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## Discussion 1: Fluids and Pressure

### Objectives

- Determine the pressure within a fluid.
- Apply Pascal's principle to hydraulics problems.

### Summary

#### *Pressure*

Pressure is the perpendicular component of force applied to a unit area,  $p = F/A$ .

#### *Density*

Density  $\rho = m/V$ .

#### *Static pressure*

$$p = p_0 + \rho gh$$

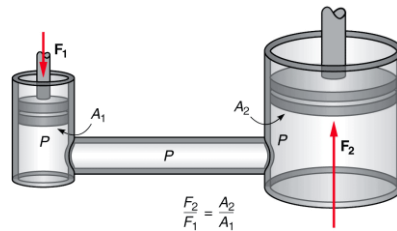
where  $p$  = pressure at depth  $h$ ,  $p_0$  = pressure at the top, and  $\rho$  = density of the fluid.

### Problems

There is not space on the sheet to work the problems. Use scratch paper.

1. A hydraulic system is filled with an incompressible fluid.

- a. If a downward force  $F_1 = 50$  N is applied to the small piston with area  $A_1 = 100$  cm<sup>2</sup>, what upward force  $F_2$  does the fluid apply to the large piston with area  $A_2 = 1000$  cm<sup>2</sup>?



- b. If the small piston with area  $A_1 = 100$  cm<sup>2</sup> moves down 10 cm, how far up does the large piston with  $A_2 = 1000$  cm<sup>2</sup> move?

2. A hydraulic lift in a garage uses a piston with a cross section of area 500 cm<sup>2</sup>.

- a. If the lift raises a 2000-kg truck, what is the pressure inside the cylinder?
- b. Is the pressure you found in part a gauge pressure or absolute pressure?
- c. Atmospheric pressure is a little bit more than 1 bar (1 bar = 100,000 Pa; 1 atm = 101,325 Pa). What is the absolute pressure inside the cylinder in bar?
- d. The lift is powered by a piston with a cross section of area 10 cm<sup>2</sup>. What force from this piston is needed to raise the truck?

- e. If the truck is to be raised 1.8 m, how far does the driving piston need to move? (It will need to use many strokes to do this.)
3. The lowest known point on Earth is the Challenger Deep, at the southern end of the Mariana Trench. Its depth is estimated as 10,920 meters below sea level.
    - a. If the sea water column has a constant density of  $1025 \text{ kg/m}^3$ , what is the water pressure (gauge pressure) at the bottom of the Challenger Deep?
    - b. Does it really matter if the pressure is reported as gauge pressure or absolute pressure?
  4. Atmospheric pressure at mean sea level is 101,325 Pa. The density of air at 1 atm pressure and standard temperature ( $25 \text{ }^\circ\text{C}$ ) is  $1.204 \text{ kg/m}^3$ .
    - a. What is the weight of a column of air from the surface of the Earth to the top of the atmosphere with a 1-m cross section?
    - b. If the air in Earth's atmosphere had a constant density, how thick would the atmosphere be?