Physics 151 Class Exercise: Fluids - KEY

1.   A brick weighs 17.8 N and is resting on the ground. Its dimensions are 0.203 m x 0.0890 m x 0.0570 m. A number of the bricks are then stacked on top of this one. What is the smallest number of whole bricks (including the one on the ground) that could be used, so that their weight creates a pressure of at least one atmosphere on the ground beneath the first brick. (Hint: First decide which face of the brick is in contact with the ground).

Note that to get the largest pressure with the smallest number of bricks, we want the face of the brick with the smallest area in contact with the ground. This is the 0.0890 m x 0.0570 m face.

$$\frac{W}{A} = P_{atm}$$

$$\frac{nW_{one}}{A} = P_{atm}$$

$$n = \frac{P_{atm}A}{W_{one}} = \frac{\left(1.013 \times 10^5 \frac{N}{m^2}\right)(0.0890m \times 0.0570m)}{(17.8N)} = 28.8\,bricks$$

Thus, it would require 29 bricks.

2.   A mechanic is raising a car with a hydraulic lift to make repairs to the underside. The smaller piston has a radius of 15 cm while the large piston has a radius of 85 cm.   To raise a 1800 kg car 1.4 m,
a) how much force must the mechanic apply to the small piston, and
b) through what distance must she move the small piston.

Pascal's principle states that an external pressure applied to an enclosed fluid is transmitted unchanged to every point within the fluid. Thus, the pressure on the small piston is equal to that on the large piston.

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

$$F_1 = \frac{F_2 A_1}{A_2} = \frac{(1800 kg)\left(9.81\frac{m}{s^2}\right)\pi(0.15m)^2}{\pi(0.85m)^2} = 550N$$

Note that the volume of fluid displaced on the two sides must be equal.

$$A_1 d_1 = A_2 d_2$$

$$d_1 = \frac{A_2 d_2}{A_1} = \frac{\pi(0.85m)^2(1.4m)}{\pi(0.15m)^2} = 45m$$

Thus, the mechanic can raise the car with a much smaller force than the weight, but the distance through which the force is applied is much larger than the distance the car moves. Makes sense from a work perspective!