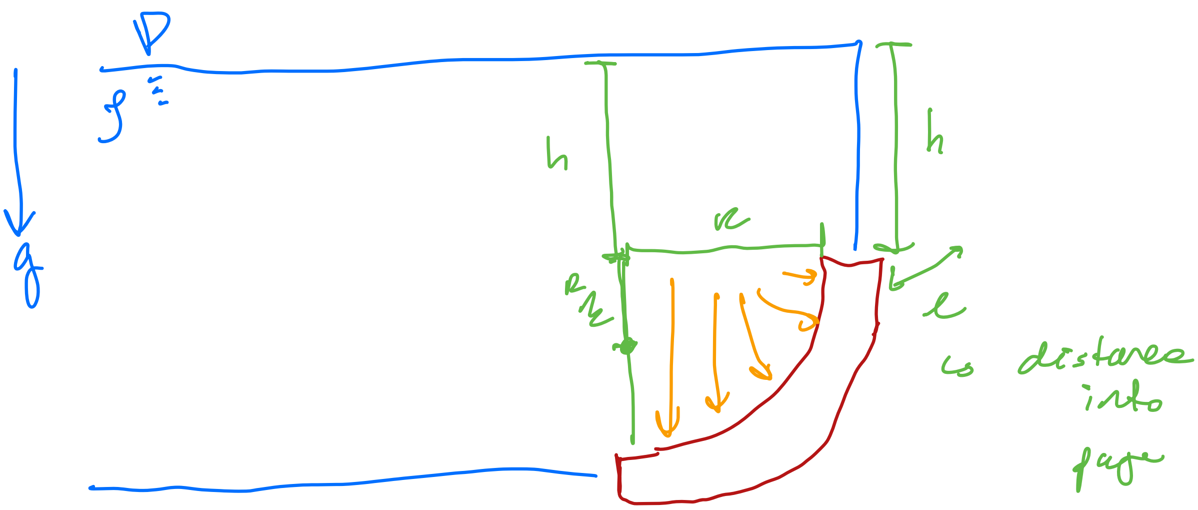
tam 335 lect 8 09/08

→ curved surfaces and calculating forces submerged in fluid

→ no general equation !! ∩

→ newtons 3rd law to solve all problems



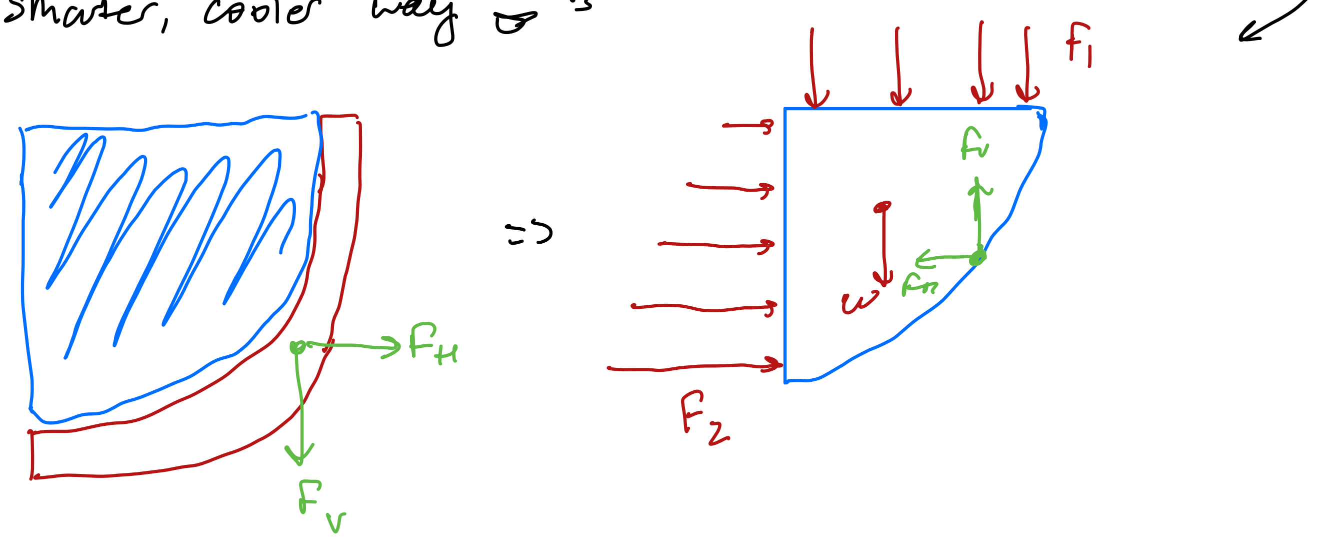
find : a) magnitude of force F_R

b) direction

(i) brute force method ✗

(ii) smarter, cooler way ✓

body focussed on



F_1 : $P_1 \cdot A$ } only focusing on area that force is applied on

$= \rho g h \cdot R l$

F_2 : $\rho g h_c \cdot A$ } acts at the centroid of the vertical side

$= \rho g (h + \frac{R}{2})(Rl)$

$W = \rho V g$

$= \rho (\frac{\pi R^2}{4} l) g$

• x-axis: $\sum F_x = 0$

$F_H = F_2$

$= \rho g (h + \frac{R}{2})(Rl)$

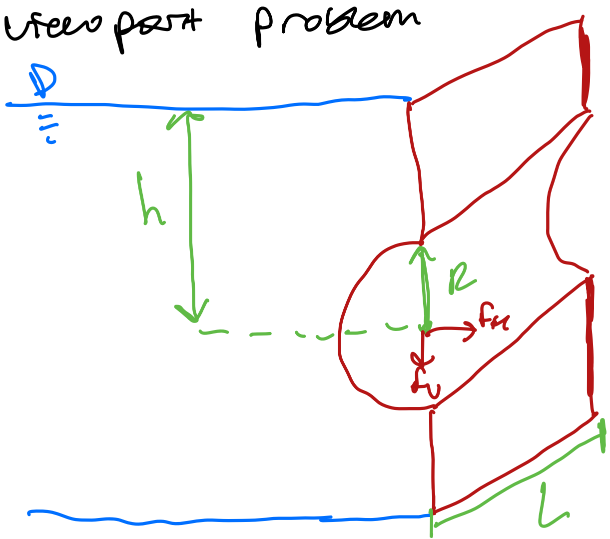
• y-axis: $\sum F_y = 0$

$F_V = F_1 + W$

$= \rho g h_1 (Rl) + \rho g l (\frac{\pi R^2}{4})$

• homework problem:

viewport problem



$R = 0.5m$ $L = 4m$

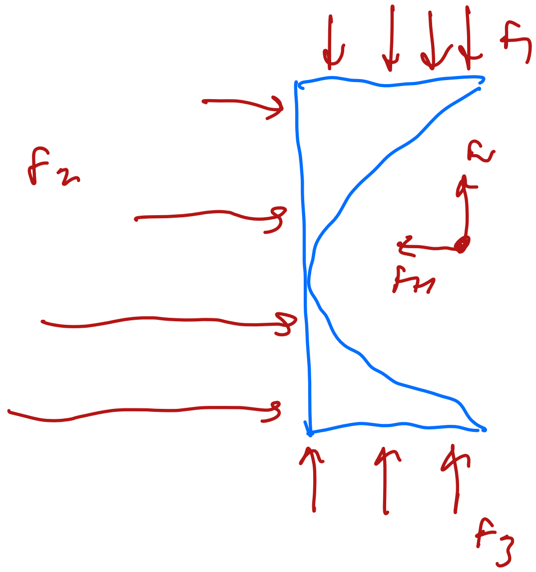
$h = 2m$ $\rho = 10^3 \frac{kg}{m^3}$

$g = 10 \, m s^{-2}$

a.) find magnitude of F_R

b.) find direction of F

• consider water around weapon is the system:



$f_1 = \rho g (h-R)(Rh)$
$f_3 = \rho g (h+R)(Rh)$
} vertical forces

$f_2 = \rho g h (2R \cdot L)$

$w = \rho \cdot V \cdot g$

$= \rho g \left(\underbrace{2R^2}_{} - \frac{\pi R^2}{2} \right) \ell$

↳ area of entire rectangle

$\underline{x\text{-axis}}$: $F_H = F_2$

$= \rho g (2R\ell) = \underline{8 \times 10^4 N}$

$\underline{y\text{-axis}}$: $F_V = f_1 + w - f_3$

$= \rho g R\ell (h-R) - \rho g R\ell (h+R)$
$+ \rho g \ell \left(2R^2 - \frac{\pi R^2}{2} \right)$

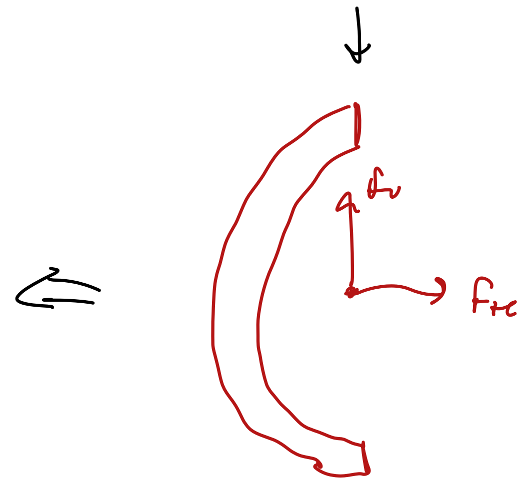
$= -\rho g \left(L \frac{\pi R^2}{2} \right) = \underline{-1.57 \times 10^4 N}$

↳ initial direction of F_V drawn was incorrect so new FBD

↓

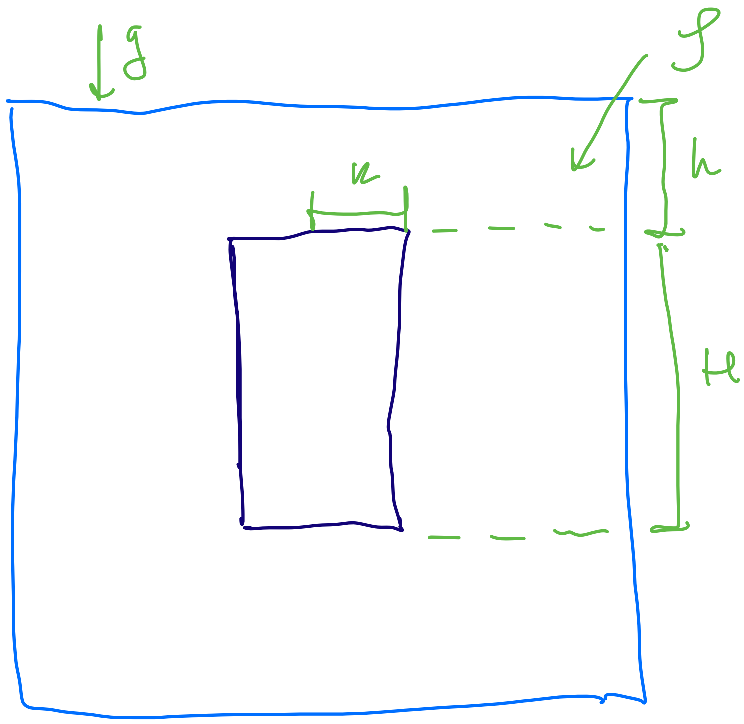
$$\tan\theta = \frac{f_v}{f_x}$$

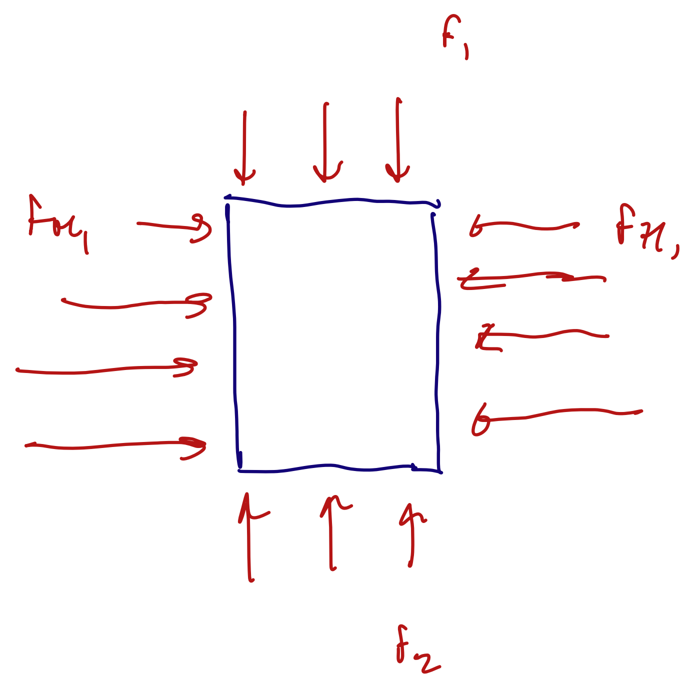
$$\theta = 60.9^\circ$$



- buoyancy: resultant fluid force acting on a body which is completely submerged

- archimedes' principle: buoyancy has a magnitude equal to the weight of the fluid displaced by the body





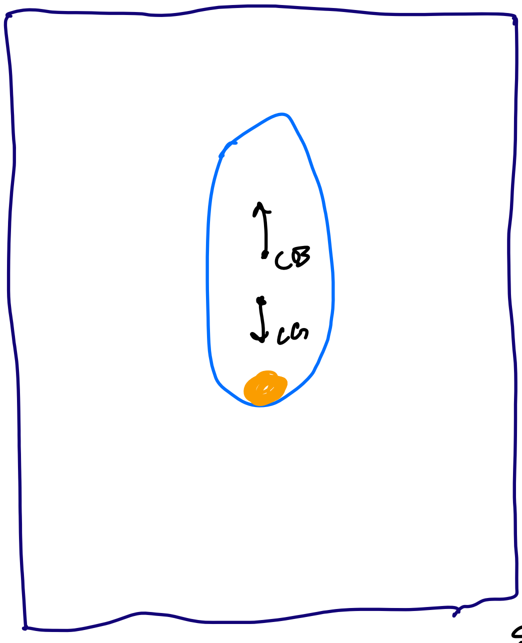
↳ F_x cancel out

$$\left.\begin{aligned} F_1 &= \rho g h (\pi R^2) \\ F_2 &= \rho g (h + H)(\pi R^2) \end{aligned}\right\} \rightarrow f_2 - f_1 = \rho g (H + h - H)\pi R^2$$

$$= \rho_w g (h \pi R^2)$$

$= \rho_w g V$

• stability & equilibrium



the displaced fluid

• center of buoyancy is the center of gravity of the displaced volume of the fluid

↳ if you slightly rotate the ellipsoid, a torque results and return to original position

• stable equilibrium: COG is below COB
• unstable equilibrium: COG is above COB

↳ only true for fully submerged bodies

• for floating bodies location of COB can move as the floating body rotates