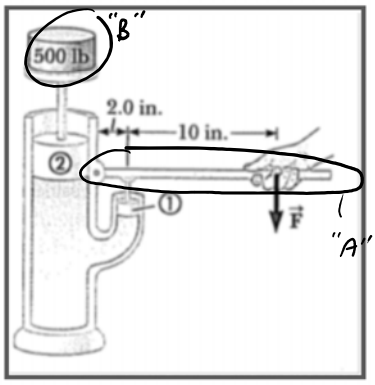
SI

500 lb → 226.796 kg 0.25 in → 0.00635 m
2 in → 0.0508 m 1.5 in → 0.0381 m
10 in → 0.254 m

Week 6 Challenge Homework Solutions

Question 1



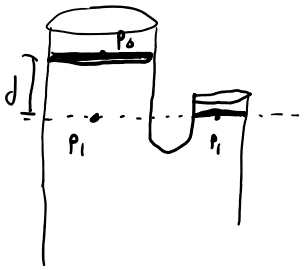
Piston 1 in the figure to the right has a diameter of 0.250 in. Piston 2 has a diameter of 1.50 in and is 2 inches higher than piston 1. The hydraulic fluid is oil.

(a) In jacks like this (think changing a flat tire on your car), there are two forms of mechanical advantage simultaneously working to make the force applied much smaller than what it lifts. What are the two forms of mechanical advantage in this system?

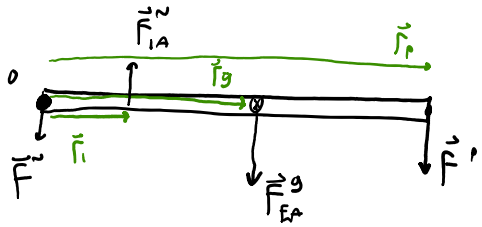
(b) Determine the magnitude (F) of the force necessary to support the 500 lb. load in the absence of friction.

(c) Use *Order of Magnitude* sense-making to determine if not including the height difference of the fluid is a problem when calculating the force in part (b).

(a) MA FROM TORQUE (I.E. LEVER ARMS)
MA FROM FLUIDS (I.E. DIFFERENT AREA PISTONS)



e-FBD A 1



$\Sigma \tau_O = I_O \alpha^0$

$\tau^0 + \tau^N_{1A} + \tau^g_{EA} + \tau^P = 0$ (ASSUME NEGLIGIBLE)

$R_1 F^N_{1A} - R_p F^P = 0$

$F^P = \frac{R_1}{R_p} F^N_{1A}$

$P_1 = P_0 + \rho_f g d$ NEGLIGIBLE $\Rightarrow P_1 \approx P_0$

$P_0 = \frac{m_B g}{A_2}$ $P_1 = \frac{F^N_{A1}}{A_1}$

$P_1 \approx \frac{m_B g}{A_2}$

$\frac{F^N_{A1}}{A_1} = \frac{m_B g}{A_2}$

$F^N_{A1} = \frac{A_1}{A_2} m_B g$

$F^N_{A1} = \left(\frac{r_1}{r_2}\right)^2 m_B g$

$F^P = \frac{R_1}{R_p} \left(\frac{r_1}{r_2}\right)^2 m_B g$

$F^P = \frac{R_1}{R_p} \left(\frac{d_1}{d_2}\right)^2 m_B g$

$= \left(\frac{1}{6}\right)\left(\frac{1}{36}\right) m_B g$

$= \frac{1}{216} m_B g$

b) Using $P_1 = P_0 + \rho_f g d$ and $P_0 = \frac{m_B g}{A_2}$

$\frac{m_B g}{\pi r_2^2} \rightarrow \frac{10^2 \cdot 10^1}{(10^{-1})^2} \rightarrow 10^5 P_a$

$\rho_{oil} g d \rightarrow 10^3 \cdot 10 \cdot 10^{-1} \rightarrow 10^3 P_a$

So $P_1 = 10^5 + 10^3 \rightarrow 10^5$ NEGLIGIBLE

$F^P = \frac{1}{216} m_B g = 10.3 N$

MA LEVER = 6
MA FLUIDS = 36
$MA_{TOTAL} = 216$