40 \times 10^{-7}\ N$$

$$F_T = \sqrt{f_{12}^2 + f_{13}^2} = \sqrt{(40 \times 10^{-7})^2 + (40 \times 10^{-7})^2}$$

$$= 56.4 \times 10^{-7}\ N$$

x 4

$\left[\ \right]^2$

x 4

6

$= 40 \times 10^{-7}$ N

$\frac{4 \times 6}{\frac{4}{10^4}}$

7 N

$\sqrt{(40\times10^{-7})^2 + (40\times10^{-7})^2}$

$= 56.4 \times 10^{-7}$ N

FLUID

FLUID IS A SUBSTANCE THAT CAN FLOW.

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

DENSITY

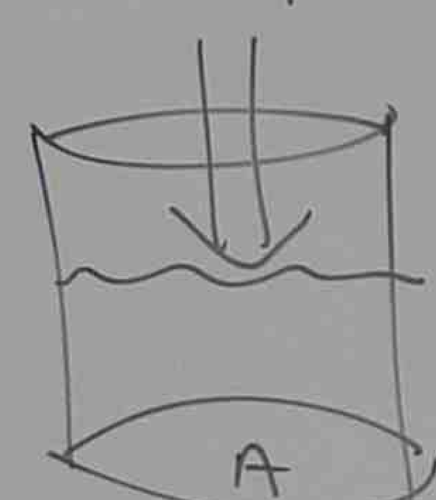
AIR = 1.21 kg/m^3
(20°C)

WATER = $= 1 \times 10^3$
20°C, 50 atm

IRON = 7.9×10^3

PRESSURE

FORCE



$$\underset{(Pa)}{\text{PRESSURE}} = \frac{\text{FORCE}}{\text{AREA}} = \frac{F\,(N)}{A\,(m^2)}$$

If $F = mg$

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

for 1 unit area $A = 1$

unit pressure $= mg$

mass = density x volume

$m = \rho \times V$

unit pressure $= \rho V \times g$

FLUID

" CAN FLOW.

THE

ATUM

$\frac{1}{2}\rho V_2^2 + \rho g h_2$

If $F = mg$

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

FOR 1 UNIT AREA $A = 1$

UNIT PRESSURE $= mg$

MASS = DENSITY $\times$ VOLUME

$m = \rho \times V$

UNIT PRESSURE $= \rho V \times g$

Pb A LIVING ROOM HAS THE FLOOR DIMENSION 3.5m × 4.2m AND A HEIGHT OF 2.4m.

(a) WHAT DOES THE AIR IN THE ROOM WEIGH WHEN THE AIR PRESSURE IS 1 ATM?

(b) WHAT IS THE MAGNITUDE OF THE ATMOSPHERE'S DOWNWARD FORCE ON THE TOP OF YOUR HEAD WHICH WE TAKE TO HAVE AN AREA OF $0.04\,m^2$?

(a) $F_{AIR} = \rho V g$

$= 1.21\ kg/m^3 \times (3.5 \times 4.2 \times 2.4) \times 9.8 = 420\ N$

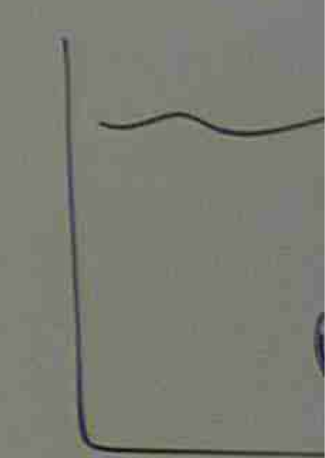
(b) $F = p \times A$

$= (1\ ATM) \times \left\{ \dfrac{1.01 \times 10^5\ N/m^2}{1\ ATM} \right\} \times 0.04\ m^2$

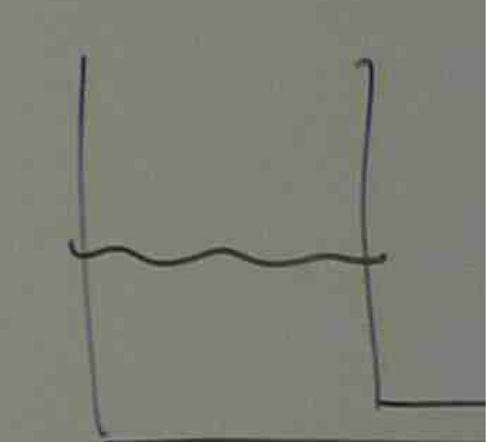
$1\ ATM \rightarrow 1.01 \times 10^5\ N/m^2$

$= 4 \times 10^3\ N$

FLUID PRESSU



$P_2 = P_0$ -



Pb THE

TWO L

DENSITY OF

$\ell = 135$ m

WHAT (

...OOR DIMENSION AND A HEIGHT OF 2.4m.
3.5m × 4.2m
...HE ROOM WEIGH WHEN THE AIR PRESSURE

...OF THE ATMOSPHERE'S DOWNWARD FORCE
...AD WHICH WE TAKE TO HAVE AN AREA
...AD

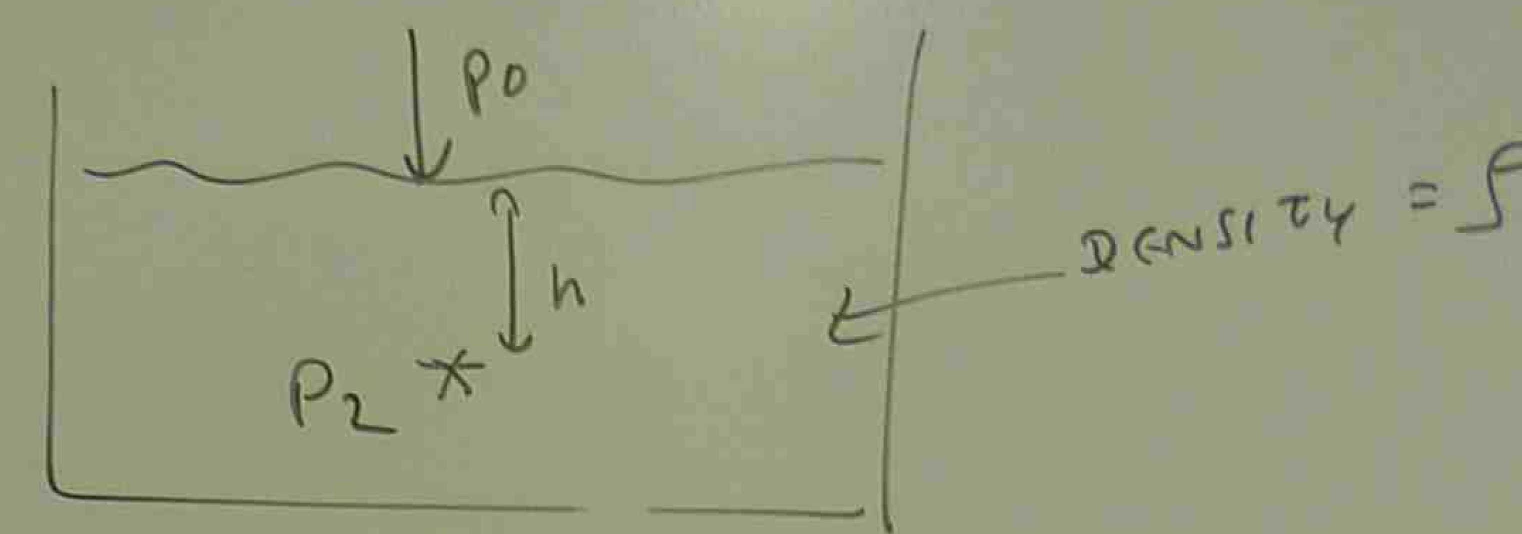
$\ldots 2 \times 2.4) \times 9.8 = 420\,N$

$\times\ 10^5\ N/m^2 \Big\} \times 0.04\ m^2$

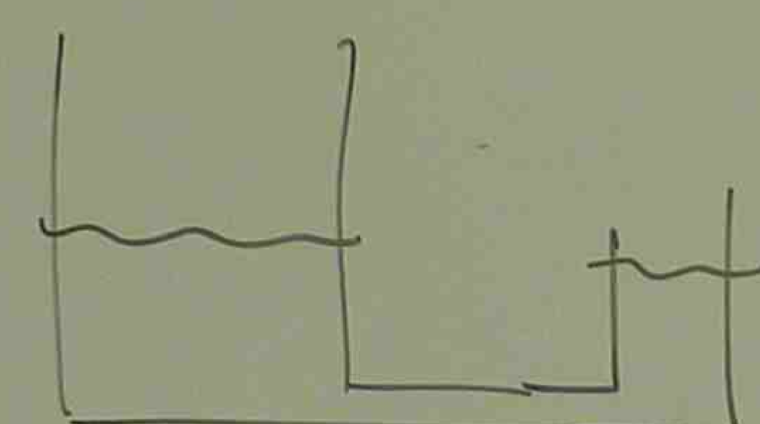
ATM

$= 4 \times 10^3\ N$

FLUID PRESSURE AT DEPTH "h"



$P_2 = P_0 + \rho g h$

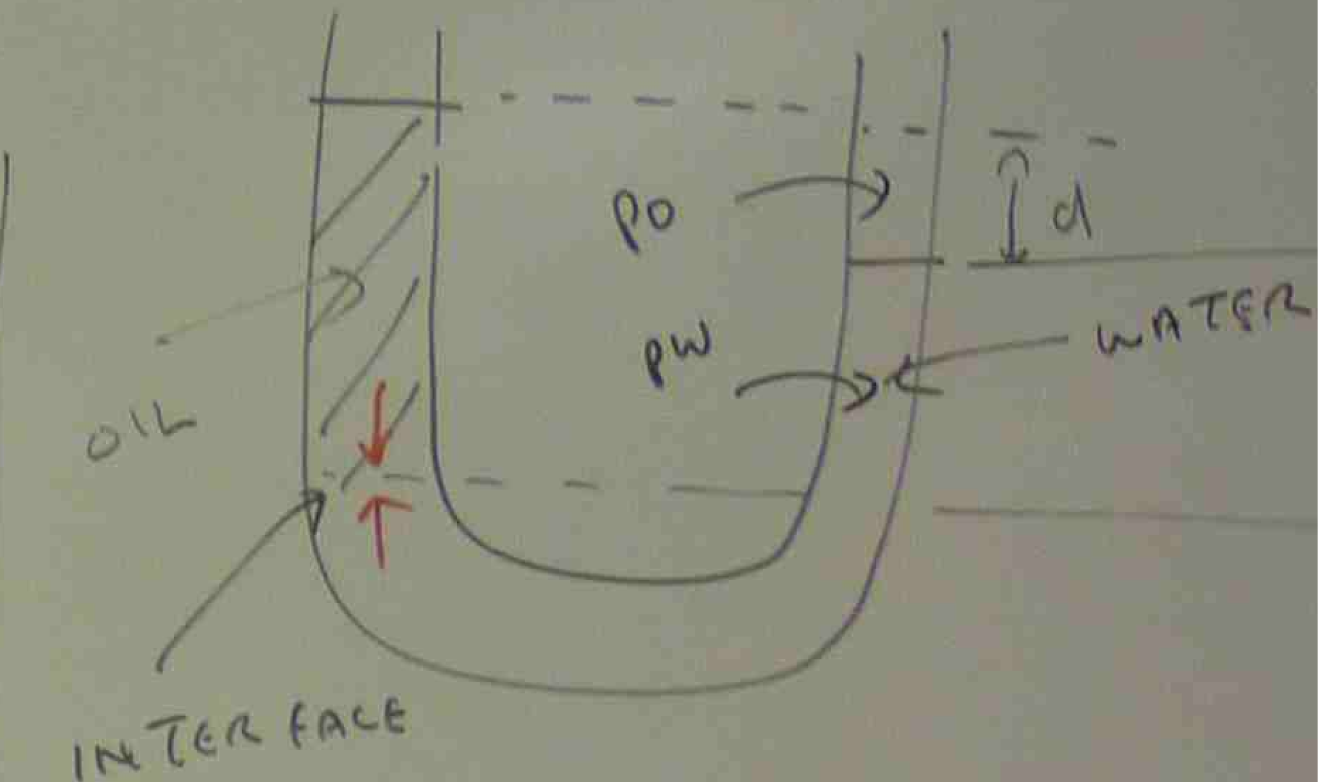


pb THE U TUBE IN FIGURE CONTAINS TWO LIQUIDS IN STATIC EQUILIBRIUM.

DENSITY OF WATER $\rho_w = 998\ kg/m^3$.

$l = 135\ mm,\ d = 12.3\ mm$.

WHAT IS THE DENSITY OF OIL?



AT THE INTERFACE

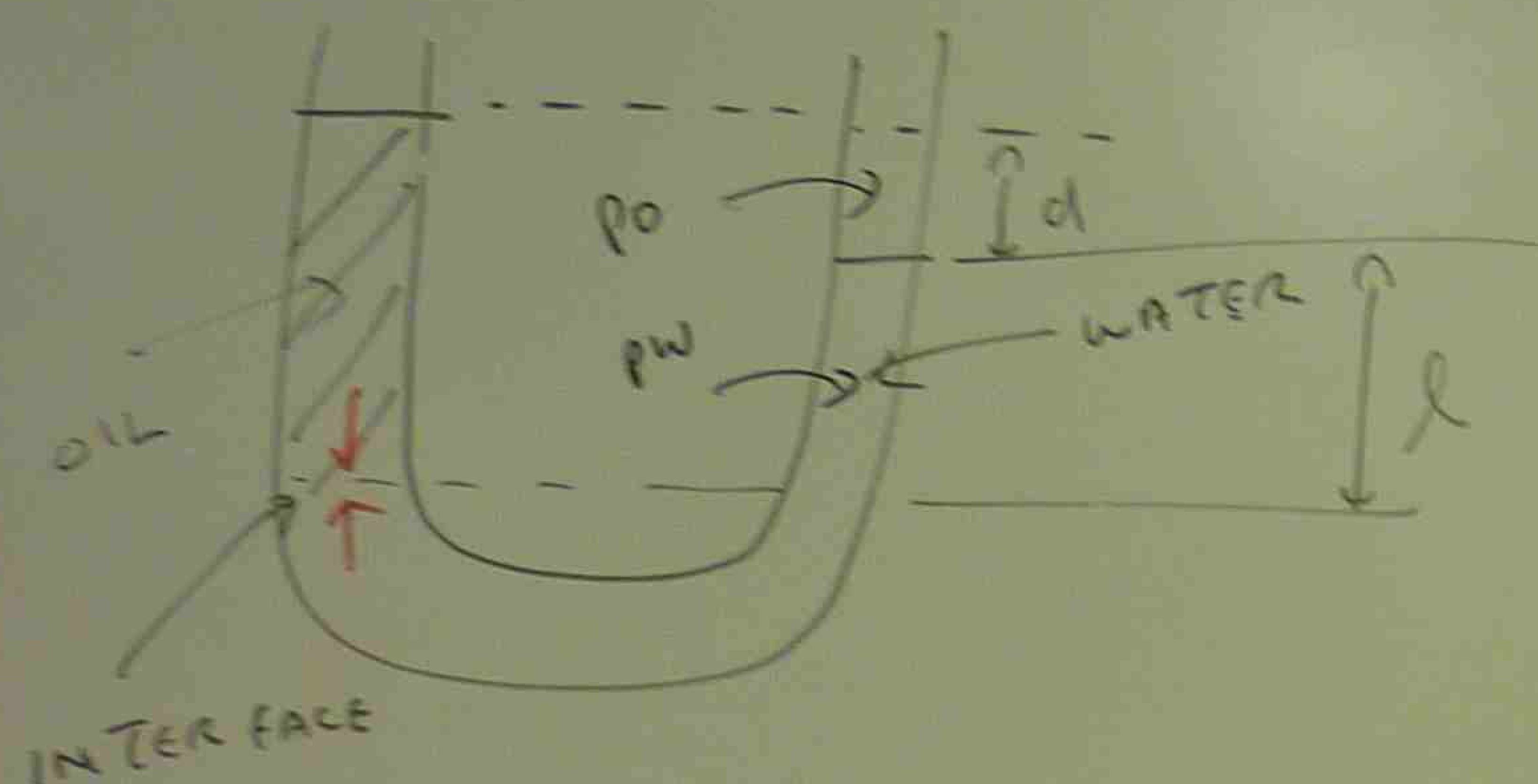
↓ OIL PRESSURE = ↑ WA...

$P_{INT} = P_w + \ldots$

$P_{INT} = \rho_x\, g(\ldots$

OIL DENSITY $\rho_x = \ldots$

$\rho_x = 1 \times \ldots$



AT THE INTERFACE

$\downarrow$ OIL PRESSURE = $\uparrow$ WATER + AIR PRESSURE

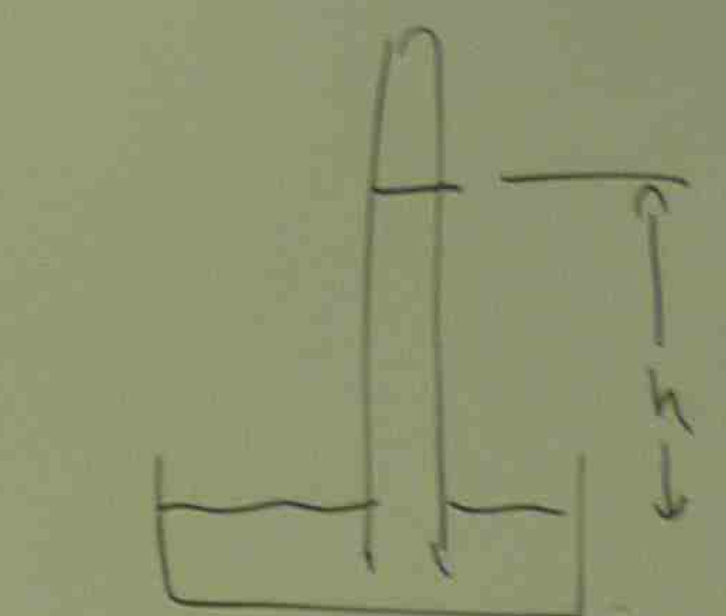
$$P_{INT} = P_W + P_0$$

$$P_{INT} = \rho_x \, g(l+d) + P_0$$

$$\boxed{\text{OIL DENSITY } \rho_x = \underbrace{\rho^W}_{\text{WATER DENSITY}} \times \frac{l}{l+d}}$$

$$\rho_x = 1 \times \frac{135}{135+12\text{-}3} = 915\,kg/m^3$$

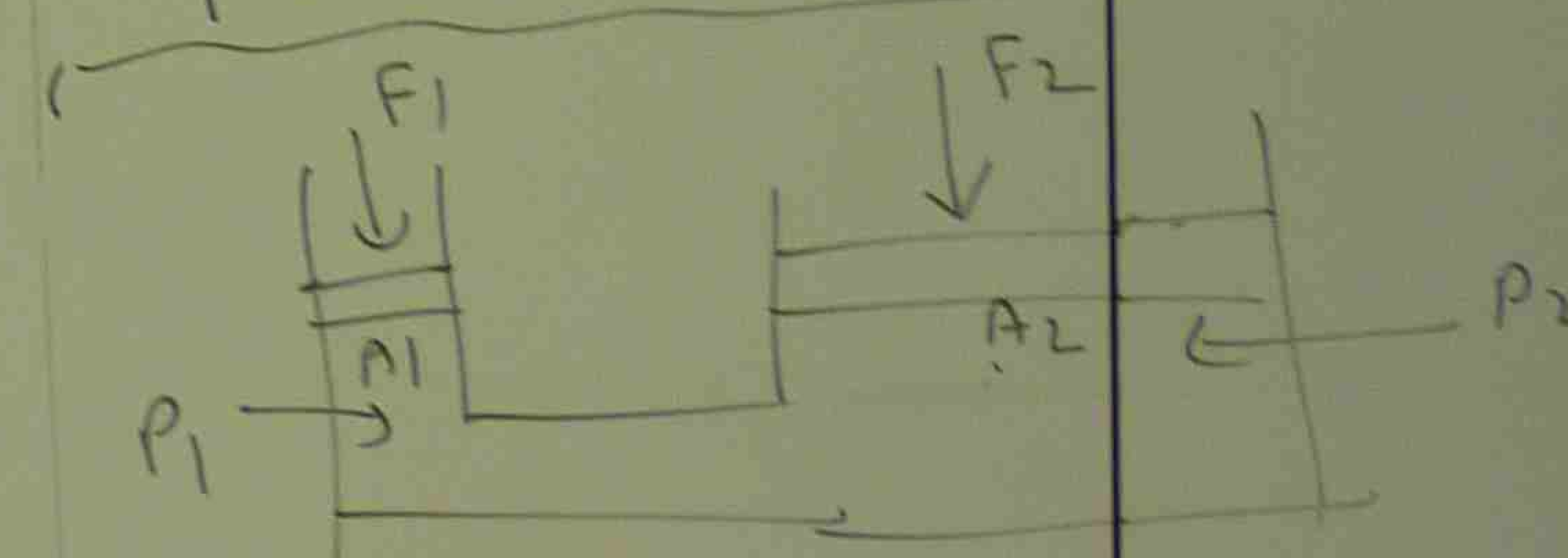
BAROMETER



AIR PRESSURE = HEIGHT OF MERCURY

$$P = \rho g h$$

PASCAL'S PRINCIPLE



$$\boxed{\begin{gathered} P_1 = P_2 \\ \frac{F_1}{A_1} = \frac{F_2}{A_2} \end{gathered}}$$

NS

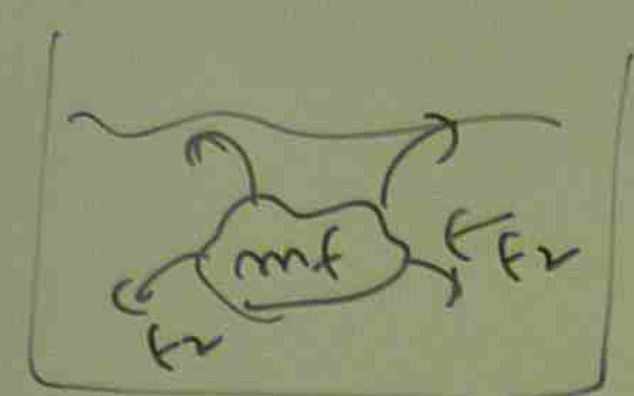
lium.

3 .

of MERCURY

P_2

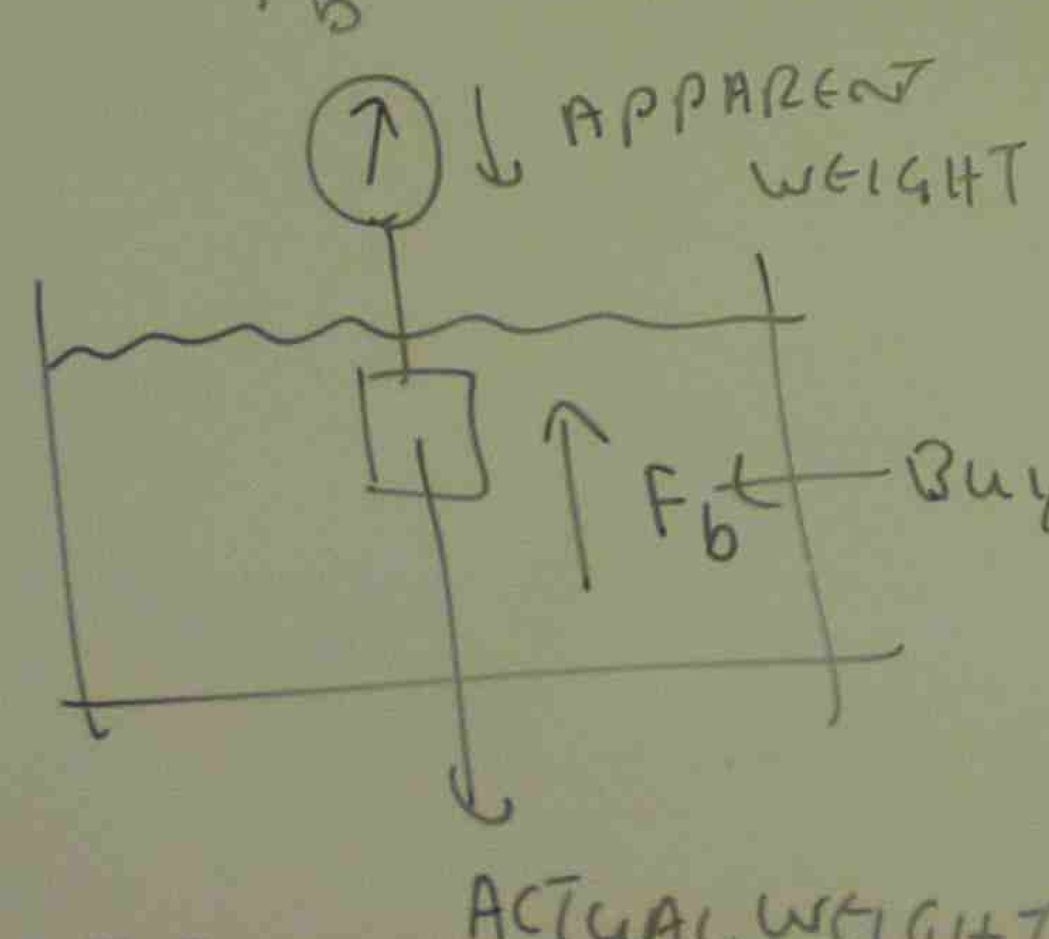
ARCHIMEDES' PRINCIPLE



MASS REMOVES THE EQUAL AMOUNT OF FLUID

WHEN A BODY IS FULLY OR PARTIALLY SUBMERGED IN A FLUID A BUOYANT FORCE $\vec{F_2}$ FROM THE SURROUNDING FLUIDS ACTS ON THE BODY. THE FORCE IS DIRECTED UPWARD AND HAS A MAGNITUDE EQUAL TO THE WEIGHT $m_f g$ OF THE FLUID THAT HAS BEEN DISPLACED BY THE BODY

$$F_b = m_f g \quad \text{(BUOYANT FORCE)}$$



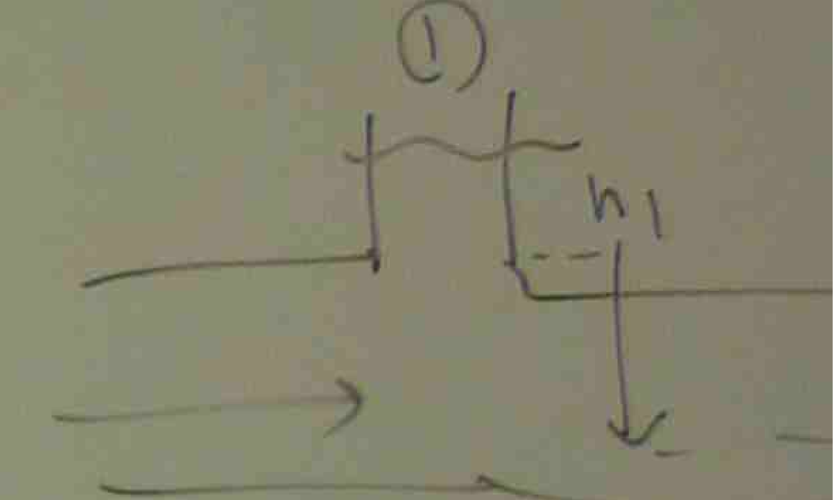
APPARENT WEIGHT = ACTUAL FORCE − MAGNITUDE OF BUOYANT FORCE

BERNOULL

WHEN THE FLU

FORCE (PRESSURE

SAME.



MOVING FLUID

①

$P_1 + \frac{1}{2}\rho$

PRESSURE V

... MERGED IN A FLUID
... FLUIDS ACTS ON THE
... HAS A MAGNITUDE
... E FLUID THAT HAS BEEN

... FORCE)

...ARENT = ACTUAL FORCE − MAGNITUDE OF BUOYANT FORCE
...HT

BERNOULLI'S EQUATION

WHEN THE FLUID IS FLOWING, TOTAL FORCE (PRESSURE + GRAVITY (HEIGHT) + VELOCITY) IS THE SAME.

MOVING FLUID

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

PRESSURE VELOCITY GRAVITY

HEIGHT

FLUID

"CAN